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ENCYCLOPÆDIA BRITANNICA

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OF

ARTS, SCIENCES, AND GENERAL LITERATURE.

SEVENTH EDITION,

WITH PRELIMINARY DISSERTATIONS ON THE HISTORY OF THE SCIENCES,

AND

OTHER EXTENSIVE IMPROVEMENTS AND ADDITIONS;

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A GENERAL INDEX,

AND NUMEROUS ENGRAVINGS.

VOLUME XX.

ADAM AND CHARLES BLACK, EDINBURGH;
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ENCYCLOPÆDIA BRITANNICA.

SCULPTURE.

Origin of sculpture.

SCULPTURE is the art of imitating visible form by means of solid substances, such as marble, wood, or metals. The art is one of very great antiquity, and is generally thought to have originated from idolatry, as it was found necessary to place before the people the images of their gods, to enliven the fervour of their devotion. The pyramids and obelisks of Egypt, which were probably temples, or rather altars, dedicated to the sun, were covered with hieroglyphical emblems of men, beasts, birds, fishes, and reptiles, at a period prior to that in which there is any unexceptionable evidence that mere statue-worship prevailed even in that nursery of idolatry.

But though it appears thus evident that picture-writing was the first employment of the sculptor, we are far from imagining that idolatrous worship did not contribute to carry his art to that perfection which it attained in some of the nations of antiquity. Even in the dark ages of Europe, when the other fine arts were almost extinguished, the ceremonies of the Church of Rome, and the veneration which she taught for her saints and martyrs, preserved among the Italians some vestiges of the sister arts of sculpture and painting; and therefore, as human nature is everywhere the same, it is reasonable to believe that a similar veneration for heroes and demigods would, among the ancient nations, have a similar effect. But if this be so, the presumption is, that the Chaldæans were the first who invented the art of hewing blocks of wood and stone into the figures of men and other animals; for the Chaldæans were unquestionably the first idolaters, and their early progress in sculpture is confirmed by the united testimonies of Berosus, Alexander Polyhistor, Apollodorus, and Pliny, not to mention the eastern tradition that the father of Abraham was a sculptor.

Mr Bromley's theory that sculpture was invented by the Scythians.

Against this conclusion, however, Mr Bromley, in his History of the Fine Arts, has urged some plausible arguments. In stating these, he professes not to be original, or to derive his information from the fountain-head of antiquity. He adopts, as he tells us, the theory of a French writer, who maintains, that in the year of the world 1949, about three hundred years after the deluge, the Scythians under Brouma, a descendant of Magog the son of Japhet, extended their conquests over the greater part of Asia. According to this system, Brouma was not only the civilizer of India, and the author of the Brahminical doctrines, but also diffused the principles of the Scythian mythology over Egypt, Phœnicia, Greece, and the continent of Asia.

Of these principles Mr Bromley has given us no distinct enumeration; the account which he gives of them is not to be found in one place, but must be collected from a variety of distant passages. In attempting therefore to present the substance of his scattered hints in one view, we shall not be confident that we have omitted none of them. The ox, says he, was the Scythian emblem of the generator of animal life, and hence it became the principal divinity of the Arabians. The serpent was the symbol of the source of intelligent nature. These were the common points of union in all the first religions of the earth. From Egypt the Israelites carried with them a religious veneration for the ox and the serpent. Their veneration for the ox appeared soon after they marched into the wilderness, when, in the absence of Moses, they called upon Aaron to make them gods which should go before them. The idea of having an idol to go before them, says our author, was completely Scythian; for so the Scythians acted in all their progress throughout Asia, with this difference, that their idol was a living animal. The Israelites having gained their favourite god, which was an ox, not a calf, as it is rendered in the book of Exodus, next proceeded to hold a festival, which was to be accompanied with dancing; a species of gaiety common in the festivals which were held in adoration of the emblematic *urotal* or ox, in that very part of Arabia, near Mount Sinai, where this event took place. It is mentioned too as a curious and important fact, that the ox which was revered in Arabia was called *Adonai*. Accordingly Aaron, announcing the feast to the ox or golden calf, speaks thus, *To-morrow is a feast to Adonai*, which is in our translation rendered *to the Lord*. In the time of Jeroboam we read of the golden calves set up as objects of worship at Bethel and

Dan. Nor was the reverence paid to the ox confined to Scythia, to Egypt, and to Asia. It extended much farther. The ancient Cimbri, as the Scythians did, carried an ox of bronze before them on all their expeditions. Mr Bromley also informs us, that as great respect was paid to the living ox among the Greeks as was offered to its symbol among other nations.

The emblem of the serpent, continues Mr Bromley, was marked yet more decidedly by the express direction of the Almighty. That animal had ever been considered as emblematical of the supreme generating power of intelligent life. And was that idea, says he, discouraged, so far as it went to be a sign or symbol of life, when God said to Moses, "Make thee a brazen serpent, and set it on a pole, and it shall come to pass that every one who is bitten, when he looketh on it, shall live?" In Egypt the serpent surrounded Isis and Osiris, the diadems of their princes, and the bonnets of their priests. The serpent made a distinguished figure in Grecian sculpture. The fable of Echidne, the mother of the Scythians, gave her figure terminating as a serpent to all the founders of states in Greece; from which their earliest sculptors represented in that form the Titan princes, Cecrops, Draco, and even Ericthonius. Beside the spear of the image of Minerva, which Phidias made for the citadel of Athens, he placed a serpent, which was supposed to guard that goddess.

In Egypt, as well as in Scythia and India, the divinity was represented on the leaves of the tamara or lotus. Pan was worshipped as a god in that country, as well as over the east. Their sphinxes, and all their combined figures of animal creation, took their origin from the mother of the Scythians, who brought forth an offspring that was half a woman and half a serpent. Their pyramids and obelisks arose from the idea of flame, the first emblem of the supreme principle, introduced by the Scythians, and which even the influence of Zoroaster and the Magi could not remove.

We are told that the Bacchus of the Greeks is derived from the Brouma of the Indians; that both are represented as seated on a swan swimming over the waves, to indicate that each was the god of humid nature; not the god of wine, but the god of waters. The mitre of Bacchus was shaped like half an egg; an emblem taken from this circumstance, that at the creation the egg from which all things sprung was divided in the middle. Pan also was revered among the Scythians; and from that people were derived all the emblems by which the Greeks represented this divinity.[1]

This theory erroneous.

To form conclusions concerning the origin of nations, the rise and progress of the arts and sciences, without the aid of historical evidence, by analogies which are sometimes accidental, and often fanciful, is a mode of reasoning which cannot readily be admitted. There may indeed, we acknowledge, be resemblances in the religion, language, manners, and customs, of different nations, so striking and so numerous, that to doubt of their being descended from the same stock would savour of scepticism. But historical theories must not be adopted rashly. We must be certain that the evidence is credible and satisfactory before we proceed to draw any conclusions from it. We must first know whether the Scythian history itself be authentic, before we make any comparison with the history of other nations. But what is called the Scythian history, every man of learning knows to be a collection of fables. Herodotus and Justin are the two ancient writers from whom we have the fullest account of that warlike nation; but these two historians contradict each other, and both write what cannot be believed of the same people at the same period of their progress. By Strabo[2] and Herodotus[3] they are represented as the most savage of mortals, delighting in war and bloodshed, cutting the throats of all strangers who came among them, eating their flesh, and making cups and pots of their skulls. It is not conceivable that such savages could be sculptors; or that, even supposing their manners to have been such as Justin represents them, a people so simple and ignorant could have imposed their mythology upon the Chaldæans, Phœnicians, and Egyptians, whom we know by the most incontrovertible evidence to have been great and polished nations so early as in the days of Abraham.

Taking for granted, therefore, that the Scythians did not impose their mythology on the eastern nations, and that the art of sculpture, as well as idolatrous worship, prevailed first among the Chaldæans, we shall endeavour to trace the progress of this art through some other nations of antiquity, till we bring it to Greece, where it was carried to the highest perfection to which it has yet attained. We shall then follow out the art in its decline and subsequent revivals in modern times.

The first intimation that we have of the art of sculpture is in the book of Genesis, where we are informed, that when Jacob, by the divine command, had returned to Canaan, his wife Rachel carried along with her the teraphim or idols of her father. These we are assured were small, since Rachel found it so easy to conceal them from her father, notwithstanding his anxious search. We are ignorant, however, how these images were made, or of what materials they were composed. The first person mentioned as an artist of eminence is Bezaleel, who formed the cherubim which covered the mercy-seat.

1.—EGYPTIAN, PHŒNICIAN, AND ETRURIAN SCULPTURE.

Egyptian sculpture.

The Egyptians practised the art of sculpture very extensively; and the number and variety of their works remaining, from the most rude to the most perfect in execution, give us reason to believe we have specimens of their earliest as well as latest productions. Two circumstances appear to have obstructed the progress and advancement of the art in Egypt. First, the persons of the Egyptians were not possessed of the graces of form, elegance, or symmetry; and consequently they had no perfect standard on which to model their taste. They resembled the Chinese in the cast of their face, and in the clumsy rounding of their contours. Secondly, they were confined by their laws to the principles and practices of their ancestors, and were not permitted to introduce any innovations. Their statues were always formed in the same stiff attitude, with the arms hanging perpendicularly down the sides. So far were they from attempting any improvements, that in the time of Hadrian the art continued in the same rude state as at first; and when their slavish adulation for that emperor induced them to place amongst the objects of their worship the statue of his favourite Antinous, the same inanimate stiffness in the attitude of the body and position of the arms was observed.

First styl

Notwithstanding the attachment of the Egyptians to ancient usages, Winckelman thinks he has discovered two different styles of sculpture, which prevailed at different periods. The first of these ends with the conquest of Egypt by Cambyses; the second begins at that time, and extends beyond the reign of Alexander the Great. In the first style, the lines which form the contour are straight, and projecting a little; the position is stiff and unnatural. In sitting figures the legs are parallel, the feet squeezed together, and the arms fixed to the sides; but in the figures of women the left arm is folded across the breast; the bones and muscles are faintly discernible; the eyes are flat and looking obliquely, and the eyebrows sunk,—features which destroy entirely the beauty of the head; the cheek-bones are high, the chin small and piked; the ears are generally placed higher than in nature, and the feet are too large and flat. In short, if we are to look for any model in the statues of Egypt, it is not for the model of beauty, but of deformity. The statues of men are naked, only they have a short apron, and a few folds of drapery surrounding their waist. The vestments of women are only distinguishable by the border, which rises a little above the surface of the statue. In this age it is evident the Egyptians knew little of drapery.

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[1] It would be tedious to follow our author through the whole of this subject; and were we to submit to the labour of collecting and arranging his scattered materials, we should still view his system with some degree of suspicion. It is drawn, as he informs us, from the work of M. D'Ancarville, entitled *Recherches sur l'Origine, l'Esprit, et les Progrès, des Arts de la Grèce.*

[2] Lib. vii.

[3] Lib. iv. cap. 62.

Second style.

Of the second style of sculpture practised amongst the Egyptians, Winckelman thinks he has found specimens in the two figures of basaltes in the Capitol, and in another figure at the Villa Albani, the head of which has been renewed. The first two of these, he remarks, bear visible traces of the former style, which appear especially in the form of the mouth and the shortness of the chin. The hands possess more elegance; and the feet are placed at a greater distance from each other than was customary in more ancient times. In the first and third figures the arms hang down close to the sides; in the second they hang more freely. Winckelman suspects that these three statues were made after the conquest of Egypt by the Greeks. They are clothed with a tunic, a robe, and a mantle. The tunic, which is puckered into many folds, descends from the neck to the ground. The robe in the first and third statues seems close to the body, and is only perceptible by some little folds. It is tied under the breast, and covered by the mantle, the two buttons of which are placed under the epaulette.

The Egyptian statues were not only formed by the chisel; they were also polished with great care. Even those on the summit of an obelisk, which could only be viewed at a distance, were finished with as much labour and care as if they had admitted a close inspection. As they are generally executed in granite or basalt, stones of a very hard texture, it is impossible not to admire the indefatigable patience of the artists. The eye was often of different materials from the rest of the statue; sometimes it was composed of a precious stone or metal. We are assured that the valuable diamond of an empress of Russia, the largest and most beautiful hitherto known, formed one of the eyes of the famous statue of Scheringham in the temple of Brahma.

Herodotus mentions two Egyptian statues, one placed before the temple of Vulcan at Memphis, the other in the city of Sais by king Amasis, each of which was seventy-five feet long. The colossal sphinx near the great pyramid rises twenty-five feet. The sitting statues of Memnon, the mother and son of Osmandue, at Thebes, are each fifty-eight feet high. To these we might add a number of similar works known by remaining fragments, or described by authors. Most of the great works of the Egyptians were executed in the reign of Sesostris, who lived in the time of Rehoboam king of Israel, a thousand years before the Christian era, which shows that the arts of Egypt and of Greece were in a progressive state of improvement at the same time.

The enormous works of Egypt have struck foreign visiters with wonder and awe, from Herodotus down to the members of the French Institute. Herodotus says, "one of their buildings is equal to many of the most considerable Greek buildings taken together;" and M. Ripaud observes, "these works are so prodigious, they make every thing we do look little." The Egyptians had notions of durability in their works which no other nation has succeeded in imitating: they seemed to work as if they laughed at time, war, barbarism. Quantity was every thing with them, or almost so; quality but little. They wished to please themselves and astonish posterity, and they succeeded.

The ancient authors who give the most satisfactory accounts of Egyptian antiquities are, Herodotus, Diodorus Siculus, Josephus, Strabo, Clemens of Alexandria, Jamblicus, and Orus Apollo. Among the modern writers, we may mention Pocock, Savary, Norden, and Denon, as worthy of perusal on this subject.

Phœnician sculpture.

The Phœnicians possessed both a character and a situation highly favourable to the cultivation of statuary. They had beautiful models in their own persons, and their industrious character qualified them to attain perfection in every art for which they had a taste. Their situation raised a spirit of commerce, and commerce induced them to cultivate the arts. Their temples shone with statues and columns of gold, and a profusion of emeralds was everywhere scattered about. All the great works of the Phœnicians have been unfortunately destroyed; but many of the Carthaginian medals are still preserved, ten of which are deposited in the cabinet of Florence. But though the Carthaginians were a colony of Phœnicians, we cannot from their works judge of the merit of their ancestors.

This art not cultivated among the Persians.

The Persians made no distinguished figure in the arts of design. They were indeed sensible to the charms of beauty, but they did not study to imitate them. Their dress, which consisted of long flowing robes concealing the whole person, prevented them from attending to the beauties of form. Their religion, too, which taught them to worship the divinity in the emblem of fire, and that it was impious to represent him under a human form, seemed almost to prohibit the exercise of this art, by taking away those motives which alone could give it dignity and value; and as it was not customary among them to raise statues to great men, it was impossible that statuary could flourish in Persia.

Etrurian sculpture.

The Etrurians, or ancient Tuscans, in the opinion of Winckelman, carried this art to some degree of perfection at an earlier period than the Greeks. It is said to have been introduced before the siege of Troy by Dædalus, who, in order to escape the resentment of Minos king of Crete, took refuge in Sicily, whence he passed into Italy, where he left many monuments of his art. Pausanias and Diodorus Siculus inform us, that some works ascribed to him were to be seen when they wrote; and that these possessed that character of majesty which afterwards distinguished the labours of Etruria.

A character strongly marked forms the chief distinction in those productions of Etruria which have descended to our times. Their style was indeed hard and overcharged; for it is not to be supposed that a people of such rude manners as the Etrurians could communicate to their works that vividness and beauty which the elegance of Grecian manners inspired. On the other hand, there are many of the Tuscan statues which bear so close a resemblance to those of Greece, that antiquaries have thought it probable that they were conveyed from that country, or Magna Græcia, into Etruria, about the time of the Roman conquest, when Italy was adorned with the spoils of Greece.

First style.

Among the monuments of Etrurian art two different styles have been observed. In the first the lines are straight, the attitude stiff, and no idea of beauty appears in the formation of the head. The contour is not well rounded, and the figure is too slender. The head is oval, the chin piked, the eyes flat, and looking asquint. These are the defects of an art in the state of infancy, which an accomplished master could never fall into, and are equally conspicuous in Gothic statues as in the productions of the ancient natives of Florence. They resemble so much the style of the Egyptians, that one is almost induced to suppose that there had once been a communication between these two nations; but others think that this style was introduced by Dædalus.

Second style.

Winckelman supposes that the second epoch of this art commenced in Etruria about the time at which it had reached its greatest perfection in Greece, in the age of Phidias. But this conjecture is not supported by any proofs. The joints are strongly marked, the muscles raised, and the bones distinguishable; but the whole mien is harsh. In designing the bone of the leg, and the separation of the muscles of the calf, there is an elevation and strength above life. The statues of the gods are designed with more delicacy. In forming them, the artists were anxious to show that they could exercise their power without that violent distension of the muscles which is necessary in the exertions of beings merely human; but in general their attitudes are unnatural, and the actions strained. If a statue, for instance, hold any thing with its fore-fingers, the rest are stretched out in a stiff position.

II.—GRECIAN SCULPTURE.

According to ancient history, the Greeks did not emerge from the savage state till a long time after the Egyptians, Chaldæans, and Indians, had arrived at a considerable degree of civilization. The original rude inhabitants of Greece were civilized by colonies which arrived among them, at different times, from Egypt and Phœnicia. These brought along with them the religion, the letters, and the arts of their parent countries; and if sculpture had its origin from the worship of idols, there is reason to believe that it was one of the arts which were thus imported; for that the gods of Greece were of Egyptian and Phœnician extraction is a fact incontrovertible. The original statues of the gods, however, were very rude. The earliest objects of idolatrous worship have everywhere been the heavenly bodies; and the symbols consecrated to them were generally pillars of a conical or pyramidal figure. It was not till hero-worship was ingrafted on the planetary that the sculptor thought of giving to the sacred statue any part of the human form; and it appears to have been about the era of their revolution in idolatry that the art of sculpture was introduced among the Greeks. The first representations of their gods were round stones placed upon cubes or pillars; and these stones they afterwards formed roughly, so as to give them something of the appearance of a head. Agreeable to this description was a Jupiter which Pausanias saw in Tegeum, in Arcadia. These representations were called Hermes; not that they represented Mercury, but from the word which signified a rough stone. It is the name which Homer gives to the stones which were used to fix vessels to the shore. Pausanias saw at Pheres thirty deities made of unformed blocks or cubical stones. The Lacedæmonians represented Castor and Pollux by two parallel posts; and a transverse beam was added, to express their mutual affection.

If the Greeks derived from foreign nations the rudiments of the arts, it must redound much to their honour, that in a few centuries they carried them to such wonderful perfection as entirely to eclipse the fame of their masters. It is by tracing the progress of sculpture among them that we are to study the history of this art; and we shall see its origin and successive improvements correspond with nature, which always operates slowly and gradually.

Causes which promoted the art of sculpture in Greece.

The great superiority of the Greeks in the art of sculpture may be ascribed to a variety of causes. The influence of climate over the human body is so striking, that it must have fixed the attention of every thinking man who has reflected on the subject. The violent heats of the torrid zone, and the excessive cold of the polar regions, are unfavourable to beauty. It is only in the mild climates of the temperate regions that it appears in its most attractive charms. Perhaps no country in the world enjoys a more serene air, less tainted with mist and vapours, or possesses in a higher degree that mild and genial warmth which can unfold and expand the human body into all the symmetry of muscular strength, and all the delicacies of female beauty, in greater perfection, than the happy climate of Greece; and never was there any people that had a greater taste for beauty, or were more anxious to improve it. Of the four wishes of Simonides, the second was to have a handsome figure. The love of beauty was so great among the Lacedæmonian women, that they kept in their chambers the statues of Nereus, of Narcissus, of Hyacinthus, and of Castor and Pollux, hoping that by often contemplating them they might have beautiful children.

There was a variety of circumstances in the noble and virtuous freedom of the Grecian manners, that rendered these models of beauty peculiarly subservient to the cultivation of the fine arts. There were no tyrannical laws, as among the Egyptians, to check their progress. They had the best opportunities to study them in the public places, where the youth, who needed no other veil than that of chastity and purity of manners, performed their various exercises quite naked. They had the strongest motives to cultivate sculpture, for a statue was the highest honour which public merit could attain. It was an honour ambitiously sought, and granted only to those who had distinguished themselves in the eyes of their fellow-citizens. As the Greeks preferred natural qualities to acquired accomplishments, they decreed the first rewards to those who excelled in agility and strength of body. Statues were often raised to wrestlers. Even the most eminent men of Greece, in their youth, sought renown in gymnastic exercises. Chrysippus and Cleanthes distinguished themselves in the public games before they were known as philosophers. Plato appeared as a wrestler both at the Isthmian and Pythian games; and Pythagoras carried off the prize at Elis. The passion by which they were inspired was the ambition of having their statues erected in the most sacred place of Greece, to be seen and admired by the whole people. The number of statues erected on different occasions was immense; of course the number of artists must have been great, their emulation ardent, and their progress rapid.

As most of the statues were decreed for those who vanquished in the public games, the artists had the opportunity of seeing excellent models; for those who surpassed in running, boxing, and wrestling, must in general have been well formed, yet would exhibit different kinds of beauty.

The high estimation in which sculptors were held was very favourable to their art. Socrates declared artists to be the only wise men. An artist could be a legislator, a commander of armies, and might hope to have his statue placed beside those of Miltiades and Themistocles, or those of the gods themselves. Besides, the honour and success of an artist did not depend on the caprice of pride or of ignorance. The productions of art were estimated and rewarded by the greatest sages in the general assembly of Greece; and the sculptor who had executed his work with ability and taste was confident of obtaining immortality.

It was the opinion of Winckelman, that liberty was highly favourable to this art; but, though liberty is absolutely necessary to the advancement of science, it may be doubted whether the fine arts owe their improvement to this cause. Sculpture flourished most in Greece when Pericles exercised the power of a king, and in the reign of Alexander when Greece was conquered. It attained no perfection in Rome until Augustus had enslaved the Romans. It revived in Italy under the patronage of the family of Medici, and in France under the despotic rule of Louis XIV. It is the love of beauty, luxury, wealth, or the patronage of a powerful individual, that promotes the progress of this art.

Grecian ideas of beauty.

The head.

It will now be proper to give a particular account of the ideas which the Greeks entertained concerning the standard of beauty in the different parts of the human body. And with respect to the head, the profile which they chiefly admired is peculiar to dignified beauty. It consists in a line almost straight, or marked by such slight and gentle inflections as are scarcely distinguishable from a straight line. In the figures of women and young persons, the forehead and nose form a line approaching to a perpendicular.

The forehead.

Ancient writers, as well as artists, assure us that the Greeks reckoned a small forehead a mark of beauty, and a high forehead a deformity. From the same idea, the Circassians wore their hair hanging down over their foreheads almost to their eyebrows. To give an oval form to the countenance, it is necessary that the hair should cover the forehead, and thus make a curve about the temples, otherwise the face, which terminates in an oval form in the inferior part, will be angular in the higher part, and the proportion will be destroyed. This rounding of the forehead may be seen in all handsome persons, in all the heads of ideal beauty in ancient statues, and especially in those of youth. It has been overlooked, however, by modern statuaries. Bernini, who modelled a statue of Louis XIV. in his youth, turned back the hair from the forehead.

The eyes.

It is generally agreed that large eyes are beautiful; but their size is of less importance in sculpture than their form, and the manner in which they are enchased. In ideal beauty, the eyes are always sunk deeper than they are in nature, and consequently the eyebrows have a greater projection. But in large statues, placed at a certain distance, the eyes, which are of the same colour with the rest of the head, would have little effect if they were not sunk. By deepening the cavity of the eye, the statuary increases the light and shade, and thus gives the head more life and expression. The same practice is used in small statues. The eye is a characteristic feature in the heads of the different deities. In the statues of Apollo, Jupiter, and Juno, the eyes are large and round. In those of Pallas they are also large; but by lowering the eyelids, the virgin air and expression of modesty are delicately marked. Venus has small eyes, and the lower eyelid being raised a little, gives them a languishing look and enchanting sweetness. It is only necessary to see the Venus de' Medicis to be convinced that large eyes are not essential to beauty, especially if we compare her small eyes with those which resemble them in nature. The beauty of the eyebrows consists in the fineness of the hair, and in the sharpness of the bone which covers them; and masters of the art considered the joining of the eyebrows as a deformity, though it is sometimes to be met with in ancient statues.

The mouth.

The beauty of the mouth is peculiarly necessary to constitute a fine face. The lower lip must be fuller than the upper, in order to give an elegant rounding to the chin. The teeth seldom appear, except in laughing satyrs. In human figures the lips are generally close, and a little opened in the figures of the gods. The lips of Venus are half open. In figures of ideal beauty, the Grecian artists never interrupted the rounding of the chin by introducing a dimple; for this they considered not as a mark of beauty, and only to be admitted to distinguish individuals. The dimple indeed appears in some ancient statues, but antiquaries suspect it to be the work of a modern hand. It is suspected, also, that the dimple which is sometimes found on the cheeks of ancient statues is a modern innovation.

The ears.

No part of the head was executed by the ancients with more care than the ears, though little attention has been given to them by modern artists. This character is so decisive, that if we observe in any statue that the ears are not highly finished, but only roughly marked, we may conclude with certainty that we are examining a modern production. The ancients were very attentive to copy the precise form of the ear in taking likenesses. Thus, where we meet with a head the ears of which have a very large interior opening, we know it to be the head of Marcus Aurelius.

The hair.

The manner in which the ancient artists formed the hair also enables us to distinguish their works from those of the moderns. On hard and coarse stones the hair was short, and appeared as if it had been combed with a wide comb; for that kind of stone was difficult to work, and could not without immense labour be formed into curled and flowing hair. But the figures executed in marble in the most flourishing period of the art have the hair curled and flowing; at least where the head was not intended to be an exact resemblance, for then the artist conformed to his model. In the heads of women, the hair was thrown back, and tied behind in a waving manner, leaving considerable intervals; which gives the agreeable variety of light and shade, and produces the effects of the claro-oscuro. The hair of the Amazons is disposed in this manner. Apollo and Bacchus have their hair falling down their shoulders; and young persons, until they arrived at manhood, wore their hair long. The colour of the hair which was reckoned most beautiful, was fair; and this they gave without distinction to the most beautiful of their gods, Apollo and Bacchus, and likewise to their most illustrious heroes.

The hands.

Although the ravages of time have preserved but few of the hands or feet of ancient statues, it is evident from what remains how anxious the Grecian artists were to give every perfection to these parts. The hands of young persons were moderately plump, with little cavities or dimples at the joints of the fingers. The fingers tapered very gently from the root to the points, like well-proportioned columns, and the joints were scarcely perceptible. The terminating joint was not bent, as it commonly appears in modern statues.

The legs and feet.

In the figures of young men the joints of the knee are faintly marked. The knee unites the leg to the thigh without making any remarkable projections or cavities. The most beautiful legs and best-turned knees, according to Winckelman, are preserved in the Apollo Saurocthones, in the Villa Borghese; in the Apollo which has a swan at its feet; and in the Bacchus of the Villa Medicis. The same able connoisseur remarks, it is rare to meet with beautiful knees in young persons, or in the elegant representations of art. As the ancients did not cover the feet as we do, they gave to them the most beautiful turning, and studied the form of them with the most scrupulous attention.

The breast and lower part of the body.

The breasts of men were large and elevated. The breasts of women did not possess much amplitude. The figures of the deities have always the breasts of a virgin, the beauty of which the ancients made to consist in a gentle elevation. So anxious were the women to resemble this standard, that they used several arts to restrain the growth of their breasts. The breasts of the nymphs and goddesses were never represented swelling, because that is peculiar to those women who suckle. The paps of Venus contract and end in a point, this being considered as an essential characteristic of perfect beauty. Some of the moderns have transgressed these rules, and have fallen into great improprieties. The lower part of the body in the statues of men was formed like that of the living body after a profound sleep and good digestion. The navel was considerably sunk, especially in female statues.

Ideal beauty.

As beauty never appears in equal perfection in every part of the same individual, perfect or ideal beauty can only be produced by selecting the most beautiful parts from different models; but this must be done with such judgment and care, that these detached beauties when united may form the most exact symmetry. Yet the ancients sometimes confined themselves to one individual, even in the most flourishing age. Theodorus, whom Socrates and his disciples visited, served as a model to the artists of his time.

Phryne also appears to have been a model to the painters and sculptors. But Socrates, in his conversation with Parrhasius, says, that when a perfect beauty was to be produced, the artists joined together the most striking beauties which could be collected from the finest figures. We know that Zeuxis, when he was going to paint Helen, united in one picture all the beauties of the most handsome women of Crotona.

The drapery of statues.

The Grecian sculptors, who represented with such success the most perfect beauty of the human form, were not regardless of the drapery of their statues. They clothed their figures in the most proper stuff, which they wrought into that shape which was best calculated to give effect to their design.

The vestments of women in Greece generally consisted of linen cloth, or some other light stuff, and in later times of silk, and sometimes of woollen cloth. They had also garments embroidered with gold. In the works of sculpture, as well as in those of painting, one may distinguish the linen by its transparency and small united folds. The other light stuffs which were worn by the women were generally of cotton produced in the isle of Cos; and these the art of statuary was able to distinguish from the linen vestments. The cotton cloth was sometimes striped, and sometimes embellished with a profusion of flowers. Silk was also employed; but whether it was known in Greece before the time of the Roman emperors cannot easily be determined. In paintings it is distinguishable by changing its colour in different lights, to red, violet, and sky-blue. There were two sorts of purple; that which the Greeks called the colour of the sea, and Tyrian purple, which resembled lac. Woollen garments are easily known by the amplitude of their folds. Besides these, cloth of gold sometimes composed their drapery. But it was not like the modern fabric, consisting of a thread of gold or of silver spun with a thread of silk; it was composed of gold or silver alone, without any mixture.

Vestments.

The vestments of the Greeks, which deserve particular attention, are the tunic, the robe, and the mantle.

The tunic was that part of the dress which was next to the body. It may be seen in sleeping figures, or in those in deshabile; as in the Flora Farnese, and in the statues of the Amazons in the Capitol. The youngest of the daughters of Niobe, who throws herself at her mother's side, is clothed only with a tunic, which was of linen, or some other light stuff, without sleeves, fixed to the shoulders by a button, so as to cover the whole breast. None but the tunics of the goddess Ceres and comedians have long straight sleeves.

The robes of women commonly consisted of two long pieces of woollen cloth, without any particular form, attached to the shoulders by a great many buttons, and sometimes by a clasp. They had straight sleeves which came down to the wrists. The young girls, as well as the women, fastened their robe to their side by a cincture, in the same way as the high priest of the Jews fastened his, and as it is still done in many parts of Greece. The cincture formed on the side a knot of ribbons sometimes resembling a rose in shape, which has been particularly remarked in the two beautiful daughters of Niobe. In the younger of these the cincture is seen passing over the shoulders and the back. Venus has two cinctures, the one passing over the shoulder, and the other surrounding the waist. The latter is called cestus by the poets.

The mantle was called *peplon* by the Greeks, which signifies properly the mantle of Pallas. The name was afterwards applied to the mantles of the other gods, as well as to those of men. This part of the dress was not square, as some have imagined, but of a roundish form. The ancients indeed speak in general of square mantles, but they received this shape from four tassels, which were affixed to them; two of these were visible, and two were concealed under the mantle. The mantle was brought under the right arm, and over the left shoulder; sometimes it was attached to the shoulder by two buttons, as may be seen in the beautiful statue of Leucothoe at the Villa Albani.

The colour of vestments peculiar to certain statues is too curious to be omitted. To begin with the figures of the gods, the drapery of Jupiter was red, that of Neptune is supposed by Winckelman to have been sea-green. The same colour also belonged to the Nereids and the Nymphs. The mantle of Apollo was blue or violet. Bacchus was dressed in white. Martianus Capella assigns green to Cybele. Juno's vestments were sky-blue, but she sometimes had a white veil. Pallas was robed in a flame-coloured mantle. In a painting of Herculanum, Venus is in flowing drapery of a golden-yellow. Kings were arrayed in purple, priests in white, and conquerors sometimes in sea-green.

With respect to the head, women generally wore no covering but their hair; when they wished to cover the head, they used the corner of their mantle. Sometimes we meet with veils of a fine transparent texture. Old women wore a kind of bonnet upon their head, an example of which may be seen in a statue in the Capitol, called the *Præfica*; but Winckelman thinks it is a statue of Hecuba.

The covering of the feet consisted of shoes or sandals. The sandals were generally an inch thick, and composed of more than one sole of cork. Those of Pallas in the Villa Albani has two soles, and other statues had no less than five.

Ancient style of Grecian sculpture.

The most authentic monuments of the ancient style are medals, containing an inscription which leads us back to very distant times. The writing is from right to left, in the Hebrew manner, a usage which was abandoned before the time of Herodotus. The statue of Agamemnon at Elis, which was made by Ornatas, has an inscription from right to left. This artist flourished fifty years before Phidias. It is in the intervening period therefore between these two artists that we are to look for the cessation of this practice. The statues formed in the ancient style were neither distinguished by beauty of shape nor by proportion, but bore a close resemblance to those of the Egyptians and Etrurians. The eyes were long and flat; the section of the mouth not horizontal; the chin was pointed; the curls of the hair were ranged in little rings, and resembled grains enclosed in a heap of raisins. What was still worse, it was impossible by inspecting the head to distinguish the sex. The characters of this ancient style were these: the designing was energetical, but harsh; it was animated, but without gracefulness; and the violence of the expression deprived the whole figure of beauty.

The grand style.

The grand style was brought to perfection by Phidias, Polycletus, Scopas, Alcamenes, Myron, and other illustrious artists. It is probable, from some passages of ancient writers, that in this style were preserved some characters of the ancient manner, such as the straight lines, the squares, and angles. The ancient masters, being the legislators of proportions, and thinking they had a right to distribute the measures and dimensions of the parts of the human body, have undoubtedly sacrificed some degree of the form of beauty, to a grandeur which is harsh, in comparison of the flowing contours and graceful forms of their successors.

Phidias.

Phidias, the great master of this art, was born at Athens in the seventy-third Olympiad, about 488 years B. C. He was the contemporary of Socrates, Plato, Xenophon, and other eminent men, and was engaged by Pericles to superintend the decoration of the temple of Minerva and other public works. "His superior genius," says Flaxman, "in addition to his knowledge of painting, which he practised previous to sculpture, gave a grandeur to his compositions, a grace to his groups, a softness to flesh, and flow to draperies, unknown to his predecessors, the character of whose figures was stiff rather than dignified; their forms either meagre or turgid; the folds of drapery parallel, poor, and resembling geometrical lines, rather than the simple but ever-varying appearances of nature." Quintilian says of Phidias, " his Athenian Minerva, and Olympian Jupiter at Elis, possessed beauty which seemed to have added something to religion, the majesty of the work was so worthy of the divinity." The greatest work of this chief of sculptors was the Jupiter at Elis, sixty feet in height, formed of ivory, enriched with the radiance of golden ornament and precious stones, and justly esteemed one of the seven wonders of the world.

The graceful style.

The third style of Grecian sculpture was the graceful or beautiful. Praxiteles and Lysippus introduced this style. Being more conversant than their predecessors with the sweet, the pure, the flowing, and the beautiful lines of nature, they avoided the square forms, which the masters of the second style had too much employed. They were of opinion that the use of the art was rather to please than to astonish, and that the aim of the artists should be to raise admiration by giving delight. The artists who cultivated this style did not, however, neglect to study the sublime works of their predecessors. They knew that grace is consistent with the most dignified beauty, and that it possesses charms which must ever please; they knew also that these charms are enhanced by dignity. Grace is infused into all the movements and attitudes of their statues, and it appears in the delicate turns of the hair, and even in the adjusting of the drapery. Every sort of grace was well known to the ancients; and great as the ravages of time have been amongst the works of art, specimens are still preserved, in which can be distinguished dignified beauty, attractive beauty, and a beauty peculiar to infants.

Praxiteles.

Praxiteles, a native of Magna Græcia, was born about 364 years B. C. He excelled in the highest graces of youth and beauty. " None," says a judicious writer on sculpture, " ever more happily succeeded in uniting softness with force,—elegance and refinement with simplicity and purity: his grace never degenerates into the affected, nor his delicacy into the artificial. Over his compositions he has thrown an expression spiritual at once and sensual; a voluptuousness and modesty which touch the most insensible, yet startle not the most retiring." Among the known works of this master are his Satyr, Cupid, Apollo the Lizard-killer, and Bacchus leaning on a Fawn. The famous Venus of Gnidos was also his work. This statue seems to offer the first idea of the Venus de' Medicis, the statue which still " enchants the world," and " fills the air around with beauty," and which is probably the repetition of another Venus of Praxiteles.

Lysippus.

Lysippus of Sicyon, the younger, the contemporary and rival of Praxiteles, it is believed worked only in metal. Although he is said to have executed upwards of six hundred works, not one remains. The Tarentine Jupiter, sixty feet high, was one of his great works. He excelled in the knowledge of symmetry, and many of his works were finished with the utmost delicacy and truth. He was so great a favourite with Alexander, that he alone was allowed to make casts of the prince. It gives us some idea of the high consideration in which his works were held by the Romans, that even Tiberius trembled in his palace at an insurrection of the people, occasioned by the removal from one of the public baths of a figure by Lysippus.

Existing specimens of Grecian sculpture.

The works that remain to us of ancient art sufficiently attest the excellence of the Greeks in sculpture. We can only allude very briefly to some of the most celebrated of these productions. The Apollo Belvidere, believed to be the Apollo of Calamis mentioned by Pliny, has with justice been deemed one of the most admirable works of Grecian art. This statue " breathes the flame with which 'twas wrought," as if the sculptor had left a portion of his own soul within the marble, to half-animate his glorious creation. The Dying Gladiator is another greatly-valued work, finely designed, full of truth, and admirably executed. The Fawn of the Florence Gallery, so wonderfully restored by Michel Angelo, is an exquisite and characteristic representation. The Fighting Gladiator, and several of the statues of Venus, Diana, Mercury, and Bacchus, are expressive productions of the best days of Grecian sculpture. These precious monuments of art, the ancient groups, display the sentiment, heroism, beauty, and sublimity of Greece, existing as it were before us. The Laocoon, animated with the hopeless agony of the father and sons, is the work of Apollodorus, Athenodorus, and Agesander of Rhodes. The groups of Dirce, Hercules, and Antæus, Atreus, Orestes, and Electra, and Ajax supporting Patroclus, are examples of fine form, character, and sentiment. The group of Niobe and her youngest daughter, by Scopas, is an exquisite specimen of art, replete with heroic beauty and exalted passion. The group of the Wrestlers is a representation of difficult but harmonious composition; and that of Cupid and Psyche shows much elegance combined with graceful proportion.

The Elgin Marbles, now the property of the British nation, belong to a period in the history of Grecian sculpture when the art had reached its highest excellence. " These marbles," we quote from the Library of Useful Knowledge, " chiefly ornamented one edifice, dedicated to the guardian deity of Athens, raised at the time of the greatest political power of the state, when all the arts which contribute to humanize life were developing their beneficial influence. Many of the writers of Athens, whose works are the daily text-books of our schools, saw in their original perfection the mutilated marbles which we cherish and admire. The Elgin collection has presented us with the external and material forms in which the art of Phidias gave life and reality to the beautiful mythi which veiled the origin of his native city, and perpetuated in groups of matchless simplicity the ceremonies of the great national festival. The lover of beauty, and the friend of Grecian learning, will here find a living comment on what he reads; and as in the best and severest models of antiquity we always discover something new to admire, so here we find fresh beauties at every visit, and learn how infinite in variety are simplicity and truth, and how every deviation from these principles produces sameness and satiety."

Materials of Grecian statues.

Clay was the first material employed in statuary. An instance of this may be seen in a figure of Alcamenes in bas-relief in the Villa Albani. The ancients used their fingers, and especially their nails, to render certain parts more delicate and lively; and hence arose the phrase *ad unguem factus homo*, an accomplished man. It was the opinion of Count Caylus, that the ancients did not use models in forming their statues. But to disprove this, it is only necessary to mention an engraving on a stone in the cabinet of Stosch, which represents Prometheus engraving the figure of a man, with a plummet in his hand to measure the proportions of his model. The ancients as well as the moderns made works in plaster; but no specimens remain except some figures in bas-relief, of which the most beautiful were found at Baiæ.

The works made of ivory and silver were generally of a small size. Sometimes, however, statues of a prodigious size were formed of gold and ivory. The colossal Minerva of Phidias, which was composed of these materials, was twenty-six cubits in height.

The Greeks generally hewed their marble statues out of one block, though they afterwards worked the heads separately, and sometimes the arms. The heads of the famous group of Niobe and her Daughters have been adapted to their bodies after being separately finished. It is proved by a large figure representing a river, which is preserved in the Villa Albani, that the ancients first hewed their statues roughly before they attempted to finish any part. When the statue had received its perfect figure, they next proceeded to polish it with pumice-stone, and again carefully retouched every part with the chisel. The ancients, when they employed porphyry, usually made the head and extremities of marble. It is true, that at Venice there are four figures entirely composed of porphyry; but these are the production of the Greeks of the middle age; some of their noblest works were cast in bronze. They also made statues of basalt and alabaster.

III.—ROMAN SCULPTURE.

1.—*Ancient Italian Sculpture.*

The Romans made the conquest of the world so much the passion of their hearts, that they had little enthusiasm to spare for art. They admired the works of Greece, and filled Rome with statues; but though they inherited the empire, they succeeded not to the genius of that little knot of republics. In their hands sculpture soon degenerated; it became more vulgar and more absurd every succeeding reign. As they worshipped the gods of Greece, they were content to find them ready made to their hands, and their chief works were statues of their great men, and triumphal columns and arches. Their best and most characteristic sculpture was history. The Trajan Column represents, in one continued winding relief, from the base to the summit, the actions of the emperor; and his statue stood at the top to show him as the consummation of all glory. The Romans, when they conquered Britain, adorned the temples and courts of justice with statues of divinities. These remains are executed with such deficiency of skill as countenances the conjecture, that the gods and altars, as well as the roads of the time, were executed by the soldiers.

Almost the only excellence to which the Romans could lay claim, was their collection of busts. These, from Julius to Galienus, embracing a period of three centuries, exhibit a series invaluable in the history of art, and in some instances worthy of comparison with the best works of the kind executed in the earlier ages. The busts are confined to the emperors of Rome; all others were forbid to be sculptured. The most perfect specimens cease with the reign of Augustus. Towards the close of the first century, forcible and free execution is substituted for purity of design and natural expression. A stiffness and laboured appearance marks the works of the reign of Hadrian. Some traits of good workmanship are observable in the busts of Aurelius. In the times of Severus the art had degenerated, and every subsequent reign shows a farther debasement, till all traces of excellence finally disappear.

2.—*Modern Italian Sculpture.*

The first revival of modern art may be reckoned from the reign of Constantine, when Christianity was established. We will not, in this sketch, dwell on the works of this period, which indeed do not afford much matter for interesting contemplation; but pass on to the time when indications of real power and genius first appeared. The most distinguished restorer of sculpture was Donatello, born at Florence in 1383. Some of his works, both in bronze and marble, might be placed beside the best productions of ancient Greece without discredit. His alto-relievo of Two Singing Boys is a superior piece of sculpture. The bronze statue of Mercury by this master, at Florence, is equally remarkable. His marble statue of St George was greatly admired by Michel Angelo, who, after gazing at it for some time in silence, suddenly exclaimed "March!" A similar anecdote is told of this great man, who addressed these words to another work of Donatello's, Saint Mark, "Marco, perche non mi parli?" The basso-relievos of the life of Christ by Donatello abound in noble conceptions, but they were the works of advanced age, and were finished by his scholars.

Donatello.

Ghiberti.

Lorenzo Ghiberti, born in 1378, showed his great talents at the early age of twenty-three, when he commenced that splendid work, the doors of the Baptistry at Florence. These doors are three in number, all in bronze. The southern door, on the panels of which are sculptured the life of St John the Baptist, is by Andrea da Pisa. The northern and eastern doors are by Ghiberti. On the former is represented the life of our Saviour, and the latter exhibits the principal events recorded in the Old Testament. They occupied Ghiberti for forty years, and are justly considered noble specimens of art. The eastern door was regarded by Michel Angelo as worthy to be the gate of Paradise.

Michel A gelo Buonarotti.

We come now to notice Michel Angelo, the most illustrious master of modern art, whether regarded as sculptor, painter, or architect. Born in 1474, and living to the advanced age of ninety, this celebrated man was the means of influencing by his mighty genius the efforts of art during the greater part of the sixteenth century. Whatever be the various opinions of Michel Angelo, all unite in acknowledging the wondrous power of his works in sculpture. It is only when he has overstrained the muscular energy of his subjects that fault can be found at all. In some instances we no doubt find him exaggerated, and deficient in repose. His conceptions were generally vast, almost superhuman, and in this spirit they were executed. With him expression and character were primary considerations, and he made ideal beauty and form subservient to his forcible representations. His works have a strong, marked character of their own; his thoughts are always elevated, and his figures full of dignity. He is never feeble. If not sublime, he is never insipid. The sentiment of aggrandizing his subject often prevails. His statue of Moses in S. Pietro, in Vincoli, though severely criticised, is a great work. "The true sublime," says Forsyth, "resists all ridicule. The offended lawgiver frowns on undepressed, and awes you with inherent authority." The recumbent statues in the monument of Julian de' Medicis, in the Medici chapel, of Daybreak and Night, are grand and mysterious, and denote a mighty mind and hand. The pensive sitting figure of Lorenzo de' Medicis is finely conceived; and the Madonna and Child in the same chapel has, in the opinion of Flaxman, "a sentiment of maternal affection never found in Grecian sculpture, but frequently in the works of this artist, particularly in his paintings, and that of the most tender kind." Michel Angelo brought the principles of art to great perfection. "Anatomy," says Flaxman, "the motion and perspective of figure, the complication, grandeur, and harmony of his grouping, with the advantages and facility of execution in painting and sculpture, besides his mathematical and mechanical attainments in architecture and building, which, together with the many and prodigious works he accomplished, demonstrate how greatly he contributed to the restoration of art."

Giovanni Bologna, Cellini, Bernini.

Giovanni di Bologna, a Frenchman by birth, was one of the most celebrated of Michel Angelo's scholars. His Venus coming from the Bath, both standing and kneeling, are remarkable for delicacy and grace; and his Mercury is beautifully conceived and finely executed. Benvenuto Cellini obtained celebrity for his group of Perseus and Medusa. Bernini enjoyed great reputation in his day, but his Apollo and Daphne seems his only work of distinguished merit, although he has been also esteemed for the ease and nature of his portraits. His larger works were considered by Flaxman as remarkable for presuming airs, affected grace, and unmeaning flutter.

Canova.

Sculpture continued to flourish in Italy during a portion of the seventeenth century, but after that it rapidly declined. An illustrious man, however, was destined to raise it to a new existence. Antonio Canova, born in Possagno in 1757, though weakly in constitution, gave early indications of future excellence. His diligence in studying sculpture was unwearied, and he was distinguished among the Venetian artists by a laborious exercise of hand, a restless activity of fancy, and an enthusiastic longing for fame. The people of Venice felt the beauty of Canova's works. He went to Rome and executed his group of Theseus and the Minotaur, which was pronounced by the first judges as "one of the most perfect works which Rome had beheld for ages." From this fortunate hour to the end of his life, he produced a rapid succession of statues and groups, which carried his fame far and wide over the world. Before 1800 he had given to the world some of his most successful performances; the monuments of Ganganelli and Rezzonico; the groups of Venus and Adonis, and of Cupid and Psyche; the Hebe, and the Sommariva Magdalene. These statues were entirely by his own hands, unassisted by workmen. When his success produced wealth, his protection of rising merit was admirable. His liberality in this respect was as boundless as his enthusiasm for the arts. He died in 1822, having executed fifty-three statues, twelve groups, and monuments, busts, and relievos amounting to the extraordinary number of 176 complete works, which are now dispersed all over Europe. Canova principally excelled in the beautiful and graceful. He never attempted to tread

Di Michel Angeol la terribil via.

Hence his favourite subjects were those of female grace or youthful beauty. Paris, Perseus, Palamedes, Psyche, Hebe, Venus, Nymphs, and Dancers, are the most popular of all his works. In some of these there is an approach to affectation and French taste, especially in the draperies; and, perhaps, in avoiding the extremes of anatomical force and muscular development, he has too much addicted himself to flowing outline and polished surface. But his taste improved with his progress in the art. He felt the superiority of simplicity over affectation, as is visibly shown in the noble productions of his riper years, his Pauline, the mother of Buonaparte, the Endymion, and the recumbent Magdalene. Although his power of conception was inferior to the illustrious artists of Greece, he nevertheless rivalled them in the vivid grace and exquisite skill of his works. Well did Byron say, in the lifetime of this great artist,

Such as the great of yore, Canova is to-day.

Living artists of the Italian school.

The genius of Canova gave a new impulse to Italian sculpture. Thorwaldsen, though a Dane by birth, may be considered an Italian artist. His Triumph of Alexander, the Mercury, the Night, and Aurora, are works which have sufficiently established the claim of this great artist to the admiration of his own age, and that of posterity. Danneker, the sculptor of the Ariadne at Francfort, seems also to belong to the existing school of Italy. There are others, whom we cannot enumerate, who are also in the fair road to eminence; but, singular to say, few of these are sons of that land which has so well been called

Mother of arts, as once of arms.

IV.—ENGLISH SCULPTURE.

The Romans, when they withdrew their troops from Britain, left some taste for sulpture behind them, and their successors the Saxons made attempts to imitate the human form. The Normans introduced a better style of art, and the return of the crusaders brought a relish for Grecian statuary into this country. In the reign of Henry III. the works of English artists were characterized by good sense and simple grace, which redeemed the imperfections of workmanship. In the chapel of Henry VII. we see monuments carved with great skill. The Protestant religion was not favourable to the art, and our sculptures, after the Reformation, were mostly by foreigners. The first English sculptor of note was Gibbons, who, about the close of the seventeenth century, executed many admirable works in wood. About the same time lived Cibber, an artist of originality and power. The far-famed figures of Raving and Melancholy, carved in stone, are his best-known productions, and, in spite of Pope's satirical lines on the "brainless brothers," they stand foremost in conception and second in execution among the efforts of English sculpture. The bas-reliefs on the sides of the monument in London, and some statues at Chatsworth, are from his chisel.

Gibbons, Cibber.

Roubiliac.

Roubiliac, a Frenchman by birth, was so long resident in England that he has been adopted as a British artist. Although Flaxman has pronounced a poor opinion of Roubiliac's works, they have nevertheless taken a lasting hold of public admiration. He was a man deeply imbued with poetic feelings, and had an unbounded enthusiasm for his profession. Some of his works are fanciful and conceited, but others again possess much elegance of action, and all are very beautifully executed. His figure of Eloquence is masterly and graceful. Canova said it was one of the noblest statues he had seen in England. The statue of Sir Isaac Newton is another of his masterpieces; Chantrey calls it "the noblest of all our English statues. There is an air of nature and a loftiness of thought about it, which no other artist has in this country, I suspect, reached. You cannot imagine any thing grander in sentiment, and the execution is every way worthy of it." His most famous work is the monument of Mrs Nightingale, in Westminster Abbey: with some allegorical extravagance, it exhibits feeling and pathos, and the workmanship is quite marvellous.

Banks.

"Banks," says Cunningham, "was the first of our native sculptors whose aims were uniformly lofty and heroic, and who desired to bring poetry to the aid of all his compositions." His groups and statues were, however, coldly received. His sketches, which are full of vigour and feeling, have been highly esteemed. The statue of Achilles mourning the loss of Briseis has not been excelled for fine action and noble proportions. Nollekens, like Banks, was ambitious to introduce a purer and more tasteful style of art, but his great works hardly came up to expectation. His busts are however excellent, and will preserve his fame. Cunningham, from whose agreeable publication on English art we have already quoted, says, "the claims of Nollekens to distinction are threefold; bust sculpture, monumental sculpture, and poetic sculpture. He attained to eminence in all, but to lasting fame, I apprehend, only in the first, and even then the permanent meed is secured to him more from the lasting importance of some of his subjects, than from the splendour of the art with which he has invested them." Bacon infused more English sense into sculpture than any of his predecessors, or his contemporaries Banks and Nollekens. His statue of Samuel Johnson, in St Paul's, is an excellent work; stern, severe, full of surly thought and conscious power. Howard, also in St Paul's, is expressive of the philanthropic and benevolent man it represents. Bacon had great skill in workmanship, and he never spared his labour. Some of his monuments are rather too much crowded with ornaments and objects of secondary interest.

Nollekens.

Bacon.

Flaxman.

The most eminent sculptor this country has yet produced, John Flaxman, was born in 1755. "The elements of his style," said Sir Thomas Lawrence, "were founded in Grecian art—on its noblest principles—on its deeper intellectual power, and not on the mere surface of its skill. Though master of its purest lines, he was still more the sculptor of sentiment than of form; and whilst the philosopher, the statesman, and the hero, were treated by him with appropriate dignity, not even in Raphael have the gentler feelings and sorrows of human nature been treated with more touching pathos than in the various degrees and models of this inestimable man. Like the greatest of modern painters, he delighted to trace, from the actions of familiar life, the lines of sentiment and passion, and, from the populous haunts and momentary peacefulness of poverty and want, to form his inestimable groups of childhood and maternal tenderness, with those nobler compositions from holy writ, as beneficent in their motive as they were novel in design." The classical productions of Flaxman are now known far and wide, and they have given the world a high idea of the genius of England. "Michel Angelo and Flaxman," observes an excellent critic, "are the only two sculptors who, with genius for the minute as well as the grand, have dared sometimes to be remiss, and leave sentiment to make its way without the accompanying graces of skilful labour." His workmanship was certainly sometimes slovenly, and his draperies heavy. The monuments he executed are not his ablest works. His illustrations of Homer, Æschylus, and Dante, are worthy of the great originals; and the engravings from these works have given Flaxman an European reputation. The mind of this great artist was essentially poetical, and his genius was, in the strictest sense of the words, original and inventive.

We must touch lightly on the living artists of this country. It is satisfactory to think that ours is not an age in which sculpture is retrograding in Britain. The splendid genius of Chantrey has nobly sustained the reputation Flaxman earned for us. His statues, now very numerous, are works of decided excellence; whilst his busts are the most admirable productions of that kind in the world. Westmacott has also shared largely in public favour. Several of his monuments and other works are ably executed. We do not name other artists of rising fame. Their merit, if they truly possess any, will be duly appreciated, for a correct taste in works of sculpture is every day becoming more generally diffused in Britain.

V.—FRENCH, SPANISH, AND GERMAN SCULPTURE.

French sculpture.

Our sketch would be imperfect did we not allude to the sculpture of France, Spain, and Germany. In France, the art began to be practised with success about the middle of the sixteenth century. Gougon finished the famous Fountain of the Innocents in 1550. The works of Cousin evince genius; and Pilon has been admired for energy in his productions. Jacques D'Angouleme, a contemporary of Michel Angelo's, possesses merit. Giovanni di Bologna, of whom we have previously spoken, filled his country with the principles of his master. Sculpture flourished in France during the reign of Louis XIV. Voltaire says of one of the artists of this time, Girandon, "il a égalé tout ce que l'antiquité a de plus beau." This is great praise, and scarcely merited, although his designs are noble and his taste correct. An example of his style is well seen in his Tomb of Richelieu. Puget is also much esteemed by his countrymen. The succeeding artists of France were followers more or less of the styles of Girandon and Puget. The art may be said to be in a flourishing state at present.

Spanish sculpture.

A great number of names have been recorded by Spanish writers as eminent in sculpture. The greater part of them seem to have been employed in ornamenting the churches of Spain, and few are known from their works in other countries. Berruguete, one of the best artists of Spain, studied under Michel Angelo at Rome, and adorned Madrid, Saragossa, and other towns, with his works, which exhibit much of the grandeur and expression of ancient art. After him Paul de Cespedes was celebrated as a sculptor of great skill. In the eighteenth century Philip de Castro became a distinguished sculptor, and contributed greatly to spread the principles of correct taste in Spain.

German sculpture.

Prior to the seventeenth century, Germany appears to have made little progress in sculpture. Ranchmuller preceded Schluter of Hamburg, who repaired to Rome, and attached himself to the manner of Michel Angelo. Messerschmidt executed many excellent pieces of sculpture in Vienna. In later times Ohnmacht, Sonnenschein, Nahl, and the two Shadofs, have distinguished themselves as artists. The Spinning Girl of the Younger Shadof is an exquisite piece of sculpture. The Germans promise to advance rapidly in sculpture, from the enthusiasm they show in acquiring the true principles of the art.

VI.—OF EXPRESSION, ACTION, AND PROPORTION IN SCULPTURE.

Expression and attitude.

Without expression, gesture, and attitude, no figure can be beautiful, because in these the graces always reside. It was for this reason that the graces are always represented as the companions of Venus.

The expression of tranquillity was frequent in Grecian statues, because, according to Plato, that was considered as the middle state of the soul between pleasure and pain. Experience, too, shows that in general the most beautiful persons are endowed with the sweetest and most engaging manner. Without a sedate tranquillity, dignified beauty could not exist. It is in this tranquillity, therefore, that we look for the complete display of genius.

The most elevated species of tranquillity and repose was studied in the figures of the gods. The father of the gods, and even inferior divinities, are represented without emotion or resentment. It is thus that Homer paints Jupiter shaking Olympus by the motion of his hair and his eyebrows. Jupiter, however, is not always exhibited in this tranquil state. In a bas-relief belonging to Rondini he appears seated on an arm-chair with a melancholy aspect. The Apollo of the Vatican represents the god in a fit of rage against the serpent Python, which he kills at a blow. The artist, adopting the opinion of the poets, has made the nose the seat of anger, and the lips the seat of disdain.

To express the action of a hero, the Grecian sculptors delineated the countenance of a noble virtuous character repressing his groans, and allowing no expression of pain to appear. In describing the actions of a hero, the poet has much more liberty than the artist. The poet can paint them such as they were before men were taught to subdue their passions by the restraints of law or the refined customs of social life. But the artist, obliged to select the most beautiful forms, is reduced to the necessity of giving such an expression of the passions as may not shock our feelings and disgust us with his production. The truth of these remarks will be acknowledged by those who have seen two of the most beautiful monuments of antiquity, one of which represents the fear of death, the other the most violent pains and sufferings. The daughters of Niobe, against whom Diana has discharged her fatal arrows, are exhibited in that state of stupefaction which we imagine must take place when the certain prospect of death deprives the soul of all sensibility. The fable presents us an image of that stupor which Æschylus describes as seizing the daughters of Niobe when they were transformed into a rock. The other monument referred to is the image of Laocoon, which exhibits the most agonizing pain that can affect the muscles, the nerves, and the veins. The sufferings of the body and the elevation of the soul are expressed in every member with equal energy, and form the most sublime contrast imaginable. Laocoon appears to suffer with such fortitude, that, whilst his lamentable situation pierces the heart, the whole figure fills us with an ambitious desire of imitating his constancy and magnanimity in the pains and sufferings that may fall to our lot.

Philoctetes is introduced by the poets as shedding tears, uttering complaints, and rending the air with his groans and cries; but the artist exhibits him silent, and bearing his pains with dignity. The Ajax of Timomachus is not drawn in the act of destroying the sheep which he took for the Grecian chiefs, but in the moments of reflection which succeeded those of frenzy. So far did the Greeks carry their love of calmness and slow movements, that they thought a quick step always announced rusticity of manners. Demosthenes reproaches Nicobulus for this very thing; and from the words he makes use of, it appears that to speak with insolence and to walk hastily were reckoned synonymous.

In the figures of women the artists have conformed to the principle observed in all the ancient tragedies, and recommended by Aristotle, never to make women show too much intrepidity or excessive cruelty. Conformably to this maxim, Clytemnestra is represented at a little distance from the fatal spot, watching the murderer, but without taking any part with him. In a painting of Timomachus representing Medea and her children, when Medea lifts up the dagger they smile in her face, and her fury is immediately melted into compassion for the innocent victims. In another representation of the same subject Medea appears hesitating and indecisive. Guided by the same maxims, the artists of most refined taste were careful to avoid all deformity, choosing rather to recede from truth than from their accustomed respect for beauty, as may be seen in several figures of Hecuba. Sometimes, however, she appears in the decrepitude of age, her face furrowed with wrinkles, and her breasts hanging down.

Illustrious men, and those invested with the offices of dignity, are represented with a noble assurance and a firm aspect. The statues of the Roman emperors resemble those of heroes, and are far removed from every species of flattery, in the gesture, in the attitude, and in the action. They never appear with haughty looks, or with the splendour of royalty; no figure is ever seen presenting any thing to them with bended knee except captives, and none addresses them with an inclination of the head. In modern works too little attention has been paid to the ancient costume. Winckelman mentions a bas-relief which was executed at Rome for the fountain of Trevi, representing an architect in the act of presenting the plan of an aqueduct to Marcus Agrippa. The modern sculptor, not content with giving a long beard to that illustrious Roman, contrary to all the ancient marble statues as well as medals which remain, exhibits the architect on his knees.

In general it was an established principle to banish all violent passions from public monuments. This will serve as a decisive mark to distinguish the true antique from supposititious works. A medal has been found exhibiting two Assyrians, a man and woman, tearing their hair; with this inscription, ASSYRIA. ET. PALAESTINA. IN. POTEST. P. R. REDAC. S. C. The forgery of this medal is manifest from the word *Palaestina*, which is not to be found in any ancient Roman medal with a Latin inscription. Besides, the violent action of tearing the hair does not suit any symbolical figure. This extravagant style has been imitated by some of the modern artists. Their figures resemble comedians on the ancient theatres, who, in order to suit the distant spectators, put on painted masks, employed exaggerated gestures, and far overstepped the bounds of nature. This style has been reduced into a theory in a treatise on the passions, composed by Le Brun. The designs which accompany that work exhibit the passions in the very highest degree, approaching even to frenzy. But these are calculated to vitiate the taste, especially of the young; for the ardour of youth prompts them rather to seize the extremity than the middle; and it will be difficult for that artist who has formed his taste from such impassioned models ever to acquire that noble simplicity and sedate grandeur which distinguished the works of ancient taste.

Of proportion.

Proportion is the basis of beauty; indeed there can be no beauty without it, but proportion may exist where there is little beauty. Experience every day teaches us that knowledge is distinct from taste; and proportion, therefore, which is founded on knowledge, may be strictly observed in any figure, and yet the figure have no pretensions to beauty. The ancients considering ideal beauty as the most perfect, have frequently employed it in preference to the beauty of nature.

The body consists of three parts, as well as the members. The three parts of the body are the trunk, the thighs, and the legs. The inferior parts of the body are the thighs, the legs, and the feet. The arms also consist of three parts, and these three parts must bear a certain proportion to the whole as well as to one another. In a well-formed man the head and body must be proportioned to the thighs, the legs, and the feet, in the same manner as the thighs are proportioned to the legs and the feet, or the arms to the hands. The face also consists of three parts, that is, three times the length of the nose; but the head is not four times the length of the nose, as some writers have asserted. From the place where the hair begins to the crown of the head are only three fourths of the length of the nose, or that part is to the nose as nine to twelve.

It is probable that the Grecian as well as Egyptian artists have determined the great and small proportions by fixed rules, and established a positive measure for the dimensions of length, breadth, and circumference. This supposition alone can enable us to account for the great conformity which we meet with in ancient statues. Winckelman thinks that the foot was the measure which the ancients used in all their great dimensions, and that it was by the length of it that they regulated the measure of their figures, by giving to them six times that length. This, in fact, is the length which Vitruvius assigns (*Pes vero altitudinis corporis sextæ*, lib. iii. cap. 1). That celebrated antiquary thinks the foot is a more determinate measure than the head or the face, the parts from which modern painters and sculptors often take their proportions. This proportion of the foot to the body, which has appeared strange and incomprehensible to the learned Huet, and has been entirely rejected by Perrault, is however founded upon experience. After measuring with great care a vast number of figures, Winckelman found this proportion observed not only in Egyptian statues, but also in those of Greece. This fact may be determined by an inspection of those statues the feet of which are perfect. One may be fully convinced of it by examining some divine figures, in which the artists have made some parts beyond their natural dimensions. In the Apollo Belvidere, which is a little more than seven heads high, the foot is three Roman inches longer than the head. The head of the Venus de' Medicis is very small, and the height of the statue is seven heads and a half; the foot is three inches and a half longer than the head, or precisely the sixth part of the length of the whole statue.

VII.—PRACTICE OF SCULPTURE.

Grecian sculpture studied by modern artists.

We have been thus minute in our account of the Grecian sculpture, because it is the opinion of the ablest critics that modern artists have been more or less eminent as they have studied with the greater or less attention the models left us by that ingenious people. Winckelman goes so far as to contend that the most finished works of the Grecian masters ought to be studied in preference even to the works of nature. This appears to be paradoxical; but the reason assigned for his opinion is, that the fairest lines of beauty are more easily discovered, and make a more striking and powerful impression, by their reunion in these sublime copies, than when they are scattered far and wide in the original. Allowing, therefore, the study of nature the high degree of merit it so justly claims, it must nevertheless be granted that it leads to true beauty by a much more tedious, laborious, and difficult path, than the study of the antique, which presents immediately to the artist's view the object of his researches, and combines, in a clear and strong point of light, the various rays of beauty that are dispersed throughout the wide domain of nature.

As soon as the artist has laid this excellent foundation, acquired an intimate degree of familiarity with the beauties of the Grecian statues, and formed his taste after the admirable models they exhibit, he may then proceed with advantage and assurance to the imitation of nature. The ideas he has already formed of the perfection of nature, by observing her dispersed beauties combined and collected in the compositions of the ancient artists, will enable him to acquire with facility, and to employ with advantage, the detached and partial ideas of beauty which will be exhibited to his view in a survey of nature in her actual state. When he discovers these partial beauties, he will be capable of combining them with those perfect forms of beauty with which he is already acquainted. In a word, by having always present to his mind the noble models already mentioned, he will be in some measure his own oracle, and will draw rules from his own mind.

Two ways of imitating nature.

There are, however, two ways of imitating nature. In the one a single object occupies the artist, who endeavours to represent it with precision and truth; in the other, certain lines and features are taken from a variety of objects, and combined and blended into one regular whole. All kinds of copies belong to the first kind of imitation; and productions of this kind must be executed necessarily in the Dutch manner, that is to say, with high finishing, and little or no invention. But the second kind of imitation leads directly to the investigation and discovery of true beauty, of that beauty whose idea is connate with the human mind, and is only to be found there in its highest perfection. This is the kind of imitation in which the Greeks excelled, and in which men of genius excite the young artists to excel after their example, namely, by studying nature as they did. After having studied in the productions of the Grecian masters their choice and expression of select nature, their sublime and graceful contours, their noble draperies, together with that sedate grandeur and admirable simplicity that constitute their chief merit, the curious artists will do well to attend to the manual and mechanical part of their operations, as this is absolutely necessary to the successful imitation of their excellent manner.

Models of statues.

It is certain that the ancients almost always formed their first models in wax. To this modern artists have substituted clay, or some such composition. They prefer clay before wax in the carnations, on account of the yielding nature of the latter, and its sticking in some measure to every thing it touches. We must not, however, imagine from hence that the method of forming models of wet clay was either unknown or neglected among the Greeks. On the contrary, it was in Greece that models of this kind were invented. Their author was Dibutades of Sicyon; and it is well known that Arcesilas, the friend of Luculkus, obtained a higher degree of reputation by his clay models than by all his other productions. Indeed if clay could be made to preserve its original moisture, it would undoubtedly be the fittest substance for the models of the sculptor; but when it is placed either in the fire or left to dry imperceptibly in the air, its solid parts grow more compact, and the figure, losing thus a part of its dimensions, is necessarily reduced to a smaller volume. This diminution would be of no consequence did it equally affect the whole figure, so as to preserve its proportions entire. But this is not the case. For the smaller parts of the figure dry sooner than the larger; and thus losing more of their dimensions in the space of time than the latter do, the symmetry and proportions of the figure inevitably suffer. This inconvenience does not take place in those models that are made in wax. It is indeed extremely difficult, in the ordinary method of working the wax, to give it that degree of smoothness that is necessary to represent the softness of the carnations or fleshy parts of the body. This inconvenience may, however, be remedied by forming the model first in clay, then moulding it in plaster, and lastly casting it in wax. And, indeed, clay is seldom used but as a mould in which to cast a figure of plaster, stucco, or wax, to serve henceforth for a model by which the measures and proportions of the statue are to be adjusted. In making waxen models, it is common to put half a pound of colophony to a pound of wax; and some add turpentine, melting the whole with oil of olives.

Method of working the marble.

So much for the first or preparatory steps in this procedure. It remains to consider the manner of working the marble after the model so prepared. The method here followed by the Greeks seems to have been extremely different from that which is generally observed by modern artists. In the ancient statues we find the most striking proofs of the freedom and boldness that accompanied each stroke of the chisel, and which resulted from the artist's being perfectly sure of the accuracy of his idea, and the precision and steadiness of his hand. The most minute parts of the figure carry these marks of assurance and freedom; no indication of timorousness or diffidence appears, nothing that can induce us to fancy that the artist had occasion to correct any of his strokes. It is difficult to find, even in the second-rate productions of the Grecian artists, any mark of a false stroke or a random touch. This firmness and precision of the Grecian chisel was certainly derived from a more determined and perfect set of rules than those which are observed in modern times.

The method generally observed by the modern sculptor is as follows. First, out of a great block of marble he saws another of the size required, which is performed with a steel saw without teeth, casting water and sand thereon from time to time; then he fashions it, by taking off what is superfluous with a steel point and a heavy hammer of soft iron; after this, bringing it near the measure required, he reduces it still nearer with another finer point; he then uses a flat cutting instrument, having notches in its edge, and a chisel to take off the scratches which the former has left; till at length, taking rasps of different degrees of fineness, he by degrees brings his work into a condition for polishing.

After this, having studied his model with all possible attention, he draws upon this model horizontal and perpendicular lines which intersect each other at right angles. He afterwards copies these lines upon his marble, as the painter makes use of such transverse lines to copy a picture, or to reduce it to a smaller size. These transverse lines or squares, drawn in an equal number upon the marble and upon the model, in a manner proportioned to their respective dimensions, exhibit accurate measures of the surfaces upon which the artist is to work; but cannot determine, with equal precision, the depths that are proportioned to these surfaces. The sculptor, indeed, may determine these depths by observing the relation they bear to his model; but as his eye is the only guide he has to follow in this estimate, he is always more or less exposed to error, or at least to doubt. He is never sure that the cavities made by his chisel are exact; a degree of uncertainty accompanies each stroke; nor can he be assured that it has carried away neither too much nor too little of his marble. It is equally difficult to determine, by such lines as have already been mentioned, the external and internal contours of the figure, or to transfer them from the model to the marble. By the internal contour is understood that which is described by the parts which approach towards the centre, and which are not marked in a striking manner.

It is further to be noticed, that in a complicated and laborious work, which an artist cannot execute without assistance, he is often obliged to make use of foreign hands, which have not the talents nor the dexterity that are necessary to finish his plan. A single stroke of the chisel that goes too deep is a defect not to be repaired; and such a stroke may easily happen, where the depths are so imperfectly determined. Defects of this kind are inevitable, if the sculptor, in chipping his marble, begins by forming the depths that are requisite in the figure which he designs to represent. Nothing is more liable to error than this manner of proceeding. The cautious artist ought, on the contrary, to form these depths gradually, by little and little, with the utmost circumspection and care; and the determining of them with precision ought to be considered as the last part of his work, and the finishing touches of his chisel.

Method of copying ancient statues.

The various inconveniences attending this method determined several eminent artists to look out for one that would be liable to less uncertainty, and productive of fewer errors. The French Academy of Painting at Rome devised a method of copying the ancient statues, which some sculptors have employed with success, even in the figures which they finished after models in clay or in wax. This method is as follows. The statue that is to be copied is enclosed in a frame that fits it exactly. The upper part of this frame is divided into a certain number of equal parts, and to each of these parts a thread is fixed with a piece of lead at the end of it. These threads, which hang freely, show what parts of the statue are most removed from the centre with much more perspicuity and precision than the lines which are drawn on its surface, and which pass equally over the higher and hollow parts of the block. They also give the artist a tolerable rule to measure the more striking variations of height and depth, and thus render him more bold and determined in the execution of his plan.

But even this method is not without its defects. For as it is impossible, by means of a straight line, to determine with precision the procedure of a curve, the artist has, in this method, no certain rule to guide him in his contours; and as often as the line which he is to describe deviates from the direction of plumb-line, which is his main guide, he must necessarily feel himself at a loss, and be obliged to have recourse to conjecture. It is also evident, that this method affords no certain rule to determine exactly the proportion which the various parts of the figure ought to bear to each other, considered in their mutual relation and connections. The artist, indeed, endeavours to supply this defect by intersecting the plumb-lines by horizontal ones. This resource has, nevertheless, its inconveniences, since the squares formed by transverse lines that are at a distance from the figure, although they be exactly equal, yet represent the parts of the figure as greater or smaller, according as they are more or less removed from our position or point of view. But notwithstanding these inconveniences, the method now under consideration is certainly the best that has hitherto been employed. It is surer and more practicable than any other we know, although it appears, from the remarks we have now been making, that it does not exhibit a sure and universal criterion to a sculptor who executes after a model.

Of polishing statues.

To polish the statue, or make the parts of it smooth and sleek, pumice-stone and smelt are used; then tripoli; and when a still greater lustre is required, burned straw is employed.

SCUPPERS are pipes of lead inserted in openings bored from the deck through the sides of a ship, to carry the water off from the deck to the sea. To avoid the inconvenience of having the scuppers broken by the working of the ship, each is formed of two pipes, one of which is passed upwards to the deck through the opening in the ship's side, and having its lower end nailed on the outside planking; the other, which is of smaller diameter, after being woolded on the outside with flannel dipped in tallow, is passed downwards into the lower pipe, through the opening in the deck, and its upper end secured on the plank of the deck. In order to prevent the entrance of water by these scuppers when a ship is inclined, valves of metal are placed over the external outer ends, which close with the pressure of the external water. In merchant-vessels, leather-pipes, called scupper-hoses, are sometimes nailed round the opening for the same purpose. Sometimes scuppers are only leaden pipes passed through the ship's side, and turned and fastened at each end.

SCURVY, a dreadful disease, in the prevention and cure of which, Dr Beddoes thinks, the mineral acids, especially the nitric and vitriolic, may be employed with as much success as the vegetable acids.

SCUTAGE (*scutagium;* Saxon, *scildpening*) was a tax or contribution raised by those that held lands by knights' service, towards furnishing the king's army, at one, two, or three merks for every knight's fee. Henry III., for his voyage to the Holy Land, had a tenth granted by the clergy, and scutage, three merks of every knight's fee, by the laity. This was also levied by Henry II., Richard I., and King John.

SCUTARI, a city of the western part of Turkey, the capital of the province of the same name, sometimes also called by the Turks Iskandria. It is situated on the river Drenas, at its efflux from the Lake Bojana. It is the seat of a Greek bishop. It contains Greek and Catholic churches, several mosques, and about 4000 houses, with 16,000 inhabitants. There is a considerable employment furnished by the building of ships and exporting of timber, and by fisheries. It is not on the sea-shore; but the village of Polna is the place where vessels load and unload, and which is fortified and protected by the castles Dragos and Golbaschi.

SCUTE (*scutum*), a French gold coin of three shillings and fourpence in the reign of Henry V. Catharine queen of England had an assurance made her of sundry castles, manors, lands, &c. valued at the sum of forty thousand scutes, two of which were worth a noble.

SCUTTLES, in a ship, holes in the decks of a ship, either for air, or as passages to the store-rooms; also openings in a ship's side for the admission of air. If, in order to sink a ship, a hole be cut in her bottom, she is said, in nautical language, to be scuttled.

SCYLAX, a celebrated mathematician and geographer of Caria, flourished under the reign of Darius Hystaspes, about 558 before Christ. Some have attributed to him the invention of geographical tables. We have under his name a geographical work published by Hœschelius; but it is written by a much later author, and is perhaps only an abridgment of Scylax's Ancient Geography.

SCYLLA, in *Ancient Geography*, a rock in the *Fretum Siculum*, near the coast of Italy, dangerous to shipping, opposite to Charybdis, a whirlpool on the coast of Sicily, and both of them famous in mythology. Scylla and Charybdis have been almost subdued by the repeated convulsions of this part of the earth, and by the violence of the current, which is continually increasing the breadth of the straits. If proper allowance be made for these circumstances, we shall acquit the ancients of exaggeration, notwithstanding the dreadful colours in which they have painted this passage. It is formed by a low peninsula called Cape Pelorus, stretching eastward on the Sicilian side, immediately within which lies the whirlpool of Charybdis; and by the rocks of Scylla, which a few miles below, on the Calabrian shore, project westward. The current runs with surprising force from the one to the other alternately in the direction of the tide, and the tides themselves are very irregular. Thus vessels, by shunning the one, were in the utmost danger of being swallowed up by the other.

At present, in moderate weather, when the tide is either at ebb or flood, boats pass across the whirlpool; but, in general, it is like the meeting of two contending currents, with a number of eddies all around; and even now, there is scarcely a winter in which there are not some wrecks.

SCYROS, an island in the Ægean Sea, at the distance of about twenty-eight miles north-east from Eubœa. It is sixty miles in circumference. It was originally in the possession of the Pelasgians and Carians. Achilles retired there to avoid going to the Trojan war, and became father of Neoptolemus, by Deidamia, the daughter of King Lycomedes. Scyros, which was conquered by the Athenians under Cimon, was very rocky and barren. It is now called Sciro. Long. 25. 0. E. Lat. 38. 15. N.

SCYTALA Laconica, in *Antiquity*, a stratagem or device of the Lacedæmonians, for the secret writing of letters to their correspondents, so that if they should chance to be intercepted, nobody might be able to read them.

To this end they had two wooden rollers or cylinders, perfectly alike and equal; one of which was kept in the city, the other by the person to whom the letter was directed. For the letter, a skin of very thin parchment was wrapped round the roller, on which the matter was written; and this being done, it was taken off, and sent away to the party, who, upon putting it in the same manner upon his roller, found the lines and words in the very same disposition as when they were first written.

SCYTHE, a well-known instrument, which has been long employed in cutting grass. See Agriculture.

SCYTHIA, an ancient name for the northern parts of Asia, now known by the name of Tartary; and also for some of the north-eastern parts of Europe.

This vast territory, which extends itself from the Ister or Danube, the boundary of the Celts, that is, from about the 25th to almost the 110th degree of east longitude, was divided into Scythia in Europe and Scythia in Asia, including, however, the two Sarmatias, or, as they are called by the Greeks, Sauromatias, now Circassian Tartary, which lay between and separated the two Scythias from each other. Sauromatia was also distinguished into European and Asiatic; and was divided from the European Scythia by the river Don or Tanais, which falls into the Palus Mæotis, and from the Asiatic by the Rha or Volga, which empties itself into the Caspian Sea.

The Asiatic Scythia comprehended, in general, Great Tartary, and Russia in Asia; and, in particular, the Scythia beyond or without Imaus contained the regions of Bogdoi or Ostiacoi, and Tanguti. That within or on this side of Imaus had Turkestan and Mongul, the Usbeck or Zagatai, Kalmuck and Nagaian Tartars, besides Siberia, the land of the Samoiedes, and Nova Zembla. These three last not being so soon inhabited as the others, were, as may be reasonably supposed, wholly unknown to the ancients; and the former were peopled by the Bactrians, Sogdians, Gandari, Sacks, and Massagetes. As for Sarmatia, it contained Albania, Iberia, and Colchis, which now form Circassian Tartary and the province of Georgia.

Scythia in Europe reached, towards the south-west, to the Po and the Alps, by which it was divided from Celto-Gallia. It was bounded on the south by the Ister or Danube and the Euxine Sea. Its northern limits have been supposed to stretch to the fountain-heads of the Borysthenes or Dnieper, and the Volga, and so to that of the Tanais. The ancients divided this country into Scythia Arimaspæa, which lay eastward, joining to Scythia in Asia; and Sarmatia Europeana on the west. In Scythia properly so called were the Arimaspæi on the north, the Getæ or Dacians along the Danube on the south, and the Neuri between these two. It contained therefore European Russia or Muscovy, and the Lesser Crim Tartary, to the eastward; and, on the west, Lithuania, Poland, part of Hungary, Transylvania, Walachia, Bulgaria, and Moldavia. Sarmatia is supposed to have reached northward to that part of Sweden called *Feningia*, now Finland; in which they placed the Oœnes, Panoti, and Hippopodes. This part they divided from Northern Germany, now the western part of Sweden and Norway, by the *Mare Sarmaticum* or *Scythicum*, which they supposed to run up into the Northern Ocean, and, dividing Lapland into two parts, formed the western part of Sweden and Norway into one island, and Finland into another; supposing this also to be cut off from the continent by the gulf of the same name.

Although the ancient Scythians were celebrated as a warlike people, yet their history is too uncertain and obscure to enable us to give any detail which would not prove equally tiresome and uninteresting to the reader. Mr Pinkerton, in a dissertation on their origin, endeavours to prove that they were the most ancient of nations; and he assigns for the place of their first habitation the country known by the name of Persia. From Persia, he thinks, they proceeded in numerous hordes westward, surrounded the Euxine, and peopled Germany, Italy, Gaul, the countries bordering on the Baltic, and part of Britain and Ireland. That the Scythians were of Asiatic origin, cannot, we think, be questioned; and as Persia was peopled at a very early period, it may not improbably have been their parent country. But when our author contends that their empire had subsisted for more than 1500 years before Ninus, the founder of the Assyrian monarchy, and that it extended from Egypt to the Ganges, and from the Persian Gulf and Indian Sea to the Caspian, we cannot help thinking that his prejudices against the Celts, and his desire to do honour to his favourite Goths, have made him advance a paradox inconsistent with the most authentic records of antiquity. His dissertation however is ingenious, and replete with curious learning.

SEA, in a strict sense, signifies a large portion of water almost surrounded by land, as the Baltic and Mediterranean Seas; but it is frequently used for that vast body of water which encompasses the whole earth. See the articles Geology and Physical Geography.

Sea-Air is that part of the atmosphere which is above the sea. Sea-air has been found salubrious and beneficial in certain distempers. This may be owing to its containing a greater portion of oxygenous gas or vital air, and being less impregnated with noxious vapours, than the land. Dr Ingenhousz made several experiments to ascertain the salubrity of sea-air. By mixing equal measures of common air and nitrous air, he found that at Gravesend they occupied about 1·04, or one measure and $\frac{4}{100}$ths of a measure; whereas on sea, about three miles from the mouth of the Thames, two measures of air, one of common and one of nitrous air, occupied from 0·91 to 0·94. He attempted a similar experiment on the middle of the channel between the English coast and Ostend; but the motion of the ship rendered it impracticable. He found that in rainy and windy weather the sea-air contained a smaller quantity of vital air than when the weather was calm. On the sea-shore at Ostend it occupied from 94½ to 97; at Bruges he found it at 105, and at Antwerp 109½. Dr Ingenhousz thus concludes his paper. "It appears, from these experiments, that the air at sea and close to it is in general purer and fitter for animal life than the air on the land, though it seems to be subject to the same inconstancy in its degree of purity with that of the land; so that we may now with more confidence send our patients labouring under consumptive disorders to the sea, or at least to places situated close to the sea, which have no marshes in their neighbourhood. It seems also probable that the air will in general be found much purer far from the land than near the shore, the former being never subject to be mixed with land-air."

SEA-LIGHTS.

SEA-LIGHT, and Lighthouse, are terms which, although not strictly synonymous, are indifferently employed to denote the same thing. A *Sea-light* may be defined as *a light so modified and directed as to present to the mariner an appearance which shall at once enable him to judge of his position during the night, in the same manner as the sight of a landmark would do during the day.*

Early history.

The early history of lighthouses is very uncertain; and many ingenious antiquaries, finding the want of authentic records, have endeavoured to supply the deficiency by conjectures based upon casual and obscure allusions in ancient writers, and have invented many vague and unsatisfactory hypotheses on the subject, drawn from the heathen mythology. Some writers have gone so far as to imagine, that the Cylcopes were the keepers of lighthouses; whilst others have actually maintained that Cyclops was intended, by a bold prosopopœia, to represent a lighthouse itself. A notion so fanciful deserves little consideration; and in order to show how ill it accords with that mythology of which it is intended to be an exposition, it seems enough to quote the lines from the ninth Odyssey, where Homer, after describing the darkness of the night, informs us that the fleet of Ulysses actually struck the shore of the Cyclopean island, before it could be seen.

> Ἔνθ᾽ ὄυτις τὴν νῆσον ἐσέδρακεν ὀφθαλμοῖσιν
> Ὄυτ᾽ οὖν κύματα μακρὰ κυλινδόμενα ποτὶ χέρσον
> Ἐισίδομεν πρὶν νῆας ἐϋσσέλμους ἐπικελσαι
>
> *Odyss.* ix. 146.

There does not appear any better reason for supposing, that under the history of Tithonus, Chiron, or any other personage of antiquity, the idea of a lighthouse was conveyed; for such suppositions, however reconcileable they may appear with some parts of the mythology, involve obvious inconsistencies with others. Nor does it seem at all probable, that in those early times, when navigation was so little practised, the advantages of beacon-lights were so generally known and acknowledged, as to render them the objects of mythological allegory.

Colossus of Rhodes.

About three hundred years before the Christian era, Chares, the disciple of Lysippus, constructed the celebrated brazen statue, called the Colossus of Rhodes, which was of such dimensions as to allow vessels to sail into the harbour between its legs, which spanned the entrance. There is considerable probability in the idea, that this figure served the purposes of a lighthouse; but we do not remember any passage in ancient writers, where this use of the Colossus is expressly mentioned There is much inconsistency in the account of this fabric by early writers, who, in describing the distant objects which could be seen from it, appear to have forgotten the height which they assign to the figure. It was partly demolished by an earthquake, about eighty years after its completion; and so late as the year 672 of our era, the brass of which it was composed, was sold by the Saracens to a Jewish merchant of Edessa, for a sum, it is said, equal to L.36,000.

Pharos of Alexandria.

Little is known with certainty regarding the Pharos of Alexandria, which was regarded by the ancients as one of the seven wonders of the world. It was built by Ptolemy Philadelphus, about 300 years before Christ; and it is recorded by Strabo, that the architect Sostratus, the son of Dexiphanes, having first secretly cut his own name on the solid walls of the building, covered the words with plaster, and, in obedience to Ptolemy's command, made the following inscription on the plaster: "King Ptolemy to the gods, the saviours, for the benefit of sailors." What truth there may be in this account of the fraud of Sostratus, there is now no means of determining; and the story is only now interesting, in so far as it shows the object of the royal founder and the use of the tower. The accounts which have reached us of the dimensions of this remarkable edifice, are exceedingly various; and many of the statements regarding the distance at which it could be seen, are clearly fabulous. Josephus approaches nearest to probability, and informs us, that the fire which was kept constantly burning in the top, was visible by seamen at a distance equal to about forty miles. If the reports of some writers are to be believed, this tower must have far exceeded in size the great pyramid itself; but the fact that a building of comparatively so late a date, should have so completely disappeared, whilst the pyramid remains almost unchanged, is a sufficient reason for rejecting, as erroneous, the dimensions which have been assigned by most writers to the Pharos of Alexandria. Some have pretended that large mirrors were employed to direct the rays of the beacon-light on its top, in the most advantageous direction; but there is nothing like respectable evidence in favour of this supposition. Others, with greater probability, have imagined that this celebrated beacon was known to mariners, simply by the uncertain and rude light afforded by a common fire. In speaking of the Pharos,[1] the poet Lucan, on most occasions sufficiently fond of the marvellous, takes no notice of the gigantic mirrors which it is said to have contained. It is true that, by using the word "*lampada*," which can only with propriety be applied to a more perfect mode of illumination than an open fire, he appears to indicate that the "*flammis*" of which he speaks, were not so produced. The word *lampada* may, however, be used metaphorically; and *flammis* would, in this case, not improperly describe the irregular appearance of a common fire. Those who are desirous of knowing all that occurs in ancient authors, on the subject of the Pharos of Alexandria, may consult Pliny, l. xxxvi. c. 12.; l. v. c. 13., and l. xiii c. 11. Strabo, l. xvii. p. 791, et seq. Cæsar, *Comment. de Bell. Civil,* l. iii. Pompon. Mela. l. ii. c. 7. Ammian. Marcellin. l. xxii. c. 16. Joseph. *de Bell. Judaic.* l. vi. Nicolas Lloyd's *Lexicon Geographicum*, and the *Notitia Orbis Antiqui* of Celarius, l. iv. c. 1, p. 13.

Coruna Tower.

Mr. Moore, in his *History of Ireland,* (vol. i. p. 16.) speaks of the Tower of Coruña, which he says is mentioned in the traditionary history of that country, as a lighthouse erected for the use of the Irish in their frequent early intercourse with Spain. In confirmation of this opinion, he cites a somewhat obscure passage from Æthius, the cosmographer. This in all probability is the tower which Humboldt mentions in his Narrative under the name of the *Iron*

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[1] Septima nox, Zephyro nunquam laxante rudentes,
Ostendit Phariis Ægyptia littora *flammis.*
Sed prius orta dies nocturnam *lampada* texit,
Quam tutas intraret aquas.

Pharsal. ix. 1004.

Tower, which was built as a lighthouse by Caius Saevius Lupus, an architect of the city of Aqua Flavia, the modern Chaves.

Modern history.

Such seems to be the sum of our knowledge of the ancient history of lighthouses, which, it must be admitted, is neither accurate nor extensive. Our information regarding modern lighthouses, is of course more minute in its details, and more worthy of credit, as the greater part of it is drawn from authentic sources, or is the result of the actual observation of the writer of this article, who has visited the most important lighthouses of Europe. It seems sufficient here to notice briefly the most remarkable establishments of the kind now in existence; reserving for the latter part of the article, the more appropriate and important topics of the methods of illumination, and the systems of management.

Tour de Corduan.

The first lighthouse of modern days which merits attention, is the Tour de Corduan, which, in point of architectural grandeur, is unquestionably the noblest edifice of the kind in the world. It is situated on an extensive reef at the mouth of the River Garonne, and serves as a guide to the shipping of Bordeaux and the Languedoc Canal, and indeed of all that part of the Bay of Biscay. It was founded in the year 1584, and was not completed till 1610, under Henri IV. It is minutely described in Belidor's *Architecture Hydraulique*. The building is 197 feet in height, and consists of a pile of masonry, forming successive galleries, enriched with pillasters and friezes, and rising above each other with gradually diminished diameters. These galleries are surmounted by a conical tower, which terminates in the lantern. Round the base is a wall of circumvallation, 134 feet in diameter, in which the light-keepers' apartments are formed, somewhat in the style of casemates. This wall is an outwork of defence, and receives the chief shock of the waves. The tower itself contains a chapel, and various apartments; and the ascent is by a spacious staircase. The first light exhibited in the Tour de Corduan, was obtained by burning billets of oak-wood, in a choffer at the top of the tower; and the use of coal instead of wood, was the first improvement which the light received. A rude reflector, in the form of an inverted cone, was afterwards added, to prevent the loss of light which escaped upwards. About the year 1780, M. Lenoir was employed to substitute reflectors and lamps; and in 1822, the light received its last improvement, by the introduction of the dioptric instruments of M. Fresnel.

Plate I. fig. 7, shews the form of this celebrated lighthouse, and is made from drawings in the possession of the writer of this article, who, in 1834, spent several days there.

Eddystone.

The history of the celebrated lighthouse on the Eddystone rocks is well known to the general reader, from the narrative of Mr. Smeaton the Engineer. These rocks are 9½ miles from the Ram-Head, on the coast of Cornwall; and from the small extent of the surface of the chief rock, and its exposed situation, the construction of the lighthouse was a work of very great difficulty. The first erection was of timber, designed by Mr. Winstanley, and was commenced in 1696. The light was exhibited in November 1698. It was soon found, however, that the sea rose upon this tower to a much greater height than had been anticipated, so much so, it is said, as to "*bury under the water*" the lantern, which was sixty feet above the rock; and Mr. Winstanley was therefore afterwards under the necessity of enlarging the tower, and carrying it to the height of 120 feet. In November 1703, some considerable repairs were required, and Mr. Winstanley, accompanied by his workmen, went to the lighthouse to attend to their execution; but the storm of the 26th of that month, carried away the whole erection, when the engineer and all his assistants unhappily perished.

The want of a light on the Eddystone, soon led to a fatal accident; for not long after the destruction of Mr. Winstanley's lighthouse, the Winchilsea man-of-war was wrecked on the Eddystone rocks, and most of her crew were lost. Three years, however, elapsed, after this melancholy proof of the necessity of a light before the Trinity House of London could obtain a new act to extend their powers; and it was not till the month of July 1706, that the construction of a new lighthouse was begun under the direction of Mr. John Rudyerd of London. On the 28th of July 1708, the new light was first shewn, and continued to be regularly exhibited till the year 1755, when the whole fabric was destroyed by accidental fire, after standing forty-seven years. But for this circumstance, it is impossible to tell how long the lighthouse might, with occasional repair, have lasted, as Mr. Rudyerd seems to have executed his task with much judgment, carefully rejecting all architectural decoration, as unsuitable for such a situation, and directing his attention to the formation of a tower which should offer the least resistance to the waves. The height of the tower, which was of a circular form, and constructed of timber, was, including the lantern, 92 feet, and the diameter at the base, which was a little above the level of high water, was 23.

The advantages of a light on the Eddystone having been so long known and acknowledged by seamen, no time was permitted to elapse before active measures were taken for its restoration; and Mr. Smeaton, to whom application was made for advice on the subject, recommended the exclusive use of stone as the material, which, both from its weight and other qualities, he considered most suitable for the situation. On the 5th of April 1756, Mr. Smeaton first landed on the rock, and made arrangements for erecting a lighthouse of stone, and preparing the foundations, by cutting the surface of the rock into regular horizontal benches, into which the stones were carefully dovetailed or notched. The first stone was laid on 12th June 1757, and the last on the 24th of August 1759. The tower measures 68 feet in height, and 26 feet in diameter at the level of the first entire course, and the diameter under the cornice is 15 feet. The first twelve feet of the tower form a solid mass of masonry, and the stones are united by means of stone joggles, dovetailed joints, and oak treenails. It is remarkable, that Mr. Smeaton should have adopted an arched form for the floors of his building, instead of employing these floors as tie-walls formed of dovetailed stones. To counteract the injurious tendency of the outward thrust of these arched floors, Mr. Smeaton had recourse to the ingenious expedient of laying, in circular trenches or beds in the stones which form the outside casing, sets of chains, which were heated by means of an application of hot lead, and became tight in cooling. The light was exhibited on the 16th October 1759; but such was the state of the lightroom apparatus in Britain at this period, that a feeble light from tallow candles was all that decorated this noble structure. In 1807, when the property of this lighthouse again came into the hands of the Trinity House, on the expiry of a long lease, Argand burners, and parabolic reflectors of silvered copper, were substituted for the chandelier of candles. Plate I. fig. 3, shews a section of the Eddystone lighthouse, as executed according to Mr. Smeaton's design.

Bell-Rock.

The dangerous reef called the Inch Cape, or Bell Rock, so long a terror to mariners, was well known to the earliest navigators of Scotland. Its dangers were so generally acknowledged, that the Abbots of Aberbrothick, from which the rock is distant about twelve miles, caused a float to be fixed upon the rock with a bell attached to it, which being swung by the motion of the waves, served by its tolling to warn the mariner of his approach to the reef. Amongst the many losses which occurred on the Bell-Rock in modern times, one of the most remarkable is that of the York, seventy-four, with all her crew, part of the wreck having been afterwards found on the rock, and part having come ashore on the neighbouring coast. During the survey of the rock also, many instances were discovered of the extent of loss which this reef had occasioned, and many articles of ships' furnishings were picked up on it, as well as various coins, a bayonet, a silver shoe-buckle, and many other small objects. Impressed with the great importance of some guide for the Bell-Rock, Captain Brodie, R.N., set a small subscription on foot, and erected a beacon of spars on the rock, which, however, was soon destroyed by the sea. He afterwards constructed a second beacon, which soon shared the same fate. It was not, however, until 1802, when the Commissioners of Northern Lights brought a bill into Parliament for power to erect a lighthouse on it, that any efficient measures were contemplated for the protection of seamen from this rock, which, being covered at every spring tide to the depth of twelve feet, and lying right in the fareway to the Firths of Forth and Tay, had been the occasion of much loss both of property and life. In 1806, the bill passed into a law, and various ingenious plans were suggested for overcoming the difficulties which were apprehended, in erecting a lighthouse on a rock twelve miles from land, and covered to the depth of twelve feet by the tide. But the suggestion of Mr. Robert Stevenson, the engineer to the Lighthouse Board, after being submitted to the late Mr. Rennie, was at length adopted; and it was determined to construct a tower of masonry, on the principle of the Eddystone. On the 17th of August 1807, Mr. Stevenson accordingly landed with his workmen, and commenced the work by preparing the rock to receive the supports of a temporary wooden pyramid, on which a barrack-house, for the reception of the workmen, was to be placed; and during this operation, much hazard was often incurred in transporting the men from the rock, which was only dry for a few hours at spring tides, to the vessel which lay moored off it. The lowest floor of this temporary erection, in which the mortar for the building was prepared, was often broken up and removed by the force of the sea. The foundation having been excavated, the first stone was laid on the 10th July 1808, at the depth of sixteen feet below the high-water of spring-tides, and at the end of the second season, the building was five feet six inches above the lowest part of the foundation. The third season's operations terminated by finishing the solid part of the structure, which is thirty feet in height; and the whole of the masonry was completed in October 1810. The light was first exhibited to the public on the night of the 1st of February 1811. The difficulties and hazards of this work, were chiefly caused by the short time during which the rock was accessible between the ebbing and flowing tides; and amongst the many eventful incidents which render the history of this work interesting, was the narrow escape which the engineer and thirty-one persons made from being drowned, by the rising of the tide upon the rock, before a boat came to their assistance, the attending vessel having broken adrift. This circumstance occurred before the barrack-house was erected, and is narrated by Mr. Stevenson in his account of the work, published at the expense of the Lighthouse Board in 1824, to which we may refer for more minute information on the subject of this work, and the other lights of the coast of Scotland.

The Bell-Rock Tower is 100 feet in height, 42 feet in diameter at the base, and 15 at the top. The door is 30 feet from the base, and the ascent is by a massive copper ladder. The apartments, including the lightroom, are six in number. The light is a revolving red and white light, and is produced by the revolution of a frame containing twenty Argand lamps, placed in the foci of parabolic mirrors, arranged on a quadrangular frame, whose alternate faces have shades of red glass placed before the reflectors, so that a red and white light is shewn successively. The machinery, which causes the revolution of the frame containing the lamps, is also applied to tolling two large bells, to give warning to the mariner of his approach to the rock in foggy weather. Plate I. fig. 6, shews a section of the Bell-Rock Lighthouse, and an elevation of the temporary barrack-house, which was removed on the completion of the work.

Carlingford

The most remarkable lighthouse on the coast of Ireland is that of Carlingford, near Cranfield Point, at the entrance of Carlingford Lough. It was built according to the design of Mr. George Halpin, the Inspector of the Irish Lights; and was a work of an arduous nature, being founded twelve feet below the level of high-water on the Hawlbowling Rock, which lies about two miles off Cranfield Point. The figure is that of a frustum of a cone, 111 feet in height, and 48 feet in diameter at the base. The light, which is fixed, is from oil burned in Argand lamps placed in the foci of parabolic mirrors. It was first exhibited on the night of the 20th December 1830.

Skerryvore

The Commissioners of the Northern Lighthouses have lately taken measures for erecting a lighthouse on the rock of Skerryvore, which lies in the channel between the Western Isles of Scotland and the north of Ireland. The solid rock is only about 40 yards square, and is about 13 miles from the nearest point of the Island of Tyree. It is exposed to the unbroken fury of the Atlantic, there being no land between it and the coast of America. The works were commenced last season on the rock, by the erection of part of a wooden barrack for the reception of the workmen, during the building of the tower of masonry. This barrack, which resembled that of the Bell-Rock, shewn in Plate I. fig. 6, disappeared on the night of the 3d November 1838; and when the writer of this article visited the rock, on the 16th of the same month, only a single beam remained. Several spars of a large vessel, and some of the beams of the barrack, afterwards came ashore on the Islands of Tyree and Coll; a circumstance which has led to the belief, that the fabric had sustained some injury by the collision of some heavy body in motion. From the tremendous height to which the sea was observed to rise on the rock, there is, on the other hand, some reason to suspect that the fury of the waves alone may have demolished the unfinished structure of the barrack. The works were resumed in the spring of 1839.

There are various other lighthouses which, in themselves, are sufficiently deserving of a separate notice, were it not that they have, more or less, something in common with those already described, which are unquestionably the most remarkable edifices of the kind. We shall, therefore, now proceed to consider the methods of illumination, which have been adopted in lighthouses; a subject to which much attention has of late years been directed, and which is the most important consideration connected with those establishments, whose utility depends solely upon the distance at which the light can be seen, and the facility with which the mariner can recognise their individual appearance as indicative of a particular part of the coast.

Coal lights

There can be little doubt, that down to a very late period, the only mode of illumination adopted in the lighthouses, even of the most civilized nations of Europe, was the combustion of wood or coal in a chauffer on the top of a high tower. It is needless to enlarge upon the evils of such a method; they need only be named to be understood; for it is difficult to conceive how an efficient system of lighting a coast could be managed under such disadvantages. The uncertainty caused by the effects of wind and rain, and the impossibility of rendering one light distinguishable from another, must have, at all times, rendered the early lighthouses, in a great measure, useless to the mariner.

Catoptric[1] system.

M. Teulère, a member of the Royal Corps of Engineers of Bridges and Roads in France, is, by some, considered the first who hinted at the advantages of parabolic reflectors; and he is said, in a memoir dated the 26th June 1783, to have proposed their combination with Argand lamps, ranged on a revolving frame, for the Corduan lighthouse. Whatever foundation there may be for the claim of M. Teulère, certain it is, that this plan was actually carried into effect at Corduan under the directions of the Chevalier Borda, and to him is generally awarded the merit of having conceived the idea of applying parabolic mirrors to lighthouses. These were prodigious steps in the improvement of lighthouses, as not only the power of the lights was thus greatly increased, but the introduction of a revolving frame proved a valuable source of distinction amongst lights, and has since been the means of greatly extending their utility. The exact date of the change on the light of the Corduan is not known; but as it was made by Lenoir, the same young artist to whom Borda about the year 1780, intrusted the construction of his reflecting circle, it has been conjectured by some, that the improvement was made about the same time. If this conjecture be correct, the claim of M. Teulère must of course fall to the ground. The reflectors were formed of sheet-copper, plated with silver, and had a double ordinate of 31 French inches. It was not long before these improvements were adopted in England, by the Trinity House of London, who sent a deputation to France to inquire into their nature. In Scotland, one of the first acts of the Northern Lights Board in 1786, was to substitute reflectors in the room of coal-lights, then in use at the Isle of May in the Firth of Forth, and the Cumbrae Isle in the Firth of Clyde, which had, till that period, been the only beacons on the Scotch coast. The reflectors employed were formed of facets of mirror glass, placed in hollow parabolical moulds of plaster, according to the designs of the late Mr. Thomas Smith, the engineer of the board, who, as appears from the article *Reflector* in the Supplement to the third edition of the Encyclopædia Britannica, was not aware of what had been done in France, and had, himself, conceived the idea of this combination. The system of Borda was also adopted in Ireland, and in time, variously modified, it became general wherever lighthouses were known.

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[1] From the Greek *κατοπτρον, a mirror,* a compound of *κατα, opposite to,* and *ὄπτομαι, I see.*

Paraboloidal mirrors.

The property of the parabola, by which all lines incident on its surface from the focus make with normals to the curve at the points of incidence, angles equal to the inclination of these same normals respectively to lines drawn parallel to the axis of the curve, is that which fits it for the purposes of a lighthouse. A hollow mirror, formed by the revolution of a portion of a parabola about its axis, has, in consequence of this property, the power of projecting the repeated images of a luminous point placed in its focus, in directions parallel to the axis of the generating curve, so that when the mirror is placed with its axis parallel to the horizon, a cylindric beam of light is thereby sent forward in a horizontal direction. When such mirrors are placed side by side, with their axes parallel on the faces of a quadrangular frame which revolves about a vertical axis, a distant observer receives the successive impressions which result from the passage of each face of the frame, over a line drawn between the observer's eye and the centre of the revolving frame. This arrangement constitutes what is called a revolving light. A fixed light is produced by placing side by side, round a fixed circular frame, a number of reflectors, with their axes inclined to each other, so as to be radii containing equal arcs of the frame on which they are placed. It is obvious that a perfect parabolic figure, and a luminous *point* mathematically true, would render the illumination of the whole horizon by means of a fixed light *impossible;* and it is only from the aberration caused by the size of the flame which is substituted for the point, that we are enabled to render even revolving lights practically useful. But for this aberration, even the slowest revolution in a revolving light, which would be consistent with a continued observable series, such as the practical seamen could follow, would render the flashes of a revolving light greatly too transient for any useful purpose; whilst fixed lights being visible in the azimuths only in which the mirrors are placed, would, over the greater part of the distant horizon, be altogether invisible. The size of the flame, therefore, which is placed in the focus of a parabolic mirror, when taken in connexion with the form of the mirror itself, leads to those important modifications in the paths of the rays, and the form of the resultant beam of light, which have rendered the catoptric system of lights so great a benefit to the benighted seaman.

It is obvious, from a consideration of the nature of the action which takes place in this combination of the paraboloidal mirrors with Argand lamps, that the revolving light is not only more perfect in its nature than the fixed light, but that it possesses the advantage of being susceptible of an increase of its power, by increasing the number of reflectors, which have their axes parallel to each other, so as to concentrate the effect of several mirrors in one direction. The perfect parallelism of the axes of separate mirrors, it is true, is unattainable, but approaches may be made sufficiently near for practical results; and in order to prolong the duration of the flash, the reflectors are sometimes placed on a frame, having each of its sides slightly convex, by which arrangement, the outer reflectors of each face of the frame have their axes less inclined inwards from the radii of the revolving frame which pass through their foci.

Proportions and divergence of paraboloidal mirrors.

The best proportions for the paraboloidal mirrors, depend upon the object to which they are to be applied; as mirrors which are intended to produce great divergence in the form of the resultant beam should have one form; whilst those which are designed to cause a near approach to parallelism of the rays, will have another form. These objects may also be attained by variations of the size of the flame applied in the same mirror, but it is much more advantageous to produce the effect, by a change in the form of the mirror, as any increase of the flame beyond the size which is found to be most advantageous in other respects, cannot be regarded otherwise than as a wasteful expenditure of light. The details into which a full investigation of this matter would lead us, are quite beyond the scope of this article, and it therefore seems sufficient to give the formulæ which express the relations which exist between the size of the flame, the reflecting surface, and the corresponding divergence of the reflected ray. If Δ represent the inclination of any reflected ray to the axis of a paraboloidal mirror, e the distance of the focus from the point of reflection, and d the distance from the edge of the flame to the focus in the plane of reflection, we shall have $\sin \Delta = \frac{d}{e}$, and when the flame in the given plane of reflection is circular, or has its opposite sides equi-distant from the focus of the mirror, we shall, by putting Δ' for the effective divergence of the mirror in the given plane, have $\Delta' = 2\,\Delta$. When, therefore, great divergence, as in the case of the fixed lights, is required, the prolate form of the curve is to be preferred; and the oblate is conversely more suited to revolving lights.

Power of paraboloidal mirrors.

The power of the reflectors ordinarily employed in lighthouses, is generally equal to about 360 times the effect of the unassisted flame which is placed in the focus. This value, however, is strictly applicable only at the distances at which the observations have been made, as the proportional value of the reflected beam must necessarily vary with the distance of the observer, agreeably to some law dependent upon the unequal distribution of the light in the luminous cone which proceeds from it. The ordinary burners used in lighthouses are one inch in diameter, and the focal distance generally adopted is four inches, so that the effective divergence of the mirror in the horizontal plane may be estimated at about 14° 22′. In arranging reflectors on the frame of a fixed light, however, it would be advisable to calculate upon less effective divergence, for beyond 11° the light is feeble; but the difficulty of placing many mirrors on one frame, and the great expense of oil required for so many lamps, have generally led to the adoption of the first valuation of the divergence.

Manufacture and testing of reflectors.

The reflectors used in the best lighthouses, are made of sheet copper plated in the proportion of 6 oz. of silver to 16 oz. of copper. They are moulded to the paraboloidal form, by a delicate and laborious process of beating with mallets and hammers of various forms and materials, and are frequently tested during the operation by the application of a carefully-formed mould. After being brought to the curve, they are stiffened by means of a strong bizzle, and a strap of brass which is attached to it for the purpose of preventing any accidental alteration of its figure. Polishing powders are then applied, and the instrument receives its last finish.

Two guages of brass are applied to test the form of the reflector. One is for the back, and is used by the workmen during the process of hammering, and the other is applied to the concave face as a test, while the mirror is receiving its final polish. It is then tested, by trying a burner in the focus, and measuring the intensity of the light at various points of the reflected conical beam. Another test may also be applied successively to various points in the surface, by masking the rest of the mirror. Having placed a screen in the line of the axis of the mirror at some given distance from it, it is easy to find whether the image of a very small object placed in the conjugate focus, which is due to the distance of the screen, be reflected at any distance from that point on the centre of the screen through which the prolongation of the axis of the mirror would pass, and thus to obtain a measure of the error of the instrument. For this purpose, it is necessary to find the position of the conjugate focus, which corresponds to the distance of the screen. If b be the distance which the object should be removed outwards from the principal focus of the mirror, d the distance from the focus to the screen, and r the distance from the focus to the point of the mirror which is to be tested, we shall have $b=\frac{r^2}{d}$ as the distance which the object must be removed outwards from the true focus on the line of the axis.

Argand lamps used in reflectors.

The flame generally used in reflectors, is from an Argand fountain-lamp, whose wick is an inch in diameter. Much care is bestowed upon the manufacture of these lamps for the Northern Lighthouses, which have their burners tipped with silver, to prevent wasting by the great heat which is evolved. These burners are also fitted with a slide apparatus, accurately formed, by which the burner may be removed from the interior of the mirror at the time of cleaning it, and returned exactly to the same place, and locked by means of a key. This arrangement, which is shewn in Plate II. figs. 7, 8, and 9, is very important, as it insures the burner always being in the focus, and does not require that the reflector be lifted out of its place every time it is cleaned; so that, when once carefully set and screwed down to the frame, it is never altered. In these figs. *a a a* represents one of the reflectors, *b* is the lamp, *c* is a cylindric fountain, which contains 24 oz. of oil. The oil-pipe, and fountain of the former, is connected with the rectangular frame *d*, and is moveable in a vertical direction upon the guide rods *e* and *f*, by which it can be let down and taken out of the reflector, by simply turning the handle *g*, as will be more fully understood by examining fig. 8. An aperture of an elliptical form, measuring about two inches by three, is cut in the upper and lower part of the reflector, the lower serving for the free egress and ingress of the lamp, and the upper, to which the copper tube *h* is attached, serving for ventilation; *i* shews a cross section of the main bar of the chandelier or frame, on which the reflectors are ranged, each being made to rest on knobs of brass, one of which, as seen at *k k*, is soldered on the brass band *l*, that clasps the exterior of the reflector.

Plate II. fig. 8, is a section of the reflector *a a*, shewing the position of the burner *b*, with the glass chimney *b′*, and oil-cup *l*, which receives any oil that may drop from the lamp.

Plate II. fig. 7, shews the apparatus for moving the lamp up and down, so as to remove it from the reflector at the time of cleaning it. In the diagram, *c*, the fountain, is moved partly down; *d*, *d* shews the rectangular frame on which the burner is mounted, *e e* the elongated socket-guides, *f* the rectangular guide-rod, connected with the perforated sockets on which the *checking-handle g* slides.

Arrangement of reflectors on the frame.

The modes of arranging the reflectors in the frames, are shewn in Plate I. figs. 2, 4, and 5. It seems quite unnecessary, after what is said on the subject of divergence, to do more than remark, that in revolving lights the reflectors are placed with their axes parallel to each other, so as to concentrate their power in one direction; whilst in fixed lights, it is necessary, in order to effect as equal a distribution of the light over the horizon as possible, to place the reflectors, with their axes inclined to each other, at an angle somewhat less than that of the divergence of the reflected cone. For this purpose, a brass guage, composed of two long arms, somewhat in the form of a pair of common dividers, connected by means of a graduated limb, is employed. The arms having been first placed at the angle, which is supplemental to that of the inclination of the axes of the two adjacent mirrors, are made to span the faces of the reflectors, one of which is moved about till its edges are in close contact with the flat surface of one of the arms of the guage. The different arrangements of the reflectors will be more fully understood by referring to the Plates.

Plate I. figs. 2 and 5, shew an elevation and plan of a revolving apparatus on the catoptric principle. In these figures, *n n* shews the reflector frame or chandelier; *o o*, the reflectors with their oil-fountains *p p*. The whole is attached to the revolving axis or shaft *q*. The copper tubes *r r* convey the smoke from the lamps; *s s* are cross bars which support the shaft at *t t*; *u u* is a copper pan for receiving any moisture which may accidentally enter at the central ventilator in the roof of the light-room; *l* is a cast-iron bracket, which supports the pivot on the shaft; *m m* are bevelled wheels, which convey motion from the machine to the shaft.

Plate I. fig. 4, shews a plan of one tier of reflectors arranged in the manner employed in a fixed catoptric light; *n n* shews the chandelier, *q* the fixed shaft in the centre, which supports the whole, *o o* the reflectors, and *p p* the fountains of their lamps.

Bordier Marcet's reflectors.

A variety of the parabolic reflectors has been invented by M. Bordier Marcet, the pupil and successor of Argand, who has laboured with much enthusiasm in perfecting catoptric instruments, more especially with a view to their application in the illumination of lighthouses and the streets of towns. Amongst many other ingenious combinations of parabolic mirrors, he has invented and constructed an apparatus, which is much used in harbour-lights on the French coast. The object of this apparatus is to fulfil, as economically as possible, the conditions required in a fixed light, by illuminating, with perfect equality, every part of the horizon, by means of a single burner; and M. Bordier Marcet has in his work-shop an instrument of this kind, eight feet in diameter, which he constructed on speculation. The apparatus used in harbour-lights, on the French coast, is of much smaller dimensions, and does not exceed fifteen inches in diameter. A perfect idea of the construction and effect of this apparatus, may be formed, by conceiving a parabola to revolve about its parameter as an axis, so that its upper and lower limbs would become the generating lines of two surfaces possessing the property of reflecting, in lines parallel to the axis of the parabola, all the rays incident upon them, from a light placed in the point where the parameter and axis of the generating parabola intersect each other. This point being the focus of each parabolic section of this apparatus, the light is equally dispersed in every point of the horizon, when the axes of the parabolic sections are in a plane perpendicular to a vertical line. But however perfectly this apparatus may attain this important object, it does so at the sacrifice of the most efficient part of the parabolic surface, which lies between the vertex and the parameter; and, therefore, produces a proportionally feeble effect. This beautiful little instrument is shewn in Plate II, fig. 5; in which b shews the burner p, p the upper reflecting surface, and p' p' the lower reflecting surface, both generated in the manner above described by the revolution of a parabola about its parameter x b; F is the focus of the generating parabola; and l l are small pillars, which connect the two reflecting plates, and give strength to the apparatus.

M. Bordier Marcet has also prepared a very ingenious modification of the paraboloidal mirror, which he has described under the name of *fanal à double aspect;* and the object of which is, to obtain a convenient degree of divergence from parabolic mirrors, by the use of two flames and two reflecting surfaces, each of which is acted upon by its own flame, and also by that of the other. This modification consists in the union of two portions of hollow paraboloidal mirrors, generated by the revolution of two parabolas about a common horizontal axis, and illuminated by two lamps placed in the focus of each. The first surface is generated by the revolution on its axis of a segment of a paraboloid intercepted between the parameter and some double ordinate greater than it, and may, from its form, be called the ribbon-shaped mirror. The second surface is that of a parabolic conoid, which is cut off by a vertical plane passing through a double ordinate, which is equal to the parameter of the parabolic ribbon, which is placed in front of it. The elements of the curve which forms the conoidal mirror, must be so chosen as to have its focus at a convenient distance in front of that of the ribbon-shaped mirror, so as to admit of placing the two lamps separate from each other, as well as to produce the necessary degree of divergence, which is to be obtained by the action of these mirrors respectively on the flame placed in the focus of the other. These two mirrors are thus joined together. Each mirror produces, by means of the lamp placed in its focus, an approach to parallelism of the reflected rays, which M. Bordier Marcet has not inaptly termed the *principal effect;* whilst the action of each surface on the lamp which is placed in the focus of the other, causes what the inventor calls the *secondary* or *lateral effect.* Their secondary action may be described thus: The lamp, which is in the focus of the ribbon, is much nearer the vertex of the conoid than its own focus; so that its rays making, with normals to the surface of the conoid, angles greater than those which are formed by the rays proceeding from its focus, are of necessity reflected in lines diverging from the axis of the mirror. Those, on the contrary, which proceed from the focus of the conoid, meet the ribbon-shaped surface, so as to make angles with its normals more acute than those which the rays from its own focus could do, and which are, therefore, reflected in lines converging to the axis of the mirror. These reflected rays must therefore cut the axis, and diverge from it on the other side. This apparatus has been tried with success at La Hève and some other lights on the French coast. But it is impossible not to perceive the great loss of light which results from the use of two flames in one mirror; and it must not be forgotten, that the divergence which is obtained is not confined to the horizontal direction in which only it is wanted; but the light is scattered in every direction round the edge of the mirror.

Spherical mirrors.

Spherical mirrors have been employed in lighthouses only when they can be introduced as subsidiary parts in dioptric apparatus; and any observations regarding them will, therefore, be made in treating of the dioptric lights of Fresnel.

Floating lights.

Floating lights are only resorted to in cases of absolute necessity, as their maintenance is extremely expensive, whilst they are less to be relied on, and, in all respects, less efficient than land lights. They are large vessels, built with great breadth of beam, and are generally moored off shoals, or serve as guides for taking channels. The lights are from lamps placed in front of small reflectors, ranged in lanterns, which are hoisted on the masts of the vessel. The number of lights varies from one to three as the only means of distinction, the feebleness of the light generally rendering it inexpedient to adopt the distinctions derived from the use of coloured media.

Distinctions of catoptric lights.

Catoptric lights are susceptible of nine separate distinctions, which are called *fixed, revolving white, revolving red and white, revolving red with two whites, revolving white with two reds, flashing, intermittent, double fixed lights, and double revolving white lights.* The first exhibits a steady and uniform appearance, which is not subject to any change; and the reflectors used for it, (as already noticed), are of smaller dimensions than those employed in revolving lights. This is necessary in order to permit them to be ranged round the circular frame, with their axes inclined at such an angle, as shall enable them to illuminate every point of the horizon. The revolving light is produced by the revolution of a frame with three or four sides, having reflectors of a large size grouped on each side, with their axes parallel; and as the revolution exhibits a light gradually increasing to *full strength,* and in the same gradual manner decreasing to total darkness, its appearance is extremely well marked. The succession of *red* and *white* lights is caused by the revolution of a frame whose different sides present red and white lights; and these, as already mentioned, afford three separate distinctions, namely, alternate, red, and white; the succession of two white lights after one red, and the succession of two red lights after one white light. The *flashing* light is produced in the same manner as the *revolving* light; but owing to a different construction of the frame, and the greater quickness of the revolution, a totally different and very striking effect is produced. The brightest and darkest periods being but momentary, this light is characterised by a rapid succession of bright flashes, from which it gets its name. The *intermittent* light is distinguished by bursting suddenly into view and continuing steady for a short time, after which it is suddenly eclipsed for half a minute. This striking appearance is produced by the perpendicular motion of circular shades in front of the reflectors, by which the light is alternately hid and displayed. This distinction, as well as that called the *flashing light,* are peculiar to the Scotch coast, having been first introduced by the present Engineer of the Northern Lights Board. The double lights, which are generally used only where there is a necessity for a *leading* line, as a guide for taking some channel or avoiding some danger, are exhibited from two towers, one of which is higher than the other; and when seen in one line, form a direction for the course of shipping. At the Calf of Man, a striking variety has been introduced into the character of leading lights, by substituting, for two *fixed* lights, two lights which revolve in the same periods, and exhibit their flashes at the same instant; and these lights are, of course, susceptible of the other variety enumerated above, that of two revolving red and white lights revolving in equal periods. The utility of all these distinctions is chiefly to be imputed to their at once striking the eye of an observer and being instantaneously obvious to strangers.

[1]Dioptric system of Fresnel.

Before entering upon the subject of the dioptric lights, the writer of this article embraces with pleasure the opportunity afforded to him, of acknowledging the liberality of M. Léonor Fresnel, the present Secretary of the Lighthouse Commission of France. It was entirely owing to the readiness with which M. Fresnel afforded him access to every avenue of information on the subject of lighthouses, that he was enabled to effect the object of a mission to France, on which he was sent in the year 1834, by the Commissioners of Northern Lights.

The first proposal of applying lenses to lighthouses, is recorded by Smeaton in his account of the Eddystone Lighthouse, where he mentions that, in 1759, an optician in London proposed grinding the glass of the lantern to a radius of seven feet six inches; but the description is too vague to admit of even a conjecture regarding the proposed arrangement of the apparatus. Above forty years ago, however, lenses were actually tried in several lighthouses in the south of England; but their imperfect figure, and the quantity of light absorbed by the glass, which was of inferior quality and of considerable thickness, rendered their effect so much inferior to that of the parabolic reflectors then in use, that, after trying some strange combinations of lenses and reflectors, the former were finally abandoned.

The object to be attained by the use of lenses in a lighthouse, is, of course, identical with that which is answered by employing reflectors; and both instruments effect the same end by different means, collecting the rays which diverge from a point called the *focus*, and projecting them forward in a beam, whose axis coincides with the produced axis of the instrument. The actions by which these similar results are effected, have been termed *reflection* and *refraction*. In the one case, the light, as has been already said, merely impinges on the reflecting surface, and is thrown back; whilst in the other, the rays pass through the refracting medium, and are bent or refracted from their natural course.

Polyzonal lenses.

The celebrated Buffon, to prevent the great absorption of light by the thickness of the material, which would necessarily result from giving to a lens of great dimensions a figure continuously spherical, proposed to grind out of a solid piece of glass, a lens in steps or concentric zones. This suggestion of Buffon regarding the construction of large burning glasses, was first executed, with tolerable success, about the year 1780, by the Abbé Rochon; but such are the difficulties attending the process of working a solid piece of glass into the necessary form, that it is believed the only other instrument ever constructed in this manner, is that which was made by Messrs. Cookson of Newcastle-upon-Tyne, for the Commissioners of Northern Lighthouses.

The merit of having first suggested the building of these lenses in separate pieces, seems to be due to Condorcet, who in his *Eloge de Buffon*, published so far back as 1773, enumerates the advantages to be derived from this method.[2] Sir David Brewster also described this mode of building lenses in 1811, in the *Edinburgh Encyclopædia;* and in 1822, the late eminent Fresnel, alike unacquainted with the suggestions of Condorcet, or the description by Sir David Brewster, explained with many ingenious and interesting details, the same mode of constructing these instruments. To Fresnel belongs the additional merit of having first followed up his invention, by the construction of a lens, and in conjunction with MM. Arago and Mathieu of placing a powerful lamp in its focus, and indeed of finally applying it to the practical purposes of a lighthouse. The fertile genius of the French Academician has produced many ingenious combinations of dioptric instruments for lighthouses, which we shall have occasion to notice in the sequel.

Annular lenses.

The great advantages which attend the mode of construction proposed by Condorcet, are, the ease of execution, by which a more perfect figure may be given to each zone, and spherical aberration almost entirely corrected, and the power of forming a lens of larger dimensions than could easily be made from a solid piece. Both Buffon and Condorcet, however, chiefly speak of reducing the thickness of the material, and do not seem to have thought of determining the radius and centre of the curvature of the generating arcs of each zone, having contented themselves with simply depressing the spherical surface in separate portions. Fresnel, on the other hand, determined these centres, which constantly recede from the axis of the lens in proportion as the zones to which they refer are removed from its centre; and the surfaces of the zones of the annular lens, consequently, are not parts of concentric spheres, as in Buffon's lens. It deserves notice, that the first lenses constructed for Fresnel by M. Soleil had their zones polygonal, so that the surfaces were not annular, a form which Fresnel considered less accommodated to the ordinary resources of the optician. He also, with his habitual penetration, preferred the plano-convex to the double-convex form, as more easily executed. After mature consideration, he finally adopted crown glass, which, notwithstanding its greenish colour, he considered more suitable than flint glass, as being less liable to *striæ*. All his calculations were made in reference to an index of refraction of 1·51, which he had verified by repeated experiments, conducted with that patience and accuracy for which, amidst his higher qualities, he was so remarkably distinguished. These instruments have received the name of *annular* lenses, from the figure of the surface of the zones.

Fig. 6, Plate II, exhibits a plan and section of an annular lens of the largest size, whose focal distance is 92 centimètres, or about 36·22 inches, and which subtends a luminous pyramid of 46° of inclination, having its apex in the flame.

Cylindric refractors

Having once contemplated the possibility of illuminating lighthouses by dioptric means, Fresnel quickly perceived the advantage of employing for fixed lights a lamp placed in the centre of a polygonal hoop, consisting of a series of cylindric refractors, *infinitely small* in their length, and having their axes in planes parallel to the horizon.

Such a continuation of vertical cylindric sections of various curvatures, by refracting the rays proceeding from the focus only in a direction perpendicular to the vertical sections of the cylindric parts, must distribute a zone of light *equally brilliant* in every point of the horizon. This effect will be easily understood, by considering the middle vertical section of one of the great annular lenses or burning glasses, already described, abstractly from its relation to the rest of the instrument. It will readily be perceived that this section possesses the property of simply refracting the rays at right angles to the line of the section, or in a direction parallel to the horizon, and cannot collect the rays from either side of the vertical line; and if this section, by its revolution about a vertical axis, becomes the generating line of the enveloping hoop, above noticed, such a hoop would of course possess the property of refracting an equally diffused zone of light round the horizon. The difficulty, however, of forming this apparatus, appeared so great, that Fresnel determined to substitute for it a vertical polygon, composed of what have been improperly called *cylindric lenses*, but which in reality are mixtilinear and horizontal prisms, distributing the light which they receive from the focus, equally over the horizontal sector which they subtend. This polygon has a sufficient number of sides to enable it to give at the angle formed by the junction of two of them, a light not very much inferior to what is produced by one of the sides; and upper and lower courses of curved mirrors, are so placed as to make up for the deficiency of the light at the angles. The effect sought for in a fixed light is thus obtained in a much more perfect manner, than by any combination of the parabolic mirrors used in the British lighthouses.

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[1] In all probability directly derived from the Greek *διόπτρα*, an optical instrument with holes for looking through, which is a compound of *διὰ*, *through*, and *ὄπτομαι*, *I see.*

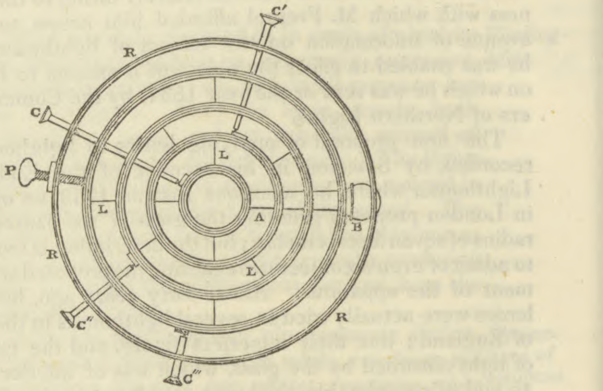
[2] On pourrait même composer de plusieurs pièces ces loups à échelons; on y gagnerait plus de facilité dans la construction, une grande diminution de dépense, l'avantage de pouvoir leur donner plus d'étendue, et celui d'employer suivant le besoin un nombre des cercles plus ou moins grand, et d'obtenir ainsi du même instrument différens dégrès de force. *Eloge de Buffon*, p. 35. *Œuvres de Condorcet*, tom. iv. Paris, 1804.

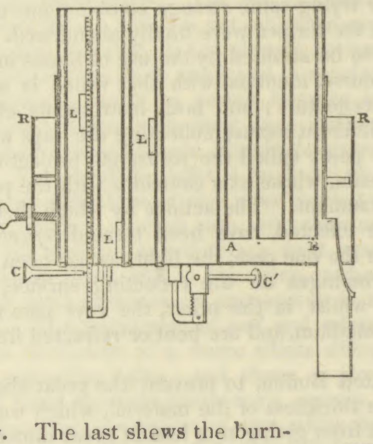
An ingenious modification of the fixed apparatus is due to the inventive mind of Fresnel, who also conceived the happy idea of placing one apparatus of this kind in front of another, with the axes of the cylindric pieces crossing each other at right angles. As these cylindric pieces have the property of refracting all the rays which they receive from the focus, into a direction perpendicular to the mixtilinear section which generates them, it is obvious that if two refracting media of this sort be arranged as proposed by Fresnel, their joint action will unite the rays which come from their common focus into a beam, whose sectional area is equal to the overlapped surface of the two instruments, and thus produce the effect of an annular lens. It was by availing himself of this property of crossed prisms, that Fresnel invented the distinction for lights, which he calls *a fixed light varied by flashes;* in which the flashes are caused by the revolution of cylindric media, with vertical axes round the fixed-light apparatus already described.

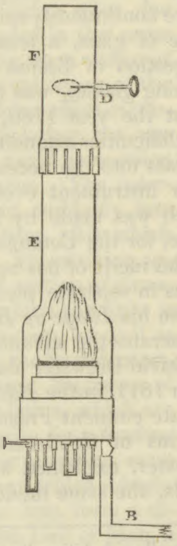
Mechanical lamp.

Fresnel immediately perceived the necessity of combining with the dioptric instruments which he had invented, a burner capable of producing a large volume of flame; and the rapidity with which he matured his notions on this subject, and at once produced an instrument admirably adapted for the end he had in view, affords one of the many proofs of that happy union of practical with theoretical talent, for which he was so distinguished. Fresnel himself has modestly attributed much of the merit of the invention of this lamp to M. Arago; but this gentleman, with great candour, gives the whole credit to his deceased friend, in a notice regarding lighthouses, which appeared in the *Annuaire du Bureau des Longitudes* of 1831. The lamp has four concentric burners, which are defended from the action of the excessive heat, produced by their united flames, by means of a superabundant supply of oil, which is thrown up from the cistern below by a clock-work movement, and constantly overflows the wicks, as in the mechanical lamp of Carcel. A very tall chimney is found to be necessary, in order to supply fresh currents of air to each wick with sufficient rapidity to support the combustion. The carbonisation of the wicks, however, is by no means so rapid as might be expected, and it is even found that after they have suffered a good deal the flame is not sensibly diminished, as the great heat evolved from the mass of flame, promotes the rising of the oil in the cotton. The writer of this article has seen the large lamp at the Tour de Corduan burn for seven hours without being snuffed, or even having the wicks raised.

The annexed diagrams will give a more perfect idea of the nature of the concentric burner than can easily be conveyed by words alone. The first shews a plan of a burner of four concentric wicks. The intervals which separate the wicks from each other and allow the currents of air to pass, diminish in width a little, as they recede from the centre. The next shews a section of this burner. C, C′, C″, C‴ are the rack handles for raising or depressing each wick, AB is the horizontal duct which leads the oil to the four wicks, L, L, L, are small plates of tin by which the burners are soldered to each other, and which are so placed as not to hinder the free passage of the air; P is a clamping screw, which keeps at the proper height the gallery R, R, which carries the chimney. The last shews the burner with its glass chimney and damper. E is the glass chimney, F is a sheet-iron cylinder, which serves to give it a greater length, and has a small damper D, capable of being turned by a handle for regulating the supply of air; and B is the pipe which supplies the oil to the wicks. The great risk in using this lamp arises from the leather valves that force the oil by a clock-work movement, being occasionally liable to derangement; and several of the lights on the French coast, and more especially the Corduan, have been extinguished by the failure of the lamp for a few minutes, an accident which has never, and scarcely can happen with the fountain lamps which illuminate the reflectors. To prevent the occurrence of such accidents, and to render their consequences less serious, various precautions have been resorted to. Amongst others, an alarum is attached to the lamp, consisting of a small cup pierced in the bottom, which receives part of the overflowing oil from the wicks, and is capable, when full, of balancing a weight placed at the opposite end of a lever. The moment the machinery stops, the cup ceases to receive the supply of oil, and the re-







mainder running out at the bottom, the equilibrium of the lever is destroyed, and in falling, it disengages a spring which rings a bell sufficiently loud to waken the keeper should he chance to be asleep. It may justly be questioned whether this alarum would not prove a temptation to the keepers to relax in their watchfulness and fall asleep. There is another precaution of more importance, which consists in having always at hand in the light-room a spare lamp trimmed and adjusted to the height for the focus, which may be substituted for the other in case of accident. It ought to be noticed, however, that it takes about twenty minutes from the time of applying the light to the wicks to bring the flame to its full strength, which, in order to produce its best effect, should stand at the height of nearly four inches ($10^{\text{cm.}}$). The inconveniences attending this lamp have led to several attempts to improve it; and amongst others M. Delaveleye has proposed to substitute a pump having a metallic piston, in place of the leather valves, which require constant care, and must be frequently renewed. A lamp was constructed in this manner by M. Lepaute, and tried at Corduan; but was afterwards discontinued until some further improvements could be made upon it. It has lately been much improved by M. Wagner, an ingenious artist whom M. Fresnel employed to carry some of his improvements into effect. In the dioptric lights on the Scotch coast, a common lamp with a large wick is kept constantly ready for lighting; and in the event of the sudden extinction of the mechanical lamp by the failure of the valves, it is only necessary to unscrew and remove its burner, and put the reserve-lamp in its place. The height of this lamp is so arranged, that its flame is in the focus of the lenses, when the lamp is placed on the ring which supports the burner of the mechanical lamp; and as its flame, though not very brilliant, has a considerable volume, it will answer the purpose of maintaining the light for an hour or two, until the light-keepers have time to repair the valves of the mechanical lamp. No occasion for the use of this reserve-lamp has yet occurred.

Mr. Oldham's lamp.

The lamp invented by Mr. Oldham of Dublin, appears, from the simplicity of its construction, to be very suitable for the purposes of a lighthouse; and the writer of this article is at present engaged in some experiments to ascertain the possibility of applying the pressure used in Mr. Oldham's lamp to produce the same regular supply of oil to the concentric burner, which is at present effected by means of the mechanism of the French lamp.

Divergence of the annular lenses.

The divergence of the annular lens is greatly less than that of the parabolic mirror. It may be estimated in the following manner. Let Δ be the angle of divergence of any ray emerging from the lens, l the distance of the point of incidence from the principal focus of the lens, and r the radius of the flame, and we have $\sin. \Delta = \frac{r}{l}$, and when Δ' is made the angle of the effective divergence of the lens, we have $\Delta' = 2\Delta$.

Adopting this rule we find the effective divergence of the lens to be about 5° 9′, which does not differ much from the observed divergence.

Manufacture of dioptric instruments.

The manufacture of the dioptric instruments is not distinguished by any peculiarity which requires special notice, the grinding and polishing being performed by means of powders gradually increasing in fineness, successively applied as in the ordinary process of grinding glass. The union of the several zones which compose an annular lens is effected by means of small slips of thin copper, which having one half passed into a groove in one zone, and the other half into a corresponding groove in the adjoining zone, prevent, in the same manner as a *joggle* in masonry, or a *chock* in carpentry, the one zone from slipping past the other. The pieces are also united by a glue which possesses the important property of being able to resist the action of considerable heat, whilst it is by no means brittle. M. Fresnel intrusted the work of building the first lens to the late M. Soleil, optician to the king of France, to whose zeal and intelligence he bears ample testimony in the *Memoire* in which he describes the invention.

Testing of lenses.

In order to test the figure of the lenses, moulds carefully made may be applied; or the lens being mounted on a stand which permits its being set at any angle, the accuracy of the whole instrument, and of each portion of it, may be separately tested by the form and size of the spectrum which is formed in the principal focus, by permitting the solar rays to fall upon the lens at right angles. When any particular portion is to be tried, the rest of the surface is covered with discs of strong grey paper or pasteboard. Another method may be employed similar to that already described as applicable to reflectors. This method consists in finding whether a small object placed in any point of the axis farther from the lens than the principal focus, has its image refracted accurately to a point on a screen placed in the conjugate focus which is due to that distance. The same principle of testing the instrument is also applied when a person stationed at a given short distance in front of the lens observes whether its whole surface be completely illuminated by a small flame placed in the conjugate focus corresponding to that distance. All that is necessary, therefore, is to determine these distances by means of formulæ which express the relations of the distances of the object and its image. If δ represent the distance of the eye from the lens, ϕ the principal focus, and ϕ' the distance of the conjugate focus corresponding to the observer's distance δ, then we have $\phi' = \frac{\delta\phi}{\delta - \phi}$.

If, again, adopting the same notation, we wish to find the distance at which the image of an object placed at a given distance from the lens greater than that of the principal focus, should be accurately impressed on a screen, we have $\delta = \frac{\phi\phi'}{\phi' - \phi}$

Curved mirrors.

The curved mirrors, as already mentioned, are, strictly speaking, generated by portions of parabolas having their foci coincident with the common flame of the system. In practice, however, they are made portions of a curve surface, ground by the radius of the circle which osculates the given parabola, and passes tangentially through the middle of the chord which subtends the arc of the mirror. These mirrors are plates of glass, silvered on the back, and set in flat cases of sheet brass. They are suspended on a circular frame by screws, which are attached to the backs of the cases, and which afford the means of adjusting them to their true position in the lightroom, so that they may reflect the horizon of the lighthouse to an observer's eye placed in the focus of the system. In order to test the accuracy of the mirrors, recourse may again be had to the formulæ of conjugate foci; thus, if we put r equal to the radius of curvature of the mirror, d equal to the given distance of any object from the mirror, and d' equal to the distance of a moveable screen, which shall receive the true image of the object if the mirror be accurately formed, we shall have for this latter distance $d' = \frac{rd}{2d - r}$.

Power of the annular lenses, cylindric refractors and curved mirrors.

The effect of an annular lens may be estimated at moderate distances to be nearly equal to that of 3000 Argand flames of about an inch diameter; that of a cylindric refractor at about 250; and that of a curved mirror may perhaps on an average be assumed at about 10 Argand flames.

Catadioptric light.

A beautiful apparatus, which has received the name of the *catadioptric* light, from the compound action by which it is characterised, was another of Fresnel's applications of dioptric instruments to the purposes of a lighthouse. This elegant apparatus consists of thirteen rings of glass of various diameters arranged one above another, in an oval form. The five middle rings have an interior diameter of 11·81 inches (30$^{cm.}$) and refract equally over the horizontal plane of the focus the light which they receive from it, and thus operate precisely in the same manner as the dioptric part of the fixed light apparatus. The other rings or prisms, five of which are upper and three lower, are ground and set in such a manner, that they project all the light derived from the focus in a direction parallel to the other rays by *total reflection*. This effect is produced by arranging the prisms, so that the incident rays, after being refracted at the first surface, shall strike the reflecting side of the prism at such an angle, that instead of passing through the prism at that point, they shall be *totally reflected* from it, and after a second refraction emerge from the third side in a direction parallel to those transmitted by the middle or simply refracting rings. When this apparatus is employed to light only a part of the horizon, the rings are discontinued on the side next to the land, and room is thus obtained for using a common fountain lamp; but when the whole horizon is to be illuminated, the apparatus must inclose the flame on every side, so that it has in this case been found necessary to employ the hydrostatic lamp of Thilorier, in which the balance is sulphate of zinc in solution. Fresnel was prevented, by an early death, the consequence of severe application to scientific pursuits, from ever constructing this beautiful instrument; and it was reserved for the present enlightened secretary of the *Commission des Phares* to complete his brother's invention.

The nature of this apparatus will be fully understood by a reference to fig. 1. Plate I. which shews its section and plan. F is the focal point in which the flame is placed, *r*, *r* cylindric refractors, forming by their union a cylinder with a lamp in its axis, and producing a zone of light of equal intensity all round the horizon, and *r′*, *r′* are cylindric refractors having their axes at right angles to those of the refractors *r*, *r*, and revolving around them. These exterior refractors in front of the inner refractors produce, by compound refraction, a beam similar to that resulting from an annular lens. *x*, *x* are catadioptric prismatic rings acting by *total reflection*, and giving out zones of light of equal intensity at every point of the horizon. The dotted lines shew the course traversed by the rays of light which proceed from the lamp and are acted upon by the rings of glass. The catadioptric rings supply the places of the curved mirrors M, M, shewn in Plate II. figs. 3 and 4; and as the reflection from the inner surface of a prism is, theoretically speaking, *total*, and the whole loss of light is merely that which is due to absorption in passing through the glass, and that which takes place at the two surfaces, there must of necessity be a much greater proportion of the incident light transmitted by the catadioptric action than can ever be obtained from the most perfect reflecting surface, the loss from reflection being held to be in no case less than one half of the incident light.

Catadioptric prisms or lights of the first order.

This consideration, together with some other views regarding the greater convenience of the catadioptric apparatus, led Mr. Alan Stevenson to propose to the Commissioners of the Northern Lighthouses, in a report, dated 8th October 1836, that an inquiry should be instituted regarding the practicability of substituting in lights of the first order, a series of catadioptric prisms in the room of the curved mirrors which are at present used in France. Having received authority from the Lighthouse Board, he corresponded with M. Fresnel at Paris, who, in the most liberal manner, furnished him with all the information regarding the steps which he had pursued in reference to the smaller apparatus, and at the same time suggested many important views regarding the larger one.

In the small apparatus of the fourth order, the nearness of the prisms to the flame makes the angle subtended by the first refracting side considerable; and as the curvature of the reflecting side of the prisms depends upon this angle, the excess of the secant, above the radius of the arc, is a notable quantity, and the radius of curvature is proportionally small. But in the prisms of the first order, Mr. A. Stevenson found, that the radius of curvature of the reflecting side is upwards of 24 feet, and that, even when the generating triangles are larger than those of the small apparatus, the excess of the secant over the radius is only about ·0125 inch. Where a flame of great size, like that which illuminates the dioptric apparatus, is used, this curvature may be safely disregarded; and is, indeed, such, that it could not be accurately ground, on account of the great length and unwieldiness of the radius. It is true, that an approximation to the true figure might be made, by giving to the reflecting side the form which would be traced by two tangents to the curve, and thus forming a trapezoidal prism; but the difficulty of such an operation, where so little glass is to be removed, and the increased source of error from the necessity of an additional shifting of the glass on the chucks, seem to be sufficient reasons for rejecting this expedient. It ought also to be recollected, that in this case the tendency of the deviation from the theoretical form, is towards the side of safety, as the error in the path of any ray which it could cause, would throw the light at its emergence from the prism below, and not above the horizon. The prisms may therefore be considered as rings generated by the revolution of isosceles triangles round a vertical axis passing through the focus of the system.

Mr. Edward Sang, F.R.S.E. in an interesting communication on the grinding of glass, which was lately read before the Society of Arts for Scotland, pointed out the advantage of adopting the highest point of the flame as the focus of the system of reflecting rings. By this arrangement, the light from the upper part of the flame, which would otherwise escape upwards, will be directed to the horizon, whilst the rays from the lower parts of the flame will be usefully directed to illuminate the space between the horizon and the lighthouse.

Arrangement of a paratus in the lighthouse.

All the lights on the dioptric principle, are illuminated by a flame placed in the centre of the apparatus or common focus of the principal lenses and cylindric refractors which are ranged round it. The burner of the lamp varies in its dimensions and its consumption of oil, according to the size of the instruments employed, which also determines what is called the *order* of the light, a name expressive of its *power* and *range*. Above and below the strictly dioptric part of the apparatus of each order, there are also accessary parts, which are generally simply catoptric, and consist of curved mirrors arranged in tiers, one above another, like the leaves of a Venetian blind and placed so as to reflect to the horizon the rays received from the lamp, which is in their common focus. At Corduan, however, and at Planier, near Marseilles, the apparatus above the principal lenses is dia-catoptric, being composed of an union of eight lenses of 19·68 inches (50$^{cm.}$) of focal distance, inclined inwards to the flame, which is in their common focus, and thus forming a frustum of an octagonal pyramid of 50° of inclination. These upper lenses are surmounted by plane mirrors, placed so as to reflect horizontally the beams transmitted by the lenses. In placing these upper lenses, it has been thought advisable to give their axes a horizontal inclination of 7° from that of the great lenses. By this arrangement, the flash of the upper lenses always precedes that of the principal lenses, as already noticed in speaking of the appearance of Corduan light. The use of the accessary apparatus is to collect the rays, which would otherwise pass above and below the main lenses, without contributing to the brilliancy of the light. The nature of the whole apparatus will be more fully understood by referring to the Plates.

Plate II. fig. 1, is a section of a revolving dioptric apparatus of the first order; F is the focal point in which the flame is placed; L, L great annular lenses, forming by their union an octagonal prism, with the lamp in its axis, and projecting in horizontal beams the light which they receive from the focus; L′ L,′ upper lenses, forming by their union a frustum of an octagonal pyramid of 50° of inclination, and having their foci coinciding in the point F. They parallelise the rays of light which pass over the lenses. M, M, plane mirrors, placed above the pyramidal lenses, and so inclined, as to project the beams reflected from them in planes parallel to the horizon; X, X shew the rollers and wheel work which give motion to the lenses; and W is the weight which moves the clock-work of the mechanical lamp H. Plate II. fig. 2, is the plan of the apparatus shewn in fig. 1.

Plate II. fig. 3, shews a section of a fixed dioptric light of the first order. F is the focal point in which the flame is placed; R, R cylindric refractors, forming by their union a prism of thirty-two sides, or a true cylinder, with the lamp in its axis, and producing a zone of light of equal intensity in every point of the horizon; M, M curved mirrors, ranged in tiers above and below the cylindric refractors, and having their foci coinciding in the point F; the effect of the mirrors increases the power of the light, by collecting and transmitting the rays which would otherwise pass above and below them, without increasing the effect of the light; W is the weight which moves the mechanical lamp H. Plate II. fig. 4, is a plan of the fixed apparatus of the first order.

The cylindric form given to the refracting belts of the first order.

Mr. Alan Stevenson having been directed by the Commissioners of the Northern Lighthouses to convert the fixed catoptric light of the Isle of May, into a dioptric light of the first order, proposed, that an attempt should be made to form a true cylindric, instead of a polygonal belt for the refracting part of the apparatus; and this task was successfully completed by Messrs. Cookson of Newcastle. The defect of the polygon lies in the excess of the radius of the circumscribing circle over that of the inscribed circle, which occasions an unequal distribution of light between its angles and the centre of each of its sides; and this fault can only be fully remedied by constructing a cylindric belt, whose generating line is the middle mixtilinear section of an *annular* lens, revolving about its principal focus as a vertical axis. This is, in fact, the only form which can possibly produce an equal diffusion of the incident light over every part of the horizon.

In a report to the Commissioners of the Northern Lights, there is the following description of the refractors constructed for the Isle of May Light. "I at first imagined," says Mr. Alan Stevenson, "that the whole hoop of refractors might be built between two metallic rings, connecting them to each other solely by the means employed in cementing the pieces of the annular lenses; but a little consideration convinced me that this construction would make it necessary to build the zone at the lighthouse itself, and would thus greatly increase the risk of fracture. I was therefore reluctantly induced to divide the whole cylinder into ten arcs, each of which being set in a metallic frame, might be capable of being moved separately. The chance of any error in the figure of the instrument has thus a probability of being confined within narrower limits; whilst the rectification of any defective part becomes at the same time more easy. One other variation from the mode of construction at first contemplated, has been forced upon me by the repeated failures which occurred in attempting to form the middle zone in one piece; and it was at length found necessary to divide this belt by a line passing through the horizontal plane of the focus. This division of the central zone, however, is attended with no appreciable loss of light, as the entire coincidence of the junction of the two pieces with the horizontal plane of the focus, confines the interception of the light to the fine joint at which they are cemented. With the exception of these trifling changes, the idea at first entertained of the construction of this instrument has been realized. An improvement of some importance might also be made upon the arrangement of this apparatus, by giving to the metallic frames which contain the prisms, a rhomboidal,[1] instead of a rectangular form. The junction of the frames being thus inclined from the perpendicular, will not in any azimuth intercept the light throughout the whole height of the refracting belt, but the interception will be confined to a small rhomboidal space, whose area will be inversely proportional to the sine of the angle of inclination; and if the helical joints be formed between the opposite angles of the present rectangular frames, the amount of intercepted light will be absolutely equal in every azimuth."

The change of the light at the Isle of May, from the catoptric to the dioptric system, was generally acknowledged to be an improvement. A committee of the Royal Society of Edinburgh made some observations on the two lights which were exhibited in contrast on the night of the 26th of October 1836, from the town of Dunbar, which is distant about thirteen miles from the lighthouse. Their report, which was drawn up by Professor Forbes, concludes in these words:

"The following conclusions seem to be warranted:

"1. That at a distance of thirteen miles, the mean effect of the new light is very much superior to the mean effect of the old light, (perhaps in the ratio of two to one.)

"2. That at *all* distances, the new light has a prodigious superiority to the old, from the equality of its effects in all azimuths.

"3. That the new light fulfils rigorously the conditions required for the distribution of light to the greatest advantage.

"4. That at distances much exceeding thirteen miles, the new light must still be a very effective one, though to what extent the committee have not observed. The light is understood to be still a good one, when seen from Edinburgh at a distance of about thirty miles."

Orders of the French lights.

The dioptric lights used in France, are divided into four orders, in relation to their power and range; but in regard to their characteristic appearances, this division does not apply, as, in each of the orders, lights of identically the same character may be found, differing only in the distance at which they can be seen, and in the expense of their maintenance. The four orders may be briefly described as follows:—

1*st*. Lights of the first order having an interior radius or focal distance of 36·22 inches, ($92^{\text{cm.}}$) and lighted by a lamp of four concentric wicks, consuming 570[2] gallons of oil per annum.

2*d*. Lights of the second order having an interior radius of 27·55 inches, ($70^{\text{cm.}}$) lighted by a lamp of three concentric wicks, consuming 384 gallons of oil per annum.

3*d*. Lights of the third order, lighted by a lamp of two concentric wicks, consuming 183 gallons of oil per annum. The instruments used in these lights are of two kinds, one having a focal distance of 19·68 inches, ($50^{\text{cm.}}$) and the other of 9·84 inches ($25^{\text{cm.}}$)

4*th*. Lights of the fourth order, or harbour lights, having an internal radius of 5·9 inches (15$^{cm.}$), and lighted by a lamp of one wick, or Argand burner, consuming 48 gallons of oil per annum.

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[1] "The form could not be exactly rhomboidal, but would be a portion of a flat helix intercepted between two planes, cutting the enveloped cylinder at right angles to its axis."

[2] The experience of two at the Isle of May and Inchkeith, shews that the annual expenditure of spermaceti oil, in lights of the first order, does not exceed 570 gallons.

The four orders, as already hinted above, and explained by M. Fresnel in his observations prefixed to the list of the French lights for 1833, are not intended as distinctions; but are characteristic of the power and range of lights, which render them suitable for different localities on the coast, according to the distance at which they can be seen. This division, therefore, is analogous to that which separates our lights into *sea-lights*, *secondary lights*, and *harbour lights*, terms which are used to designate the power and position, and not the appearance of the lights to which they are applied.

Each of the above orders is susceptible of certain combinations, which produce various appearances, and constitute the distinctions used for dioptric lights; but the following are those which have been actually employed as the most useful in practice:—

The first order contains, 1*st.* Lights producing great flashes, preceded by smaller ones, once in every minute, by the revolution of eight great annular, and eight smaller lenses, as at Corduan; 2*d.* Lights flashing once in every half minute, and composed of sixteen half lenses. These lights may have the subsidiary parts simply catoptric, as at Biarritz, or dia-catoptric, as at Planier; and, 3*d.* Fixed lights, composed of a combination of cylindric pieces, with mirrors ranged in tiers above and below them as at the Isle d'Yeu.

The second order comprises revolving lights with sixteen or twelve lenses, which make flashes every half minute; and fixed lights varied by flashes once in every four minutes, as at Pilier, an effect which is produced by the revolution of exterior cylindrical pieces.

The third order (larger diameter) contains common fixed lights, and fixed lights varied by flashes once in every four minutes, as at Aiguesmortes.

The third order, (smaller diameter,) contains fixed lights, varied by flashes once in three minutes, as at Commerce on the Loire, and common fixed lights, as at Aiguillon, Grave, and Dunkerque.

The fourth order has fixed lights varied by flashes once in every three minutes, and fixed lights of the common kind, as at Pertuis-Breton, and La Coubre. It has been thought necessary to change the term "fixed lights varied by flashes," for "fixed light with short eclipses," because it has been found that, at certain distances, a momentary eclipse precedes the flash.

These distinctions depend upon the periods of revolution, rather than upon the *characteristic appearance* of the light; and therefore seem less calculated to strike the eye of a seaman, than those employed on the coasts of Great Britain and Ireland. In conformity with this system, and in consideration of the great loss of light which results from the application of coloured media, all distinctions based upon colour have been discarded in the French lights.

Comparison of dioptric and catoptric lights.

Having thus fully described the nature of the catoptric and dioptric modes of illuminating light-houses, we shall next proceed to compare the merits of both systems, with a view to determine their eligibility in revolving or in fixed lights.

Revolving lights

Repeated experiments were made at Gulan-hill, which is distant from Edinburgh about fifteen miles, during the winters of 1832 and 1833, under the inspection of the Commissioners of Northern Lights, the result of which was, that the light of one of the great annular lenses used in the revolving lights of the first order, was equal to the united effect of about eight of the large reflectors employed in the revolving lights on the Scotch coast. It may be said, however, that the diacatoptric combination of pyramidal lenses and plane mirrors of Corduan, adds the power of more than two reflectors to the effect of the great lens; but it ought to be remembered that in the French lights, this additional power is used only to lengthen the duration of the flash, and therefore in no degree contributes to render the light visible to the mariner at a greater distance. M. Fresnel found from the smaller divergence of the lens, that the eclipses were too long, and the bright periods of the revolution too short; and he therefore determined to adopt the horizontal inclination of 7° for the upper lenses, with a view to remedy this defect. Assuming, therefore, that it were required to increase the number of reflectors in a revolving light of three sides, so as to render it equal in power to a dioptric revolving light of the first order, it would be necessary to place eight reflectors on each face, so that the greatest number of reflectors required for this purpose may be taken at *twenty-four*. M. Fresnel has stated the expenditure of oil in the great lamp of four concentric wicks at 750 grammes of oil of colza per hour; and it is found by experience at the Isle of May and Inchkeith, that the quantity of spermaceti oil consumed by the great lamp, is equal to that burned by fourteen of the Argand lamps used in the Scotch lights. It therefore follows that, by dioptric means, the consumption of oil necessary for fourteen reflectors, will produce a light as powerful as that which would require the oil of twenty-four reflectors in the catoptric system followed on the coast of Scotland; and consequently, that there is an excess of oil equal to that consumed by ten reflectors, or 400 gallons in the year, against the Scotch system. But in order fully to compare the economy of producing two revolving lights of equal power by these two methods, it will be necessary to take into the calculation the interest of the first outlay in establishing them.

The expense of fitting up a revolving light with twenty-four reflectors, ranged on three faces, may be estimated at L.1298, and the annual maintenance at L.418, 8s. 4d. The fitting up a revolving light with eight lenses, and the dia-catoptric accessary apparatus, may be estimated at L.1263, and the annual maintenance at L.280, 10s. 4d. It therefore follows, that to establish, and afterwards maintain a catoptric light, of the kind called *revolving white*, (as that of Start Point in Orkney, where the frame has only three faces,) so as to be equal in power to the dioptric light of Corduan, an annual outlay of L.137. 18s. more would be required for the reflecting light than for the lens light; whilst for a light of the kind called *revolving red and white*, (as the Bell Rock or Cape Wrath, where the frame has four faces,) thirty-six reflectors would be required to make the light equal in power to that of Corduan; and the catoptric light would in this case cost L.333 more than the dioptric light.

Fixed lights.

We shall now speak of fixed lights, to which the dioptric method is peculiarly adapted. The effect produced by the consumption of a gallon of oil in a fixed light, with twenty-six reflectors, like that formerly exhibited at the Isle of May, may be estimated as follows:—The mean intensity of the light spread over the horizontal sector subtended by one reflector, as measured at each degree by the method of shadows, is equal to that of 174 unassisted Argand burners. If, then, this quantity be multiplied by 360 degrees, we shall obtain an aggregate effect of 62640, which, divided by 1040, the number of gallons burned during a year, by twenty-six reflectors, would give *sixty* Argand flames for the intensity of light maintained throughout the year by the combustion of a gallon of oil. On the other hand, the effect of a dioptric light like that lately established at the Isle of May, may be estimated thus. The mean intensity of the light produced by the joint effect of both the dioptric and catoptric parts of a fixed light apparatus, may be valued at 376 Argand flames, which, multiplied by 360 degrees, gives an aggregate of 135360; and if this quantity be divided by 570, the number of gallons burned by the great lamp in a year, we shall have nearly 237 for the intensity of light produced by the combustion of a gallon of oil. It would thus appear that in fixed lights, the French apparatus produces nearly *four times* more light, by the combustion of the same quantity of oil, than can be obtained by the catoptric mode.

But the great superiority of the dioptric method chiefly rests upon its fulfilling *perfectly* the condition required in a fixed light, by distributing a more intense light *equally* in every point of the horizon. In the event of the whole horizon not requiring to be illuminated, the dioptric light would lose a part of its superiority in economy, and when half the horizon only is lighted, it would be more expensive than the reflected light; but the greater power and more equal distribution of the light, may be considered of so great importance, as far to outweigh any difference of expense. In the latter case, too, an additional power might be given to the light, by placing at the landward side of the lightroom, a spherical mirror with its centre in the focus of the dioptric apparatus. The luminous cone of which such a reflector forms the base, instead of passing off uselessly to the land, would thus be thrown back through the focal point, and finally refracted, so as to contribute to the effect of the light seaward.

The expense of establishing a fixed light composed of twenty-six reflectors, may be estimated at L.950, and the annual maintenance at L.425, 10s.; and the expense of fitting up a fixed light on the dioptric principle is L.1058; and the annual maintenance may be taken at L.267, 6s. 4d. It thus appears that the annual expenditure of the dioptric fixed light is L.158, 3s. 8d. less than that of a fixed light composed of twenty-six reflectors; and the light given out is *four times* more powerful, and it is at the same time more equally diffused over the horizon.

The comparative views already given of the catoptric and dioptric modes of illuminating lighthouses, demonstrate that the latter produces more powerful lights by the combustion of the same quantity of oil; while it is obvious that the catoptric system insures a more certain exhibition of the light, from the fountain lamps being less liable to derangement than the mechanical lamps used in dioptric lights. The balance, therefore, of real advantages or disadvantages, and consequently the propriety of finally adopting one or other, involves a mixed question, not susceptible of very absolute solution, and leaving room for different decisions, according to the value which may be set upon obtaining a cheaper and better light, on the one hand, as contrasted with less certainty in its exhibition, on the other. A few general considerations, which may serve briefly to recapitulate the arguments for and against the two systems, may not be out of place. And, first, regarding the fitness of dioptric instruments for revolving lights, it may be observed, that, from the details above given, it appears,

Recapitulation.

Revolving lights.

1*st.* That by placing eight reflectors on each face of a revolving frame, a light may be obtained as brilliant as that derived from the great annular lens; and that in the case of a frame of three sides, the excess of expense by the reflecting mode, would be L.137, 18s.; and in the case of a frame of four sides, the excess would amount to L.333.

2*d.* The diverging property of the lens being less than that of the reflector, it becomes difficult to produce, by lenses, the appearance which characterises catoptric revolving lights, which are already so well known to British mariners; and any change which might affect their appearance, would involve many grave practical objections.

3*d.* The uncertainty of the management of the lamp renders it more difficult to maintain the revolving dioptric lights without fear of extinction, an accident which has several times occurred at Corduan and other French lighthouses.

4*th.* The extinction of one lamp in a revolving catoptric light is not only less probable, but leads to much less serious consequences than the extinction of the single lamp in a dioptric light; because, in the first case, the evil is limited to diminishing the power of *one face* by an *eighth* part; whilst, in the second, the *whole horizon is totally deprived of light.* The extinction of a lamp, therefore, in a dioptric light, leads to evils which may be considered *infinitely great* in comparison with the consequences which attend the same accident in a catoptric light.

Fixed lights.

In comparing the fixed dioptric, and the fixed catoptric apparatus, the results may be ranged under the following heads:

1*st.* It is impossible, by means of any practical combination of parabolic reflectors, to distribute round the horizon a zone of light of exactly *equal intensity;* while this may be easily effected, by dioptric means, in the manner already described. In other words, the qualities required in fixed lights cannot be so *perfectly* obtained by reflectors as by refractors.

2*d.* The light produced by burning one gallon of oil in Argand lamps, with reflectors, has only about *one-fourth* of the intensity of that produced by burning the same quantity in the dioptric apparatus; and the annual expenditure is L.158, 3s. 8d. less for the dioptric than for the catoptric light.

3*d.* The characteristic appearance of the fixed reflecting light would not be changed by the adoption of the dioptric method, although its increased intensity would render it visible at a greater distance.

4*th.* From the equal distribution of the rays, the dioptric light would be observed at equal distances in every point of the horizon; an effect which cannot be fully attained by any practicable combination of parabolic reflectors.

5*th.* The inconveniences arising from the uncertainty which attends the use of the mechanical lamp, are not so much felt in a fixed as in a revolving light, because the less complex nature of the apparatus admits of easier access to it, in case of accident. In those situations, too, where the horizon is not illuminated all round, the mechanical lamp may perhaps be supplanted by a large fountain lamp of four concentric wicks, the use of which would, in a great measure, remove the objection of uncertainty in the exhibition of the light.

6*th.* But the extinction of a lamp in a catoptric light, leaves only one-26th part of the horizon without the benefit of the light, and the chance of accident arising to vessels from it may, therefore, be considered as incalculably less than the danger resulting from the extinction of the single lamp of the dioptric light, which deprives the whole horizon of light.

7*th.* There may also, in certain situations, be some danger arising from the irregularity in the distances at which the same fixed catoptric light may be seen in the different points of the horizon. This defect, of course, does not exist in the dioptric light.

Introduction and progress of Fresnel's system in Britain and other countries.

There can be little doubt, that the more fully the system of Fresnel is understood, the more certainly will it take the place of all other systems of illumination for lighthouses, at least, in those countries where this important branch of administration is conducted with the care and solicitude which it deserves. To the Dutch belongs the honour of having first embraced the system of Fresnel in their lights. The Commissioners of the Northern Lights followed in the train of improvement, and in 1834, sent Mr. Alan Stevenson on a mission to Paris, with full power to take such steps for acquiring a perfect knowledge of the dioptric system, and forming an opinion on its merits, as he should find necessary. The singular liberality with which he was received by M. Léonor Fresnel, brother of the late illustrious inventor of the system, and his successor as the Secretary of the Lighthouse Commission of France, afforded Mr. A. Stevenson the means of making such a report on his return, as induced the Commissioners to authorise him to remove the reflecting apparatus of the revolving light at Inchkeith, and substitute dioptric instruments in its place. This change was completed, and the light exhibited on the evening of 1st October 1835, and so great was the satisfaction which the change produced, that the Commissioners immediately instructed Mr. Stevenson to make a similar change at the fixed light of the Isle of May, where the new light was exhibited on the 22d September 1836. The Trinity House of London followed next in adopting the improved system, and employed Mr. A. Stevenson to superintend the construction of a revolving dioptric light of the first order, which was afterwards erected at the Start Point in Devonshire. Other countries begin to shew symptoms of interest in this important change; and America, it is believed, is likely soon to adopt active measures for the improvement of her lighthouses. Fresnel, who is already classed with the greatest of those inventive minds which extend the boundaries of human knowledge, will thus, at the same time, receive a place amongst those benefactors of the species who have consecrated their genius to the common good of mankind; and, wherever maritime intercourse prevails, the solid advantages which his labours have procured, will be felt and acknowledged.

Fuel of lighthouses.

The fuel commonly adopted in the best lighthouses of Great Britain, is spermaceti oil, which is obtained from the South Sea whale, *(Physeter macrocephalus)*; and in France the oil generally burned is expressed from the seed of a species of wild cabbage, *(Brassica oleracea colza)*, and is called *huile de colza*. It appears from some experiments made by M. Léonor Fresnel at Paris, in which he compared the intensity of the light produced by the combustion of equal parts of this oil and the spermaceti oil used in England, of which specimens had been sent to him by the Trinity House of London, that there is but little difference. This conclusion differs somewhat from the result of the trials at the Isle of May and Inchkeith, where flames of similar dimensions to those produced from the colza oil are obtained by the combustion of nearly one-fourth less spermaceti oil. In the lights on the shores of the Mediterranean, olive oil is chiefly used; but the light obtained from it is feeble compared with that of spermaceti or colza oil.

Gas.

In a few lighthouses which are near towns, the gas of pit coal has been used; and there are certain advantages, more especially in dioptric lights, where there is only one large central flame, which would render the use of gas desirable. The form of the flame, which is an object of considerable importance, would thus be rendered less variable, and could be more easily regulated, and the inconvenience of the clock-work of the lamp would be wholly avoided. But it is obvious, that gas is by no means suitable for the majority of lighthouses, their distant situation and generally difficult access, rendering the transport of large quantities of coal expensive and uncertain; whilst in many of them there is no means of erecting the apparatus necessary for manufacturing gas. There are other considerations which must induce us to pause before adopting gas as the fuel of lighthouses; for, however much the risk of accident may be diminished in the present day, it still forms a question, which ought not to be hastily decided, how far we should be justified in running even the most remote risk of explosion in establishments such as lighthouses, whose sudden failure might involve consequences of the most fatal description, and whose situation is often such, that their re-establishment must be a work of great expense and time. Gas is, besides, far from being suitable in catoptric lights, to which, where the frame is moveable, as in revolving lights, it could not be applied.

Drummond and Voltaic lights

The application of the Drummond and Voltaic lights to lighthouse purposes is, owing to their prodigious intensity, a very desirable consummation; but it is surrounded by so many practical difficulties, that it may safely, in the present state of our knowledge, be pronounced unattainable. The uncertainty which attends the exhibition of both these lights, is of itself a sufficient reason for coming to this conclusion. But other reasons unhappily are not wanting. The smallness of the flame renders those lights wholly inapplicable to dioptric instruments, which require a great body of flame in order to produce a degree of divergence sufficient to render the duration of the flash in revolving lights long enough to answer the purpose of the mariner. M. Fresnel made some experiments on the application of the Drummond light to dioptric instruments, which completely demonstrate their unfitness for this combination. He found that the light obtained by placing it in the focus of a great annular lens, was much more intense than that produced by the great lamp and lens of Corduan; but the divergence did not exceed 30′; so that, in a revolution like that of Corduan, the flashes would last only $1\frac{1}{3}$ second, and would not, therefore, be seen in such a manner as to suit the practical purposes of a revolving light. The great cylindric refractor used in fixed lights of the first order, was also tried with the Drummond light in its focus; but it gave coloured spectra at the top and bottom, and only a small bar of white light was transmitted from the centre of the instrument. The same deficiency of divergence completely unfits the combination of the Drummond light with the reflector for the purposes of a fixed light, and even if this cause did not operate against its application in revolving lights on the catoptric plan, the supply of the gases, which is attended with almost insurmountable difficulties, would, in any case, render the maintenance of the light precarious and uncertain in the last degree.

Mr. Gurney's lamp.

In 1835, Mr. Gurney proposed the combination of streams of oxygen with the flame of oil or wax, in order to obtain a powerful light of sufficient size to produce the divergence required for the illumination of lighthouses. The Trinity House of London entertained the proposal, and have since been engaged in making experiments on this important subject; and their efforts, it is believed, have been attended with a measure of success which holds out a reasonable prospect of this lamp being finally used in lighthouses. In applying this light to reflectors, it is intended to use three small flames, each about three-eighths of an inch in diameter, which produce, it is said, an effect equal to that of ten common Argand lamps. The burner intended for lenses has seventeen films of flame, and is said to possess six times the power of the Fresnel lamp. The light is considered cheaper than that which is obtained by the combustion of oil in atmospheric air.

We shall conclude by a brief account of the lights of various countries, and the mode of management that is adopted, so far as we have the means of speaking with certainty on this subject.

Trinity House of London.

The lights on the coast of England are under the management of the Corporation of Trinity House of Deptford Strond. Before the reign of Henry VIII., the Trinity House appears to have been merely a fraternity of seamen, and it was not till the sixth year of Henry's reign that it was incorporated by royal charter. Elizabeth afterwards granted the Trinity House certain privileges of ballastage, beaconage, and buoyage, and empowered them to erect and preserve "beacons and signs for the sea." It does not appear, however, that this body specially undertook the erection of lighthouses, till about the year 1676. Before that time it was common to grant letters patent in favour of the proprietors of the lands adjoining the site of a lighthouse, empowering them to erect a lighthouse, and to levy certain duties on shipping for its maintenance. In some cases the patentee was bound to pay an annual sum to the Trinity House towards the support of their charities; but in other cases, he was quite independent. The Trinity House have, in numerous instances, entered into new arrangements with the lessees at the expiry of their leases; but it is now the practice of this board to erect and maintain lighthouses on the coast, without the intervention of any arrangement of the nature of a lease; and the result, as might be expected, has been very favourable to the interests of the public. The lights, which were formerly maintained by lessees, whose interests, in some cases, led them to adopt every saving, without regard to the efficiency of the light, are now maintained in a manner worthy of the country to which they belong. This condemnation of the manner in which the lessees of some of the lights discharged their obligations, by no means applies indiscriminately to all of them; for there were several honourable exceptions. In 1834, the court of the corporation of Trinity House consisted of one master, four wardens, eight assistants, and eighteen elder brothers. Of these, eleven are in the honorary line of the brotherhood, and twenty-one are chosen from the merchant service. There are also younger brothers, whose number is unlimited, and who are elected by the elder brothers. The elder brothers are self-elected from the list of younger brothers. The business is managed by seven committees, who separately superintend the treasury and accounts, the examination of and granting certificates to masters in the navy and pilots, the supervision of ballastage in the Thames, the lighthouses, the collection of the dues, the pensioners and the management of the house affairs. In each of these committees a majority constitutes a quorum.

The rate of dues chargeable by the Trinity House before the passing of the last act in 1836, varied from 1-6th of a penny to one penny per ton on each light passed; and it appears from the Parliamentary Report of 1834, that in 1832, the nett amount of revenue was L.77,371, and the expense of maintaining the lights was L.36,904, leaving a surplus of L.40,467. This surplus is partly expended in the extensive charities which are distributed by the Corporation, to the annual amount of L.35,000, and partly in the erection of new lighthouses, and the maintenance of the general establishment.

Lights of England.

The public lights in England, including Heligoland, are 71 in number, and may be arranged in the following classes:—

1st, Those belonging to, and under the management of, the corporation of the Trinity House of Deptford Strond, in number............	55 lights.
2d, Those in the charge of individuals, under lease from the Trinity House, and having different periods to run, viz. the Longships, Smalls, and Mumbles, in number..................................	3 „
3d, Those let by the crown to individuals for a period of years, on leases renewed since 1822, viz. Harwich, 2; Dungeness, 1; Wintertonness and Oxfordness, 3; and Hunstanton Cliff, 1; in number..	7 „
4th, Lights held originally under patents, subsequently sanctioned by acts of Parliament, and now in the hands of proprietors, viz. the Spurn, Tynemouth Castle and Skerries, in number......	4 „
5th, One light at Heligoland.......................	1 „
6th, One floating light at Benbridge Lodge...	1 „
Total number of public general lights in England,....................................	71 „

Lights of Scotland.

The lights in Scotland may be divided into public and local or harbour lights. The public lights are under the management of a board denominated "Commissioners of Northern Lights." The Board was incorporated in 1786, by the 38th Geo. III. c. 58, and the Commissioners hold their office at the board by virtue of the public situations they fill. The Act of the 26th Geo. III. c. 101, gives authority to erect lighthouses and to collect duties.

The commissioners, twenty-five in number, are the Lord Advocate and the Solicitor-General for Scotland; the provosts of Edinburgh, Glasgow, Aberdeen, Inverness, and Campbeltown; the first bailies of Edinburgh and Glasgow; the sheriffs of the counties of Edinburgh, Lanark, Renfrew, Bute, Argyll, Inverness, Ross, Orkney, Caithness, Aberdeen, Ayr, Fife, Forfar, Wigton, Sutherland, and Kincardine, which are maritime counties or shires. The services of the commissioners are entirely gratuitous; there are two or three general meetings annually, and the general business is conducted by committees, whose meetings take place as occasion requires. A committee of the board was appointed at the time the Bell-Rock lighthouse was erected, which has been continued ever since, and to which all general business is referred; special committees have also been appointed for particular objects, as for accounts, stores, experiments on lenses, light-duties, visitation of lighthouses, special repairs and new works; and there is besides a sub-committee on each lighthouse. No public lights on the Scotch coast are in the hands of private individuals; and all the light-dues collected from the general shipping in Scotland, are received by the Commissioners of Northern Lighthouses, for public use. In the year 1641, a patent for the erection of a private light in the island of May, was ratified in the Scottish Parliament; and this is supposed to have been the earliest sea-light on the shores of Scotland. In 1814, the Commissioners purchased the Island from the Duke of Portland for L.60,000, and erected a new lighthouse there. There are now 25 land-lights under the charge of the Commissioners, for which light-dues are levied from the shipping generally; and there are 28 local or harbour lights under the management of trustees and corporations, maintained by dues levied on the trade of the respective ports where the lights are situated, and on vessels resorting to them. Some of these lights are established by act of Parliament, as those of Cumbrae, Clough, and Toward, under the 29th of Geo. III. c. 20. Others, as those of Leith and Dundee, are secured, by ancient charters, to the fraternities of the ports; and others, as those of Montrose and Arbroath, were erected and are maintained, by the ship-owners and merchants of the ports.

Before the passing of the Act 6th and 7th of William IV. there was no separate charge for each of the lights under the management of the Commissioners of the Northern Lights; but each vessel paid a fixed sum according to the limits within which she came. The rates were as follows:—For every British ship or decked vessel sailing within the limits of the light of the island of May, viz. between the Castle of Dunnottar on the north, and St. Abb's Head on the south, 2½d. per ton; and for foreign vessels sailing within these limits, 5d. per ton. For every British ship or decked vessel liable to dues without these limits, 2d. per ton; and for foreign vessels, 4d. per ton. Vessels sailing to or from any place between Holyhead and Howth Head, both inclusive, on the north, paid ¼d. per ton for each of the three lights in the Isle and Calf of Man; and foreign ships ½d. per ton; but if they had paid the other northern duties, they were exempted from the charge for these lights. The rates were levied on the registered tonnage of all vessels passing any of the lighthouses, whether loaded or in ballast, outwards or homewards bound, on a foreign voyage, or sailing coastways; and it appears from the Parliamentary Report of 1834, that the revenue of the Commissioners was L.36,283. Since the passing of the act 6th and 7th of William IV. cap. 79, in 1836, however, the rates of the duties, and the mode of levying them, have been completely altered, and in some degree assimilated to the system pursued by the Trinity House, so that a certain duty is now paid for every light that is passed.

Lights of Ireland.

The lights of Ireland have had frequent changes in regard to superintendance, and they were finally placed under "The Corporation for Preserving and Improving the Port of Dublin," by the act 50th Geo. III. c. 35. The powers of the corporation, which is generally named the Ballast Board, have received various alterations by subsequent acts. It consists of 23 members, viz. the lord mayor and sheriffs of Dublin, three aldermen chosen by the board of aldermen from their own body, and 17 members appointed in the first instance by the act of incorporation, and who are on all future vacancies empowered to elect new members. The board devotes one day a-week to the business of the lighthouses.

There are thirty-six land lights, and three floating lights, supported by the Ballast board in Ireland. Of these land lights, twenty-six are public lights, and ten are local or harbour lights. There are besides five other harbour lights on the coast, supported by the trustees of the respective harbours.

It appears from the Parliamentary Report of 1834, that the revenue derived from collection of lighthouse dues in Ireland during the year 1833, was L.42,060 The mode of charging the light dues was formerly as follows:—Any British or Irish vessel and foreign privileged vessels on oversea voyages, paid one farthing per ton for every light they passed in the track of their voyage; foreign ships not privileged paid one halfpenny per ton. Coasters, loaded, paid one farthing per ton for every lighthouse or floating light they passed; if in ballast, one eighth of a penny only per ton; and rules were laid down as to the number of lights to be paid for by vessels navigating St. George's Channel, to or from the Atlantic Ocean; as well as for passing through the northern channel bound to the northward, and returning; for going down St. George's Channel, to the eastward; and for sailing from a western port of Ireland to the eastward, without entering St. George's Channel.

New act of 6th and 7th William IV. cap. 79.

The last act of Parliament regarding lighthouses, was the result of a report of a select committee on lighthouses, which was moved for by Mr. Joseph Hume, M.P. and which sat in 1834. The act was passed in 1836. The chief alterations upon the former state of the Boards in which the management of the lights is vested, are the following. The duties levied under all former acts were repealed; and it was enacted, that every British vessel, and every privileged foreign vessel, should pay the toll of one halfpenny, for every time of passing or deriving advantage from any light, with exception of the Bell-rock, for which one penny per ton is the toll. Every foreign vessel not privileged, must pay double toll. The only exemptions from the payment of duties, are in favour of the King's vessels, those of the Trinity House, and all vessels going in ballast, or engaged in the herring fisheries. Power was also given to the Commissioners of the Northern Lighthouses, to erect beacons, and moor buoys; and the harbour lights on the Scotch coast were placed under their controul. The Act confers upon the Trinity House, the power of entering any lighthouse under the charge of the other boards, to inspect their condition, and gives them a controul as to the erection of new lighthouses, or the alteration of those already existing, both in Scotland and Ireland. But in the event of a difference of opinion arising between the Trinity House and either of the two other Boards, appeal may be made to the Privy Council. The Act further provides that an account of the receipt of all money, and a report of all alterations made during the preceding year, should be annually laid before each House of Parliament, one month after its meeting.

Expense of lights of Great Britain.

The average expense of maintaining a land light in Great Britain, is found to be about L.500, and that of a floating light about L.1200.

French lights.

The French lights, of which there are upwards of 100, including about 60 harbour lights, are managed by a particular section of the *Direction Génerale des Ponts et Chaussées*, which is called the *Commission des Phares;* and more than half of the lights are on the dioptric principle of Fresnel.

By an imperial decree of 7th March 1806, the lighthouses and beacons were placed under the charge of the Minister of the Interior; before which time they had been under the immediate direction of the Administration of Roads and Bridges. This decree required that the establishment of every new beacon or light, should proceed upon the joint recommendation of the Ministers of the Marine and the Interior, and gave rise, in 1811, to the institution of the *Commission des Phares*, the members of which, with the exception of the secretary, who is also engineer-in-chief, act without any special remuneration, and in consequence of their holding other official situations. At the time of its first constitution, it appears by the report of Admiral de Rossel, that this Commission consisted of the following gentlemen, viz. Baron Becquey, councillor of state, director-general of roads and bridges, President of the Commission; M. Halgan, rear-admiral, and councillor of state; M. De Prony, inspector-general of roads and bridges; M. Arago, astronomer-royal, member of the Institute; M. Sganzin, inspector-general of roads and bridges; M. Rolland, inspector-general of naval works; M. Tarbe De Vauxclairs, inspector-general of roads and bridges; M. Mathieu, member of the Institute; and M. Augustin Fresnel, member of the Institute, secretary and engineer-in-chief to the Commission.

All the more important plans for the improvement and establishment of lights, are submitted to this Commission; but the plans for new lighthouse towers are only discussed in reference to their fitness for the lights; and every question regarding the buildings or estimates, is submitted to the General Council of the Administration of Roads and Bridges, for their final approbation. The Engineer of the Commission prepares all the plans, and directs the fitting up of the optical apparatus and the lanterns, and sends to the engineers of the departments, the schemes for new lights, that they may make the plans for the necessary buildings connected with them. He also inspects the lights on the coast, and is responsible for their efficient condition. In the discharge of these duties, he is assisted by three *conducteurs* of works, who generally see the apparatus fitted up, and attend to the due performance of the light-room duty.

As soon as a new light is ready, the Administration causes advertisements to be made in the most extensively circulated journals of Paris, containing a notice to mariners regarding its position, appearance, and time of exhibition. This notice is also circulated in every French port by means of placards, which are affixed by the maritime authorities, and generally appear about three months before the exhibition of the light. By a late decree, too, of the Director-general of roads and bridges, the Engineer publishes every year a summary description of all the lights on the coast of France.

Other European lights.

The other lights of Europe are, with the exceptions already mentioned, on the catoptric principle. The writer of this article has seen the greater number of the lights along the coast, between St. Petersburgh and the Spanish frontier; and so far as he has been able to learn, their management is generally vested in some department of the executive government.

American lights.

The Americans have been very active in the establishment of lighthouses. There are upwards of two hundred land lights along the coast of the United States, and twenty-eight floating lights. Their management is entrusted to a board called the General Lighthouse Establishment, which appears to have been regularly organised so early as the year 1791. The total expenditure connected with the Lighthouse Establishment in the year 1837, was about L.71,352; a sum which includes about L.7000 for the maintenance of upwards of 600 buoys and beacons, which are also under the care of the Lighthouse Establishment. The Fifth Auditor of the Treasury is the chief officer of the lighthouse board.

The apparatus is on the catoptric principle; but the reflectors, which are illuminated by means of Argand lamps, are of polished tin-plate, and of small dimensions. The light is from spermaceti oil, the produce of the American South Sea fishery; but experiments have lately been made upon oil produced from cotton-seed; and there is some probability that this oil will be universally employed in the lighthouses of America.

General questions regarding lighthouses.

Distinction and distribution of lights.

There are many questions of much interest regarding Lighthouses, which appear to open an extensive field of inquiry; and it may be doubted whether some of them have received that degree of consideration to which their importance entitles them. Amongst these we may rank the numerous questions which may be raised regarding the most effective kind of distinctions for lights. Those distinctions may be naturally expected to be the most effective which strike an observer by their *appearance* alone. Thus a red and white light, a revolving and a fixed light, offer *appearances* which are calculated to produce upon the observer a stronger sense of their difference, than the same observer would receive from lights whose sole difference lies in their revolutions being performed in greater or less intervals of time. On the other hand, the distinctions derived from time, if the intervals on which they depend do not approach too closely to each other, appear to afford very suitable means for characterising lights; and the number of distinctions which may be founded upon time alone are pretty numerous. Coloured media have the great disadvantage of absorbing light, and the only colour which has hitherto been found useful in practice is red, all others, at even moderate distances, serving merely to enfeeble without characterising lights. In the system of Fresnel, as already explained, all the distinctions are based upon time alone. Mr. Robert Stevenson, the engineer of the Northern Lighthouses, has invented two distinctions, which, although they are produced by variations of the time, possess characteristic *appearances*, sufficiently marked to enable an observer to distinguish a light without counting time. The one is called a *flashing* light, in which the flashes and eclipses succeed each other so rapidly, as to give the appearance of a succession of brilliant scintillations; and the other has been called *intermittent*, from its consisting of a fixed light, which is suddenly and totally eclipsed, and again as suddenly revealed to view. The effect of this light is entirely different from that of any revolving light, both from the great inequality of the intervals of light and darkness, and also from the contrast which is produced by its sudden disappearance and reappearance, which is completely different from the gradual diminution and increase of the light in revolving lights, more especially in those on the catoptric principle. The great and still increasing number of lights renders the means of distinguishing them one of the most important considerations connected with lighthouses.

Arrangement of lights on the coast

Not less important, and very nearly allied to the subject of distinction, is that of the arrangement of lights on a line of coast. The choice of the most suitable places and the assigning to each the characteristic appearances which are most likely to distinguish it from all the neighbouring lights, are points requiring much consideration; and it ought never to be forgotten, that the indiscriminate erection of lighthouses soon leads to confusion and that the needless exhibition of a light, by involving the loss of a distinction, may afterwards prove inconvenient in the case of some future light, which time and the growing wants of trade, may call for on the same line of coast. To enter at length upon this topic, or even to lay down the general principles which ought to regulate the distribution of lights, would exceed the limits of this article; but in connection with this it may be observed, that the superintendance of lighthouses should be committed to one general body, and ought not to be left to local trusts, whose operations are too often conducted on narrow principles, without reference to general interests. The inconveniences arising from interference between the distinctions of the lights under one trust, and those of the lights under another, are thereby avoided; and the full advantage is obtained of the means of distinction at the disposal of both.

Height of tower.

Another important general inquiry, is that regarding the most advantageous height for lighthouses; but this subject is so extensive, and embraces the consideration of so many circumstances, that we can only glance at the chief elements of the question. The distance at which lights should be seen, depends very much upon their position in relation to the dangers of the coast; those which are outposts beyond the danger, require a less extensive range than those which, from unavoidable causes, are situated landward of the dangers which they are intended to point out. Upon this circumstance chiefly depends the height to which a lighthouse tower should be carried; but in many climates, the fogs by which the upper and lower regions of the atmosphere are obscured, introduce elements into the question, which, it is to be feared, must baffle all general rules.

The following works may be consulted on the subject of lighthouses: Smeaton's Narrative of the Eddystone Lighthouse. Lond. 1793. Stevenson's Account of the Bell-Rock Lighthouse. Edinburgh, 1824. Belidor, Architecture Hydraulique, vol. iv. p. 151. Peclet, Traité de l'éclairage. Paris, 1827. Fresnel's Memoire sur un Nouveau Système d'éclairage des Phares. Paris, 1822. Admiral de Rossel's Rapport, contenant l'exposition du système adopté par la Commission des Phares pour éclairer les côtes de France. Paris, 1825. Treatise on Burning Instruments, containing the method of building large polyzonal lenses. By David Brewster, LL.D. F.R.S. Edin. 1812. Fanale di Salvore, nell' Istria, illuminato a gaz. Vienna, 1821. On Construction of Polyzonal Lenses and Mirrors of Great Magnitude, for Lighthouses and for Burning Instruments, and on the Formation of a Great National Burning Apparatus. By David Brewster, LL.D. F.R.S. *(Edin. Phil. Jour.* 1823. vol. viii. p. 160.) Account of a New System of Illumination for Lighthouses. By David Brewster, LL.D. F.R.S. Edin. 1827. Saggio di Osservazione, or Observations on the Means of Improving the Construction of Lighthouses; with an Appendix, on the Application of Gas to Lighthouses. By the Chevalier G. Aldini. Milan, 1823. Bordier Marcet's Notice descriptif d'un fanal à double aspect, &c. Paris, 1823. Bordier Marcet's Parabole Soumise à l'art, ou Essai sur la catoptrique de l'éclairage. Paris, 1819. L. Fresnel's Description Sommaire des Phares et Fanaux allumés sur les côtes de France, au 1$^{\text{er}}$. d'Août. 1837. Stevenson's British Pharos. Leith, 1831. The Lighthouses of the British Islands, corrected to July 1836, from the Hydrographical Office of the Admirality. Lond. 1836. Instructions pour le service des Phares Lenticulaires. par L. Fresnel. Paris, 1836. The Lighthouses, Floating Lights, and Beacons of the United States in 1838; prepared by order of Stephen Pleasonton, fifth auditor of the Treasury, and acting commissioner of the revenue. Washington, 1838. Captain Leontey Spafarieff's New Guide for the Navigation of the Gulf of Finland. St. Petersburg, 1813. Coulier's Guide des Marins. Paris, 1825. Stevenson's Sketch of Civil Engineering in America. London, 1838, p. 296. Report of Select Committee of the House of Commons on Lighthouses. 1834. Report by a Committee of the Board to the Commissioners of the Northern Lighthouses, on the Report of the Select Committee. 1836. Report to the Commissioners of the Northern Lighthouses, on the Illumination of Lighthouses, by Alan Stevenson, M.A. Edin. 1834. Report to the same Board on the Inchkeith Dioptric Light, by Alan Stevenson. Edin. 1835. Report on the Isle of May dioptric Light, by Alan Stevenson. 1836. Report on the Isle of May Light, by a Committee of the Royal Society, (Professor Forbes, reporter.) Edin. 1836.

(B. I.)

Sea-Plants are those vegetables that grow in salt-water, within the shores of the sea. The old botanists divided these into three classes. The first class, according to their arrangement, contained the *algæ*, the *fuci*, the *sea-mosses* or *confervas*, and the different species of sponges. The second contained substances of a hard texture, like stone or horn, which seem to have been of the same nature with what we call *zoophyta*, with this difference, that we refer sponges to this class, and not to the first. The third class is the same with our *lithophyta*, comprehending corals, madrepores, &c. It is now well known that the genera belonging to the second and third of these classes, and even some referred to the first, are not vegetables, but animals, or the productions of animals. Sea-plants, then, properly speaking, belong to the class of cryptogamia, and the order of algæ; and, according to Bomare, are all comprehended under the genus fucus. We may also add several species of the ulva and conferva, and the sargazo. The fuci and marine ulvæ are immersed in the sea, are sessile, and without root. The marine confervæ are either sessile or floating. The sargazo grows beyond soundings.

Sea-Serpent, a monstrous creature, said to inhabit the northern seas, about Greenland and the coasts of Norway. "In 1756," says Guthrie, "one of them was shot by a master of a ship. Its head resembled that of a horse; the mouth was large and black, as were the eyes, a white mane hanging from its neck. It floated on the surface of the water, and held its head at least two feet out of the sea. Between the head and neck were seven or eight folds, which were very thick; and the length of this snake was more than a hundred yards, some say fathoms. They have a remarkable aversion to the smell of castor; for which reason, ship, boat, and bark masters provide themselves with quantities of that drug, to prevent being overset, the serpent's olfactory nerves being remarkably exquisite. The particularities related of this animal would be incredible, were they not attested upon oath. Egede, a very reputable author, says, that on the 6th of July 1734, a large and frightful sea-monster raised itself so high out of the water, that its head reached above the main-top-mast of the ship; that it had a long sharp snout, broad paws, and spouted water like a whale; that the body seemed to be covered with scales; the skin was uneven and wrinkled, and the lower part was formed like a snake. The body of this monster is said to be as thick as a hogshead; his skin is variegated like a tortoise-shell; and his excrement, which floats upon the surface of the water, is corrosive." No man of sound judgment, however, would think these recitals sufficient to establish the existence of such monsters.

Sea-Sickness, a disorder incident to most persons on their first going to sea, and occasioned by the agitation of the vessel. This disorder has not been much treated of, although it is very irksome and distressing to the patient during its continuance. It appears to be a spasmodic affection of the stomach, occasioned by the alternate pressure and recession of its contents against its lower internal surface, according as the rise and fall of the ship oppose the action of gravity.

Many methods of preventing, or at least mitigating, this disorder, have been recommended, of which the most efficacious appear to be the following: Not to go on board immediately after eating, and not to eat, when on board, any large quantity at a time; to lie down the moment the symptoms are felt, and to remain in the horizontal position till they are removed; to keep much upon deck, even when the weather is stormy, as the sea-breeze is not so apt to affect the stomach as the impure air of the cabin, rendered so for want of proper circulation; and not to watch the motion of the waves, particularly when strongly agitated with tempest.

Sea-Weed, or *Alga marina*, is commonly used as a manure on the sea-coast, where it can be procured in abundance. The best sort grows on rocks, and is that from which kelp is made. The next to this is called the *peasy sea-weed;* and the worst is that with a long stalk.

SEADOWLY, a port of Northern Hindustan, in the territories of the Nepaul rajah district of Mocwanpoor. To this port the British forces penetrated in 1767, and took it; but were obliged to retreat, from the pestilential effects of the climate.

SEAFORD, a town on the sea-shore, in the hundred of Flexborough and rape of Pewensey, in the county of Sussex, sixty-three miles from London. It was in former times much more extensive than it is at present. It is now a mere fishing and bathing place. It is a corporate town, with a bailiff and twelve jurats, and returned two members to the House of Commons till the year 1832. The population amounted in 1821 to 1047, and in 1831 to 1098.

SEAL, a stone, piece of metal, or other matter, usually either round or oval, on which are engraven the arms or device of some prince, state, community, magistrate, or private person, often with a legend or inscription.

The use of seals, as a mark of authenticity to letters and other instruments in writing, is extremely ancient. We read of it among the Jews and Persians in the earliest and most sacred records of history; and in the book of Jeremiah there is a very remarkable instance, not only of attestation by seal, but also of the other usual formalities attending a Jewish purchase. In the civil law, also, seals were the evidences of truth, and were required, on the part of the witnesses at least, at the attestation of every testament. But in the times of our Saxon ancestors they were not much in use in England; for though Sir Edward Coke relies on an instance of King Edwyn's making use of a seal about a hundred years before the Conquest, yet it does not follow that this was the usage among the whole nation; and perhaps the charter he mentions may be of doubtful authority, from this very circumstance of its being sealed, since we are assured by all our ancient historians that sealing was not then in common use. The method of the Saxons was, for such as could write to subscribe their names, and, whether they could write or not, to affix the sign of the cross; which custom our illiterate vulgar for the most part observe, by signing a cross for their mark when unable to write their names. And indeed this inability to write, and therefore making a cross in its stead, is honestly avowed by Cædwalla, a Saxon king, at the end of one of his charters. In like manner, and for the same insurmountable reason, the Normans, a brave but illiterate nation, at their first settlement in France used the practice of sealing only, without writing their names; and this custom continued when learning made its way among them, though the reason for doing it had ceased; and hence the charter of Edward the Confessor, to Westminster Abbey, himself being brought up in Normandy, was witnessed only by his seal, and is generally thought to be the oldest sealed charter of any authenticity in England. At the Conquest the Norman lords brought over into this kingdom their own fashions, and introduced waxen seals only, instead of the English method of writing their names, and signing with the sign of the cross. The impressions of these seals were sometimes a knight on horseback, sometimes other devices; but coats of arms were not introduced into seals, nor indeed used at all, till about the reign of Richard I. who, it is said by some, brought them from the crusade in the Holy Land, where they were first invented and painted on the shields of the knights, to distinguish the variety of persons of every Christian nation who resorted thither.

This neglect of signing, and resting only upon the authenticity of seals, remained in Scotland till the year 1540, when a statute was enacted ordering subscription for the purpose of authenticating deeds and writs.

SEAMANSHIP.[1]

Definition.

By this word we express that noble art, or, more properly, the qualifications which enable a man to exercise the noble art of working a ship. A SEAMAN, in the language of the profession, is not merely a mariner or labourer on board a ship, but a man who understands the structure of this wonderful machine, and every subordinate part of its mechanism, so as to enable him to employ it to the best advantage for pushing her forward in a particular direction, and for avoiding the numberless dangers to which she is exposed by the violence of the winds and waves. He also knows what courses can be held by the ship, according to the wind that blows, and what cannot, and which of these is most conducive to her progress in her intended voyage; and he must be able to perform every part of the necessary operation with his own hands. As the seamen express it, he must be able "to hand, reef, and steer."

Importance and difficulty of the art;

We are justified in calling it a *noble art*, not only by its importance, which it is quite needless to amplify or embellish, but by its immense extent and difficulty, and the prodigious number and variety of principles on which it is founded, all of which must be possessed in such a manner that they shall offer themselves without reflection in an instant, otherwise the pretended seaman is but a lubber, and cannot be trusted on his watch.

The art is practised by persons without what we call *education*, and in the humbler walks of life, and therefore it suffers in the estimation of the careless spectator. It is thought little of, because little attention is paid to it. But if multiplicity, variety, and intricacy of principles, and a systematic knowledge of these principles, entitle any art to the appellation of *scientific* and *liberal*, seamanship claims these epithets in an eminent degree. We are amused with the pedantry of the seaman, which appears in his whole language. Indeed it is the only pedantry that amuses. A scholar, a soldier, a lawyer, nay, even the elegant courtier, would disgust us, were he to make the thousandth part of the allusions to his profession that is well received from the jolly seaman; and we do the seaman no more than justice. His profession *must* engross his whole mind, otherwise he can never learn it. He possesses a prodigious deal of knowledge; but the honest tar cannot tell what he knows, or rather what he feels, for his science is really at his finger ends. We can say with confidence, that if a person of education, versed in mechanics, and acquainted with the structure of a ship, were to observe with attention the movements which are made on board a first or second rate ship of war during a shifting storm, under the direction of an intelligent officer, he would be rapt in admiration.

What a pity it is that an art so important, so difficult, and so intimately connected with the invariable laws of mechanical nature, should be so held by its possessors, that it cannot improve, but must die with each individual. Having no advantages of previous education, they cannot arrange their thoughts; they can hardly be said to think. They can far less express or communicate to others the intuitive knowledge which they possess; and their art, acquired by habit alone, is little different from an instinct. We are as little entitled to expect improvement here as in the architecture of the bee or the beaver. The species (pardon the the allusion, ye generous hearts of oak!) cannot improve. Yet a ship is a machine. We know the forces which act on it, and we know the results of its construction; all these are as fixed as the laws of motion. What hinders this to be reduced to a set of practical maxims, as well founded and as logically deduced as the working of a steam-engine or a cotton mill. The stoker or the spinner acts only with his hands, and may "whistle as he works, for want of thought;" but the mechanist, the engineer, thinks for him, improves his machine, and directs him to a better practice. May not the rough seaman look for the same assistance; and may not the ingenious speculist in his closet unravel the intricate thread of mechanism which connects all the manual operations with the unchangeable laws of nature, and both furnish the seaman with a better machine, and direct him to a more dexterous use of it.

which has been zealously cultivated by the French philosophers.

We cannot help thinking that much may be done; nay, we may say that much has been done. We think highly of the progressive labours of Renaud, Pitot, Bouguer, Du Hamel, Groignard, Bernoulli, Euler, Romme, and others; and are both surprised and sorry that Britain has contributed so little in these attempts. Gordon is the only one of our countrymen who has given a professedly scientific treatise on a small branch of the subject. The government of France has always been strongly impressed with the notion of great improvements being attainable by systematic study of this art; and we are indebted to the endeavours of that ingenious nation for any thing of practical importance that has been obtained. M. Bouguer was professor of hydrology at one of the marine academies of France, and was enjoined, as part of his duty, to compose dissertations both on the construction and the working of ships. His *Traité du Navire*, and his *Manœuvre des Vaisseaux*, are undoubtedly very valuable performances. So are those of Euler and Bernoulli, considered as mathematical dissertations, and they are wonderful works of genius, considered as the productions of persons who hardly ever saw a ship, and were totally unacquainted with the profession of a seaman. In this respect Bouguer had great superiority, having always lived at a sea-port, and having made many very long voyages. His treatises, therefore, are infinitely better accommodated to the demands of the seaman, and more directly instructive; but still the author is more a mathematician than an artist, and his performance is intelligible only to mathematicians. It is true, the academical education of the young gentlemen of the French navy is such, that a great number of them may acquire the preparatory knowledge that is necessary; and we are well informed that, in this respect, the officers of the British navy are greatly inferior to them.

Argument against the utility of their performances;

But this very circumstance has furnished to many persons an argument against the utility of those performances. It is said, that "notwithstanding this superior mathematical education, and the possession of those boasted performances of M. Bouguer, the French are greatly inferior, in point of seamanship, to our countrymen, who have not a page in their language to instruct them, and who could not peruse it if they had." Nay, so little do the French themselves seem sensible of the advantage of these publications, that no person among them has attempted to make a familiar abridgment of them, written in a way fitted to attract attention; and they still remain neglected in their original abstruse and uninteresting form.

We wish that we could give a satisfactory answer to this observation. It is just, and it is important. These very ingenious and learned dissertations are by no means so useful as we should expect. They are large books, and appear to contain much; and as their plan is logical, it seems to occupy the whole subject, and therefore to have done almost all that can be done. But, alas! they have only opened the subject, and the study is yet in its infancy. The whole science of the art must proceed on the knowledge of the impulsions of the wind and water. These are the forces which act on the machine; and its motions, which are the ultimatum of our research, whether as an end to be obtained or as a thing to be prevented, must depend on these forces. Now it is with respect to this fundamental point that we are as yet almost totally in the dark. And in the performances of M. Bouguer, as also in those of the other authors we have named, the theory of these forces, by which their quantity and the direction of their action are ascertained, is altogether erroneous; and its results deviate so enormously from what is observed in the motions of a ship, that the persons who should direct the operations on shipboard, in conformity to the maxims deducible from M. Bouguer's propositions, would be baffled in most of his attempts, and be in danger of losing the ship. The whole proceeds on the supposed truth of that theory which states the impulse of a fluid to be in the proportion of the square of the sine of the angle of incidence; and that its action on any small portion, such as a square foot of the sails or hull, is the same as if that portion were detached from the rest, and were exposed, single and alone, to the wind or water in the same angle. But we have shewn, in the article RESISTANCE OF FLUIDS, both from theory and experience, that both of these principles are erroneous, and this to a very great degree, in cases which occur most frequently in practice, that is, in the small angles of inclination. When the wind falls nearly perpendicular on the sails, theory is not very erroneous; but in these cases, the circumstances of the ship's situation are generally such that the practice is easy, occurring almost without thought; and in this case too, even considerable deviations from the very best practice are of no great moment. The interesting cases, where the intended movement requires or depends upon very oblique actions of the wind on the sails, and its practicability or impracticability depends on a very small variation of this obliquity; a mistake of the force, either as to intensity or direction, produces a mighty effect on the resulting motion. This is the case in sailing to windward, the most important of all the general problems of seamanship. The trim of the sails, and the course of the ship, so as to gain most on the wind, are very nice things; that is, they are confined within very narrow limits, and a small mistake produces a very considerable effect. The same thing obtains in many of the nice problems of tacking, box-hauling, wearing after lying-to in a storm, &c.

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[1] The references in this article are all made to articles written by Professor Robison, and which are reprinted in the present edition.

which are confessedly erroneous in their fundamental principles;

The error in the second assertion of the theory is still greater, and the action on one part of the sail or hull is so greatly modified by its action on another adjoining part, that a stay-sail is often seen hanging like a loose rag, although there is nothing between it and the wind; and this merely because a great sail in its neighbourhood sends off a lateral stream of wind, which completely hinders the wind from getting at it. Till the theory of the action of fluids be established, therefore, we cannot tell what are the forces which are acting on every point of the sail and hull; therefore we cannot tell either the mean intensity or direction of the whole force which acts on any particular sail, nor the intensity and mean direction of the resistance to the hull; circumstances absolutely necessary for enabling us to say what will be their energy in producing a rotation round any particular axis. In like manner, we cannot, by such a computation, find the spontaneous axis of conversion, (see ROTATION), or the velocity of such conversion. In short, we cannot pronounce with tolerable confidence *a priori* what will be the motions in any case, or what dispositions of the sails will produce the movement we wish to perform. The experienced seaman learns by habit the general effects of every disposition of the sails; and though his knowledge is far from being accurate, it seldom leads him into any very blundering operation. Perhaps he seldom makes the best adjustment possible, but seldomer still does he deviate very far from it; and in the most general and important problems, such as working to windward, the result of much experience and many corrections has settled a trim of the sails, which is certainly not far from the truth, but, it must be acknowledged, deviates widely and uniformly from the theories of the mathematician's closet. The honest tar, therefore, must be indulged in his joke on the useless labours of the mathematician, who can neither hand, reef, nor steer.

After this account of the theoretical performances in the art of seamanship, and what we have said in another place on the small hopes we entertain of seeing a perfect theory of the impulse of fluids, it will not be expected that we enter very minutely on the subject in this place; nor is it our intention. But let it be observed that the theory is defective in one point only; and although this is a most important point, and the errors in it destroy the conclusions of the chief propositions, the reasonings remain in full force, and the *modus operandi* is precisely such as is stated in the theory. The *principles* of the art are therefore to be found in these treatises; but false inferences have been drawn, by computing from erroneous quantities. The rules and the practice of the computation, however, are still beyond controversy. Nay, since the process of investigation is legitimate, we may make use of it in order to discover the very circumstance in which we are at present mistaken; for by converting the proposition, instead of finding the motions by means of the supposed forces, combined with the known mechanism, we may discover the forces by means of this mechanism and the observed motions.

though use may be made of them.

Design of this article.

We shall therefore in this place give a very general view of the movements of a ship under sail, showing how they are produced and modified by the action of the wind on her sails, the water on her rudder and on her bows. We shall not attempt a precise determination of any of these movements; but we shall say enough to enable the curious landsman to understand how this mighty machine is managed amidst the fury of the winds and waves; and, what is more to our wish, we hope to enable the uninstructed but thinking seaman, to generalise that knowledge which he possesses; to class his ideas, and give them a sort of rational system; and even to improve his practice, by making him sensible of the immediate operation of every thing he does, and in what manner it contributes to produce the movement which he has in view.

A ship considered as in free space, impelled and resisted by opposite forces.

A ship may be considered at present as a mass of inert matter in free space, at liberty to move in every direction, according to the forces which impel or resist her; and when she is in actual motion, in the direction of her course, we may still consider her as at rest in absolute space, but exposed to the impulse of a current of water moving equally fast in the opposite direction; for in both cases the pressure of the water on her bows is the same; and we know that it is possible, and frequently happens in currents, that the impulse of the wind on her sails, and that of the water on her bows, balance each other so precisely, that she not only does not stir from the place, but also remains steadily in the same position, with her head directed to the same point of the compass. This state of things is easily conceived by any person accustomed to consider mechanical subjects, and every seaman of experience has observed it. It is of importance to consider it in this point of view, because it gives us the most familiar notion of the manner in which these forces of the wind and water are set in opposition, and made to balance or not to balance each other by the intervention of the ship, in the same manner as the goods and the weights balance each other in the scales by the intervention of a beam or steelyard.

Impulse of the wind on th sails opposite to that of the water on the bows.

When a ship proceeds steadily in her course, without changing her rate of sailing, or varying the direction of her head, we must in the first place conceive the accumulated impulses of the wind on all her sails as precisely equal and directly opposite to the impulse of the water on her bows. In the next place, because the ship does not change the direction of her keel, she resembles the balanced steelyard, in which the energies of the two weights, which tend to produce rotations in opposite directions, and thus to change the position of the beam, mutually balance each other round the fulcrum; so the energies of the actions of the wind on the different sails balance the energies of the water on the different parts of the hull.

Skill of the seaman displayed in shaping his course.

The seaman has two principal tasks to perform. The first is to keep the ship steadily in that course which will bring her farthest on in the line of her intended voyage. This is frequently very different from that line, and the choice of the best course is sometimes a matter of considerable difficulty. It is sometimes possible to shape the course precisely along the line of the voyage; and yet the intelligent seaman knows that he will arrive sooner, or with greater safety, at his port, by taking a different course; because he will gain more by increasing his speed than he loses by increasing the distance. Some principle must direct him in the selection of this course. This we must attempt to lay before the reader.

Having chosen such a course as he thinks most advantageous, he must set such a quantity of sail as the strength of the wind will allow him to carry with safety and effect, and must trim the sails properly, or so adjust their positions to the direction of the wind, that they may have the greatest possible tendency to impel the ship in the line of her course, and to keep her steadily in that direction.

His other task is to produce any deviations which he sees proper from the present course of the ship; and to produce these in the most certain, the safest, and the most expeditious manner. It is chiefly in this movement that the mechanical nature of a ship comes into view, and it is here that the superior address and resources of an expert seaman is to be perceived.

Under the article Sailing, some notice has been taken of the first task of the seaman, and it was there shown how a ship, after having taken up her anchor and fitted her sails, accelerates her motion, by degrees which continually diminish, till the increasing resistance of the water becomes precisely equal to the diminished impulse of the wind, and then the motion continues uniformly the same, so long as the wind continues to blow with the same force, and in the same direction.

It is perfectly consonant to experience, that the impulse of fluids is in the duplicate ratio of the relative velocity. Let it be supposed that when water moves one foot per second, its perpendicular pressure or impulse on a square foot is m pounds. Then, if it be moving with the velocity V estimated in feet per second, its perpendicular impulse on a surface S, containing any number of square feet, must be $m\,SV^2$.

In like manner, the impulse of air on the same surface may be represented by $n\,SV^2$; and the proportion of the impulse of these two fluids will be that of m to n. We may express this by the ratio of q to 1, making $\frac{m}{n}=q$.

Impulse of the water computed in ounces on the square foot.

M. Bouguer's computations and tables are on the supposition that the impulse of sea-water moving one foot per second is twenty-three ounces on a square foot, and that the impulse of the wind is the same when it blows at the rate of twenty-four feet per second. These measures are all French. They by no means agree with the experiments of others; and what we have already said, when treating of the Resistance of Fluids, is enough to show us that nothing like precise measures can be expected. It was shown, as the result of a rational investigation, and confirmed by the experiments of Buat and others, that the impulsions and resistances at the same surface, with the same obliquity of incidence, and the same velocity of motion, are different according to the form and situation of the adjoining parts. Thus the total resistance of a thin board is greater than that of a long prism, having this board for its front or bow, &c.

We are greatly at a loss what to give as absolute measures of these impulsions.

1. With respect to water. The experiments of the French academy on a prism two feet broad and deep, and four feet long, indicate a resistance of 0·973 pounds avoirdupois to a square foot, moving with the velocity of one foot per second at the surface of still water.

Mr. Buat's experiments on a square foot wholly immersed in a stream, were as follow:

A square foot as a thin plate................	1·81	pounds
Ditto as the front of a box one foot long..	1·42	...
Ditto as the front of a box three feet long.	1·29	...

The resistance of sea water is about $\frac{1}{23}$ greater.

2. With respect to air the varieties are as great. The resistance of a square foot to air moving with the velocity of one foot per second, appears from Mr. Robins's experiments on sixteen square inches to be, on a square

foot...	0·001596	pounds.
Chevalier Borda's on sixteen inches	0·001757	...
.... on eighty-one inches	0·002042	...
Mr. Rouse's on large surfaces.........	0·002291	...

Precise measures are not to be expected, nor are they necessary in this inquiry. Here we are chiefly interested in their proportions, as they may be varied by their mode of action in the different circumstances of obliquity and velocity.

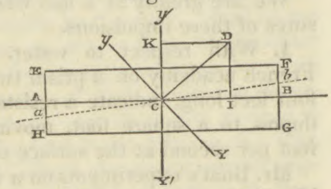
Direct impulse on the sail perpendicular to the yard.

We begin by recurring to the fundamental proposition concerning the impulse of fluids, viz. that the absolute pressure is always in a direction perpendicular to the impelled surface, whatever may be the direction of the stream of fluid. We must therefore illustrate the doctrine, by always supposing a flat surface of sail stretched on a yard, which can be braced about in any direction, and giving this sail such a position and such an extent of surface, that the impulse on it may be the same, both as to direction and intensity, with that on the real sails. Thus the consideration is greatly simplified. The direction of the impulse is therefore perpendicular to the yard. Its intensity depends on the velocity with which the wind meets the sail, and the obliquity of its stroke. We shall adopt the constructions founded on the common doctrine, that the impulse is as the square of the sine of the inclination, because they are simple; whereas, if we were to introduce the values of the oblique impulses, such as they have been observed in the excellent experiments of the Academy of Paris, the constructions would be complicated in the extreme, and we could hardly draw any consequences which would be intelligible to any but expert mathematicians. The conclusions will be erroneous, not in kind but in quantity only; and we shall point out the necessary corrections, so that the final results will be found not very different from real observation.

A ship compared to an oblong box.

If a ship were a round cylindrical body like a flat tub, floating on its bottom, and fitted with a mast and sail in the centre, she would always sail in a direction perpendicular to the yard. This is evident. But she is an oblong body, and may be compared to a chest, whose length greatly exceeds its breadth. She is so shaped, that a moderate force will push her through the water with the head or stern foremost; but it requires a very great force to push her sideways with the same velocity. A fine sailing ship or war will require about twelve times as much force to push her sideways as to push her head foremost. In this respect, therefore, she will very much resemble a chest whose length is twelve times its breadth; and whatever be the proportion of these resistances in different ships, we may always substitute a box which shall have the same resistances headways and sideways.

Fig. 1.



Makes lee way when not sailing directly before the wind.

Let EFGH (fig. 1.) be the horizontal section of such a box, and AB its middle line, and C its centre. In whatever direction this box may chance to move, the direction of the whole resistance on its two sides will pass through C. For as the whole stream has one inclination to the side EF, the equivalent of the equal impulses on every part will be in a line perpendicular to the middle of EF. For the same reason, it will be in a line perpendicular to the middle of FG. These perpendiculars must cross in C. Suppose a mast erected at C, and YC*y* to be a yard hoisted on it carrying a sail. Let the yard be first conceived as braced right athwart at right angles to the keel, as represented by Y′*y*′. Then, whatever be the direction of the wind abaft this sail, it will impel the vessel in the direction CB. But if the sail has the oblique position Y*y*, the impulse will be in the direction CD perpendicular to CY, and will both push the vessel ahead and sideways: For the impulse CD is equivalent to the two impulses CK and CI (the sides of a rectangle of which CD is the diagonal). The force CI pushes the vessel ahead, and CK pushes her sideways. She must therefore take some intermediate direction *ab*, such that the resistance of the water to the plane FG is to its resistance to the plane EF as CI to CK.

The angle *b*CB between the real course and the direction of the head is called the leeway; and in the course of this dissertation we shall express it by the symbol *x*. It evidently depends on the shape of the vessel and on the position of the yard. An accurate knowledge of the quantity of leeway, corresponding to different circumstances of obliquity of impulse, extent of surface, &c. is of the utmost importance in the practice of navigation; and even an approximation is valuable. The subject is so very difficult that this must content us for the present.

Let V be the velocity of the ship in the direction C*b*, and let the surfaces FG and FE be called A′ and B′. Then the resistance to the lateral motion is $m\mathrm{V}^2\times\mathrm{B}'\times\text{sine}^2, b\mathrm{CB}$, and that to the direct motion is $m\mathrm{V}^2\times\mathrm{A}'\times\text{sine}^2, b\mathrm{CK}$, or $m\mathrm{V}^2\times\mathrm{A}'\times\cos^2 b\mathrm{CB}$. Therefore these resistances are in the proportion of $\mathrm{B}'\times\text{sine}^2, x$ to $\mathrm{A}'\times\cos.^2, x$ (representing the angle of leeway *b*CB by the symbol *x*).

Therefore we have CI : CK, or $\mathrm{CI}:\mathrm{ID}=\mathrm{A}'\cdot\cos.^2 x:\mathrm{B}'\cdot\text{sine}^2 x, =\mathrm{A}':\mathrm{B}'\cdot\dfrac{\text{sine}^2 x}{\cos.^2 x}=\mathrm{A}':\mathrm{B}'\cdot\text{tangent}^2 x$.

How to find the quantity of leeway

Let the angle YCB, to which the yard is braced up, be called the trim of the sails, and expressed by the symbol *b*. This is the complement of the angle DCI. Now $\mathrm{CI}:\mathrm{ID}=\text{rad.}:\tan.\ \mathrm{DCI}, =1:\tan.\ \mathrm{DCI}, =1:\text{cotan.}\ b$. Therefore we have finally $1:\text{cotan.}\ b=\mathrm{A}':\mathrm{B}'\cdot\tan.^2 x$, and $\mathrm{A}'\cdot\text{cotan.}\ b=\mathrm{B}'\cdot\text{tangent}^2 x$, and $\tan.^2 x=\dfrac{\mathrm{A}'}{\mathrm{B}'}\cot.\ b$. This equation evidently ascertains the mutual relation between the trim of the sails and the leeway, in every case where we can tell the proportion between the resistances to the direct and broadside motions of the ship, and where this proportion does not change by the obliquity of the course. Thus, suppose the yard braced up to an angle of 30° with the keel. Then $\text{cotan.}\ 30°=1{\cdot}732$ very nearly. Suppose also that the resistance sideways is twelve times greater than the resistance headways. This gives $\mathrm{A}=1$ and $\mathrm{B}'=12$. Therefore $1{\cdot}732=12\times\text{tangent}^2 x$, and $\text{tangent}^2 x=\dfrac{1{\cdot}732}{12}, =0{\cdot}14434$, and $\tan.\ x=0{\cdot}3799$, and $x=20°\ 48'$, very nearly two points of leeway.

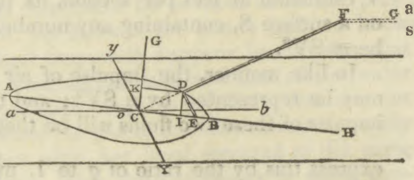
This computation, or rather the equation which gives room for it, supposes the resistances proportional to the squares of the sines of incidence. The experiments of the Academy of Paris, of which an abstract is given in the article Resistance of Fluids, show that this supposition is not far from the truth when the angle of incidence is great. In the present case the angle of incidence on the front FG is about 70°, and the experiments just now mentioned, show that the real resistances exceed the theoretical ones only $\frac{1}{180}$. But the angle of incidence on EF is only 20° 48′. Experiment shows that in this inclination the resistance is almost quadruple of the theoretical resistances. Therefore the lateral resistance is assumed much too small in the present instance. Therefore a much smaller leeway will suffice for producing a lateral resistance which will balance the lateral impulse CK, arising from the obliquity of the sail, viz. 30°. The matter of fact is, that a pretty good sailing ship, with her sails braced to this angle at a medium, will not make above five or six degrees leeway in smooth water and easy weather; and yet in this situation the hull and rigging present a very great surface to the wind, in the most improper positions, so as to have a very great effect in increasing her leeway. And if we compute the resistances for this leeway of six degrees by the actual experiments of the French Academy on the angle, we shall find the result not far from the truth; that is, the direct and lateral resistances will be nearly in the proportion of CI to ID.

which depends on trim of the sails.

It results from this view of the matter, that the leeway is in general much smaller than what the usual theory assigns. We also see, that according to whatever law the resistances change by a change of inclination, the leeway remains the same while the trim of the sails is the same. The leeway depends only on the direction of the impulse of the wind; and this depends solely on the position of the sails with respect to the keel, whatever may be the direction of the wind. This is a very important observation, and will be frequently referred to in the progress of the present investigation. Note, however, that we are here considering only the action on the sails, and on the same sails. We are not considering the action of the wind on the hull and rigging. This may be very considerable; and it is always in a lee direction, and augments the leeway; and its influence must be so much the more sensible, as it bears a greater proportion to the impulse on the sails. A ship under courses, or close-reefed topsails and courses, must make more leeway than when under all her canvass, trimmed to the same angle. But to introduce this additional cause of deviation here, would render the investigation too complicated to be of any use.

Illustration of this doctrine by experiments on models and on ships.

Fig. 2.

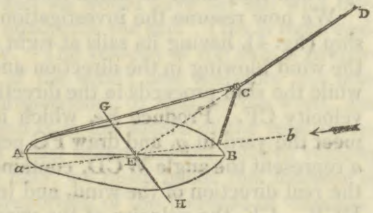


This doctrine will be considerably illustrated by attending to the manner in which a lighter is tracked along a canal, or swings to its anchor in a stream. The track-rope is made fast to some staple or bolt E on the deck (fig. 2), and is passed between two of the timber-heads of the bow D, and laid hold of at F on shore. The men or cattle walk along the path FG, the rope keeps extended in the direction DF, and the lighter arranges itself in an oblique position AB, and is thus dragged along in the direction *ab*, parallel to the side of the canal. Or, if the canal has a current in the opposite direction *ba*, the lighter may be kept steady in its place by the rope DF made fast to a post at F. In this case, it is always observed, that the lighter swings in a position AB, which is oblique to the stream *ab*. Now, the force which retains it in this position, and which precisely balances the action of the stream, is certainly exerted in the direction DF; and the lighter would be held in the same manner if the rope were made fast at C amidship, without any dependence on the timberheads at D; and it would be held in the same position, if, instead of the single rope CF, it were riding by two ropes CG and CH, of which CH is in a direction right ahead, but oblique to the stream, and the other CG is perpendicular to CH or AB. And, drawing DI and DK perpendicular to AB and CG, the strain on the rope CH is to that on the rope CG as CI to CK. The action of the rope in these cases is precisely analogous to that of the sail *y*Y; and the obliquity of the keel to the direction of the motion, or to the direction of the stream, is analogous to the leeway. All this must be evident to any person accustomed to mechanical disquisitions.

A most important use may be made of this illustration. If an accurate model be made of a ship, and if it be placed in a stream of water, and ridden in this manner by a rope made fast at any point D of the bow, it will arrange itself in some determined position AB. There will be a certain obliquity to the stream, measured by the angle B*ob;* and there will be a corresponding obliquity of the rope, measured by the angle FCB. Let *y*CY be perpendicular to CF. Then CY will be the position of the yard, or trim of the sails corresponding to the leeway *b*CB. Then, if we shift the rope to a point of the bow distant from D by a small quantity, we shall obtain a new position of the ship, both with respect to the stream and rope; and in this way may be obtained the relation between the position of the sails and the leeway, independent of all theory, and susceptible of great accuracy; and this may be done with a variety of models suited to the most usual forms of ships.

In further thinking on this subject, we are persuaded that these experiments, instead of being made on models, may with equal ease be made on a ship of any size. Let the ship ride in a stream at a mooring D (fig. 3), by means of a short hawser BCD from her bow, having a spring AC on it carried out from her quarter. She will swing to her moorings, till she ranges herself in a certain position AB with respect to the direction *ba* of the stream; and the direction of the hawser DC will point to some point E of the line of the keel. Now, it is plain to any person acquainted with mechanical disquisitions, that the deviation BE*b* is precisely the leeway that the ship will make when the average position of the sails is that of the line GEH perpendicular to ED; at least this will give the leeway which is produced by the sails alone. By heaving on the spring, the knot C may be brought into any other position we please; and for every new position of the knot the ship will take a new position with respect to the stream and to the hawser. And we persist in saying, that more information will be got by this train of experiments than from any mathematical theory: for all the theories of the impulses of fluids must proceed on physical postulates with respect to the motions of the filaments, which are exceedingly conjectural.

Fig. 3.



The comparison of a ship to an oblong body is only useful to give clear notions on the subject.

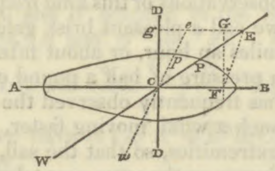
And it must now be farther observed, that the substitution which we have made of an oblong parallelopiped for a ship, although well suited to give us clear notions of the subject, is of small use in practice; for it is next to impossible (even granting the theory of oblique impulsions) to make this substitution. A ship is of a form which is not reducible to equations; and therefore the action of the water on her bow or broadside can only be had by a most laborious and intricate calculation for almost every square foot of its surface.[1] And this must be different for every ship. But, which is more unlucky, when we have got a parallelopiped which will have the same proportion of direct and lateral resistance for a particular angle of leeway, it will not answer for another leeway of the same ship; for when the leeway changes, the figure actually exposed to the action of the water changes also. When the leeway is increased, more of the lee-quarter is acted on by the water, and a part of the weather-bow is now removed from its action. Another parallelopiped must therefore be discovered, whose resistances shall suit this new position of the keel with respect to the real course of the ship.

We therefore beg leave to recommend this train of experiments to the notice of the Association for the Improvement of Naval Architecture, as a very promising method for ascertaining this important point.[2] And we proceed, in the next place, to ascertain the relation between the velocity of the ship and that of the wind, modified as they may be by the trim of the sails and the obliquity of the impulse.

The relation between the velocity of the ship and wind ascertained.

Let AB (figs. 4, 5, and 6), represent the horizontal section of a ship. In place of all the drawing sails, that is, the sails which are really filled, we can always substitute one sail of equal extent, trimmed to the same angle with the keel. This being supposed attached to the yard DCD, let this yard be first of all at right angles to the keel, as represented in fig. 4. Let the wind blow in the direction WC, and let CE (in the direction WC continued) represent the velocity V of the wind. Let CF be the velocity *v* of the ship. It must also be in the direction of the ship's motion, because when the sail is at right angles to the keel, the absolute impulse on the sail is in the direction of the keel, and there is no lateral impulse, and consequently no leeway. Draw EF, and complete the parallelogram CFE*e*, producing *e*C through the centre of the yard to *w*. Then *w*C will be the relative or apparent direction of the wind, and C*e* or FE will be its apparent or relative velocity. For if the line C*e* be carried along CF, keeping always parallel to its first position, and if a particle of air move uniformly along CE (a fixed line in absolute space) in the same time, this particle will always be found in that point of CE, where it is intersected at that instant by the moving line C*e;* so that if C*e* were a tube, the particle of air, which

Fig. 4.



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[1] Bezout's *Cours de Mathem.* vol. v. p. 72, &c.

[2] This society was instituted on the 14th of April 1791, in consequence of the patriotic and energetic endeavours of Mr. J. Sewell, a bookseller of Cornhill, who was proprietor of the European Magazine, the covers of which periodical be had for a long time previous to this date, gratuitously devoted to the reception of communications for the improvement of naval architecture. The society consisted of about one hundred and fifty noblemen and gentlemen, and numbered among its members some of the most distinguished men in the kingdom. His late Majesty was the president. The Earls Stanhope, Leicester, and Uxbridge, Lords Radnor and Mulgrave, Sir John Borlase Warren, Sir Joseph Banks, and Sir Charles Middleton, were vice-presidents. Unfortunately its energies were expended in the futile examination of plans, to the neglect of the more sure course for the improvement of an infant science—the investigation of principles. The consequence was, that dissatisfied at the absence of all useful results from their labours, the members gradually ceased to take an interest in them, and the society fell to pieces, without, we believe, any formal dissolution. Had the members adopted the suggestions of Professor Robison, and their energies and resources been directed by his talents and experience, how different might have been the result!

really moves in the line CE, would always be found in the tube Ce. While CE is the real direction of the wind, Ce will be the position of the vane at the mast head, which will therefore mark the apparent direction of the wind, or its motion relative to the moving ship.

We may conceive this in another way. Suppose a cannon-shot fired in the direction CE at the passing ship, and that it passes through the mast at C with the velocity of the wind. It will not pass through the off-side of the ship at P, in the line CE; for while the shot moves from C to P, the point P has gone forward, and the point p is now in the place where P was when the shot passed through the mast. The shot will therefore pass through the ship's side in the point p, and a person on board seeing it pass through C and p will say that its motion was in the line Cp.

When a ship is in motion the apparent direction of the wind is always different from the real direction.

Thus it happens, that when a ship is in motion the apparent direction of the wind is always ahead of its real direction. The line wC is always found within the angle WCB. It is easy to see from the construction, that the difference between the real and apparent directions of the wind is so much the more remarkable as the velocity of the ship is greater. For the angle WCw or ECe depends on the magnitude of Ee or CF, in proportion to CE. Persons not much accustomed to attend to these matters are apt to think all attention to this difference to be nothing but affectation of nicety. They have no notion that the velocity of a ship can have any sensible proportion to that of the wind. "Swift as the wind," is a proverbial expression; yet the velocity of a ship always bears a very sensible proportion to that of the wind, and even very frequently exceeds it. We may form a pretty exact notion of the velocity of the wind by observing the shadows of the summer clouds flying along the face of a country, and it may be very well measured by this method. The motion of such clouds cannot be very different from that of the air below; and when the pressure of the wind on a flat surface, while blowing with a velocity measured in this way, is compared with its pressure when its velocity is measured by more unexceptionable methods, they are found to agree with all desirable accuracy. Now observations of this kind frequently repeated, show that what we call a pleasant brisk gale blows at the rate of about ten miles an hour, or about fifteen feet in a second, and exerts a pressure of half a pound on a square foot. Mr. Smeaton has frequently observed the sails of a windmill, driven by such a wind, moving faster, nay much faster, towards their extremities, so that the sail, instead of being pressed to the frames on the arms, was taken aback, and fluttering on them. Nay, we know that a good ship, with all her sails set, and the wind on the beam, will in such a situation sail above ten knots an hour in smooth water. There is an observation made by every experienced seaman, which shows this difference between the real and apparent directions of the wind very distinctly. When a ship that is sailing briskly with the wind on the beam tacks about, and then sails equally well on the other tack, the wind always appears to have shifted and come more ahead. This is familiar to all seamen. The seaman judges of the direction of the wind by the position of the ship's vanes. Suppose the ship sailing due west on the starboard tack, with the wind apparently N.N.W., the vane pointing S.S.E. If the ship put about, and stands due east on the larboard tack, the vane will be found no longer to point S.S.E., but perhaps S.S.W., the wind appearing N.N.E., and the ship must be nearly close-hauled in order to make an east course. The wind appears to have shifted four points. If the ship tacks again, the wind returns to its old quarter. We have often observed a greater difference than this. The celebrated astronomer Dr. Bradley, taking the amusement of sailing in a pinnace on the river Thames, observed this, and was surprised at it, imagining that the change of the wind was owing to the approaching to or retiring from the shore. The boatmen told him that it always happened at sea, and explained it to him in the best manner they were able. The explanation struck him, and set him a musing on an astronomical phenomenon which he had been puzzled by for some years, and which he called the aberration of the fixed stars. Every star changes its place a small matter for half a year, and returns to it at the completion of the year. He compared the stream of light from the star to the wind, and the telescope of the astronomer to the ship's vane, while the earth was like the ship, moving in opposite directions when in the opposite point of its orbit. The telescope must always be pointed ahead of the real direction of the star, in the same manner as the vane is always in a direction ahead of the wind; and thus he ascertained the progressive motion of light, and discovered the proportion of its velocity to the velocity of the earth in its orbit, by observing the deviation which was necessarily given to the telescope. Observing that the light shifted its direction about 40″, he concluded its velocity to be about 11,000 times greater than that of the earth; just as the intelligent seaman would conclude from this apparent shifting of the wind, that the velocity of the wind is about triple that of the ship. This is indeed the best method for discovering the velocity of the wind. Let the direction of the vane at the mast-head be very accurately noticed on both tacks, and let the velocity of the ship be also accurately measured. The angle between the directions of the ship's head on these different tacks being halved, will give the real direction of the wind, which must be compared with the position of the vane in order to determine the angle contained between the real and apparent directions of the wind or the angle ECe; or half of the observed shifting of the wind will show the inclination of its true and apparent directions. This being found, the proportion of EC to FC (fig. 6), is easily measured.

Observation of Dr. Bradley on this subject.

We have been very particular on this point, because since the mutual actions of bodies depend on their relative motions only, we should make prodigious mistakes if we estimated the action of the wind by its real direction and velocity, when they differ so much from the relative or apparent.

Velocity of a ship when its sails are at right angles to the keel.

We now resume the investigation of the velocity of the ship (fig. 4), having its sails at right angles to the keel, and the wind blowing in the direction and with the velocity CE, while the ship proceeds in the direction of the keel with the velocity CF. Produce Ee, which is parallel to BC, till it meet the yard in g, and draw FG perpendicular to Eg. Let a represent the angle WCD, contained between the sail and the real direction of the wind, and let b be the angle of trim DCB. CE, the velocity of the wind, was expressed by V, and CF, the velocity of the ship, by v.

The absolute impulse on the sail is (by the usual theory) proportional to the square of the relative velocity, and to the square of the sine of the angle of incidence; that is, to $\text{FE}^2 \times \sin.^2 w\text{CD}$. Now the angle $\text{GFE} = w\text{CD}$, and EG is equal to $\text{FE} \times \sin.\,\text{GFE}$; and EG is equal to $\text{E}g - g\text{G}$. But $\text{E}g = \text{EC} \times \sin.\,\text{EC}g, = \text{V} \times \sin.\,a$; and $g\text{G} = \text{CF}, = v$. Therefore $\text{EG} = \text{V} \times \sin.\,a - v$, and the impulse is proportional to $(\text{V} \times \sin.\,a - v)^2$. If S represent the surface of the sail, the impulse, in pounds, will be $n\text{S}(\text{V} \times \sin.\,a - v)^2$.

Let A be the surface which, when it meets the water perpendicularly with the velocity v, will sustain the same pressure or resistance which the bows of the ship actually meet with. This impulse, in pounds, will be $m\text{A}v^2$. Therefore, because we are considering the ship's motion as in a state of uniformity, the two pressures balance each other; and therefore $m\text{A}v^2 = n\text{S}(\text{V} \times \sin.\,a - v)^2$ and $\frac{m}{n}\text{A}v^2 = \text{S}(\text{V} \times \sin.\,a - v)^2$;

therefore $\sqrt{\frac{m}{n}}\sqrt{\text{A}} \times v = \sqrt{\text{S}} \times \text{V} \times \sin.\,a - v\sqrt{\text{S}}$, and $v =$

$$\frac{\sqrt{\text{S}} \times \text{V} \times \sin.\,a}{\sqrt{\frac{m}{n}\text{A}} + \sqrt{\text{S}}} = \frac{\text{V} \times \sin.\,a}{\sqrt{\frac{m\text{A}}{n\text{S}}} + 1} = \frac{\text{V} \times \sin.\,a}{\sqrt{q\frac{\text{A}}{\text{S}}} + 1}.$$

We see, in the first place, that the velocity of the ship is, *cæteris paribus*, proportional to the velocity of the wind, and to the sine of its incidence on the sail jointly; for while the surface of the sail S and the equivalent surface for the bow remains the same, v increases or diminishes at the same rate with $V \cdot \sin. a$. When the wind is right astern, the sine of a is unity, and then the ship's velocity is $\dfrac{V}{\sqrt{\dfrac{mA}{nS}}+1}$.

Note, that the denominator of this fraction is a common number; for m and n are numbers and A and S being quantities of one kind, $\dfrac{A}{S}$ is also a number.

It must also be carefully attended to, that S expresses a quantity of sail actually receiving wind with the inclination a. It will not always be true, therefore, that the velocity will increase as the wind is more abaft, because some sails will then becalm others. This observation is not, however, of great importance; for it is very unusual to put a ship in the situation considered hitherto; that is, with the yards square, unless she be right before the wind.

If we should discover the relation between the velocity and the quantity of sail in this simple case of the wind right aft, observe that the equation $v = \dfrac{V}{\sqrt{\dfrac{mA}{nS}}+1}$, gives us $\sqrt{\dfrac{mA}{nS}}\,v + v = V$, and $\sqrt{\dfrac{mA}{nS}}\,v = V - v$, and $\dfrac{mA}{nS}\,v^2 = \overline{V-v}^2$, and $\dfrac{nS}{mA} = \dfrac{v^2}{(V-v)^2}$; and because n and m and A are constant quantities, S is proportional to $\dfrac{v^2}{(V-v)^2}$, or the surface of sail is proportional to the square of the ship's velocity directly, and to the square of the relative velocity inversely. Thus, if a ship be sailing with one-eighth of the velocity of the wind, and we would have her sail with one-fourth of it, we must quadruple the sail. This is more easily seen in another way. The velocity of the ship is proportional to the velocity of the wind; and therefore the relative velocity is also proportional to that of the wind, and the impulse of the wind is as the square of the relative velocity. Therefore, in order to increase the relative velocity by an increase of sail only, we must make this increase of sail in the duplicate proportion of the increase of velocity.

Let us, in the next place, consider the motion of a ship whose sails stand oblique to the keel.

Its velocity when the sails stand oblique to the keel.

The construction for this purpose differs a little from the former, because, when the sails are trimmed to any oblique position DCB, (figs. 5 and 6), there must be a deviation from the direction of the keel, or a leeway B*Cb*. Call this x. Let CF be the velocity of the ship. Draw, as before, Eg perpendicular to the yard, and FG perpendicular to Eg; also, draw FH perpendicular to the yard: then, as before, EG, which is in the subduplicate ratio of the impulse on the sail, is equal to Eg—Gg. Now Eg is, as before, $= V \times \sin. a$, and Gg is equal to FH, which is $= CF \times \sin. FCH$, or $= v \times \sin. (b+x)$. Therefore we have the impulse $= nS(V \cdot \sin. a - v \cdot \sin. (b+x))^2$.

This expression of the impulse is perfectly similar to that in the former case, its only difference consisting in the subductive part, which is here $v \times \sin. \overline{b+x}$ instead of v. But it expresses the same thing as before, viz. the diminution of the impulse. The impulse being reckoned solely in the direction perpendicular to the sail, it is diminished solely by the sail withdrawing itself *in that direction* from the wind; and as gE may be considered as the real impulsive motion of the wind, GE must be considered as the relative and effective impulsive motion. The impulse would have been the same had the ship been at rest, and had the wind met it perpendicularly with the velocity GE.

Fig. 5.

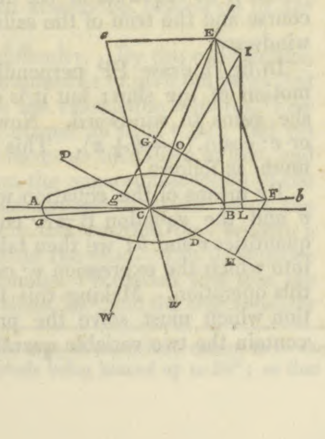
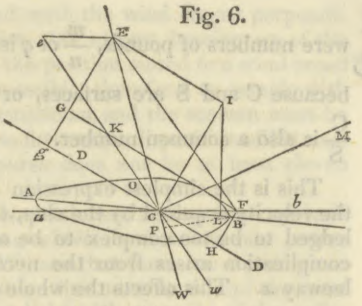


Fig. 6.



We must now show the connexion between this impulse and the motion of the ship. The sail, and consequently the ship, is pressed by the wind in the direction CI perpendicular to the sail or yard with the force which we have just now determined. This (in the state of uniform motion) must be equal and opposite to the action of the water. Draw IL at right angles to the keel. The impulse in the direction CI (which we may measure by CI) is equivalent to the impulses CL and LI. By the first the ship is impelled right forward, and by the second she is driven sideways. Therefore we must have a leeway, and a lateral as well as a direct resistance. We suppose the form of the ship to be known, and therefore the proportion is known, or discoverable, between the direct and lateral resistances corresponding to every angle x of leeway. Let A be the surface whose perpendicular resistance is equal to the direct resistance of the ship corresponding to the leeway x, that is, whose resistance is equal to the resistance really felt by the ship's bows in the direction of the keel when she is sailing with this leeway; and let B in like manner be the surface whose perpendicular resistance is equal to the actual resistance to the ship's motion in the direction LI, perpendicular to the keel. (This is not equivalent to A′ and B′ adapted to the rectangular box, but to $A' \cdot \cos.^2 x$ and $B' \cdot \sin.^2 x$). We have therefore $A : B = CL : LI$, and $LI = \dfrac{CL \cdot B}{A}$. Also, because $CI = \sqrt{CL^2 + LI^2}$, we have $A : \sqrt{A^2+B^2} = CL : CI$, and $CI = \dfrac{CL \cdot \sqrt{A^2+B^2}}{A}$. The resistance in the direction LC is properly measured by $m\,A\,v^2$ as has been already observed. Therefore the resistance in the direction IC must be expressed by $m\sqrt{A^2+B^2}|v^2$; or (making C the surface which is equal to $\sqrt{A^2+B^2}$, and which will therefore have the same perpendicular resistance to the water having the velocity v) it may be expressed by mCv^2.

Connection between the impulse and motion of the ship.

Therefore, because there is an equilibrium between the impulse and resistance, we have $mCv^2 = nS(V \cdot \sin. a - v \cdot \sin. \overline{b+x})^2$, and $\dfrac{m}{n}\,Cv^2$, or $qCv^2 = S(V \cdot \sin. a - v \cdot \sin. \overline{b+x})^2$, and $\sqrt{q}\sqrt{C}v = \sqrt{S}(V \cdot \sin. a - v \cdot \sin. \overline{b+x})$.

$$\text{Therefore } v = \frac{\sqrt{S} \cdot V \cdot \sin. a}{\sqrt{q}\sqrt{C} + \sqrt{S} \cdot \sin. \overline{b+x}}, = \frac{V \cdot \sin. a}{\sqrt{q}\dfrac{\sqrt{C}}{\sqrt{S}} + \sin. \overline{b+x}} = V\frac{\text{Sin. } a}{\sqrt{q}\dfrac{\sqrt{C}}{\sqrt{S}} + \sin. \overline{b+x}}.$$

Observe that the quantity which is the coefficient of V in this equation is a common number; for sin. a is a number, being a decimal fraction of the radius 1, sin. $\overline{b+x}$ is also a number, for the same reason. And since m and n

were numbers of pounds, $\frac{m}{n}$ or q is a common number. And because C and S are surfaces, or quantities of one kind, $\frac{C}{S}$ is also a common number.

This is the simplest expression that we can think of for the velocity acquired by the ship, though it must be acknowledged to be too complex to be of very prompt use. Its complication arises from the necessity of introducing the leeway x. This affects the whole of the denominator; for the surface C depends on it, because C is $=\sqrt{A^2+B^2}$, and A and B are analogous to $A'\cos.^2x$ and $B'\sin{}^2x$.

Important consequences deduced from the foregoing theorem.

But we can deduce some important consequences from this theorem.

While the surface S of the sail actually filled by the wind remains the same, and the angle DCB, which in future we shall call the trim of the sails, also remains the same, both the leeway x and the substituted surface C remains the same. The denominator is therefore constant; and the velocity of the ship is proportional to $\sqrt{S}\cdot V\cdot\sin.a$; that is, directly as the velocity of the wind, directly as the absolute inclination of the wind to the yard, and directly as the square root of the surface of the sails.

We also learn from the construction of the figure, that FG parallel to the yard cuts CE in a given ratio. For CF is in a constant ratio to Eg, as has been just now demonstrated. And the angle DCF is constant. Therefore CF $\cdot$ sin. b, or FH or Gg, is proportional to Eg, and OC to EC, or EC is cut in one proportion, whatever may be the angle ECD, so long as the angle DCF is constant.

We also see that it is very possible for the velocity of the ship on an oblique course to exceed that of the wind. This will be the case when the number $\frac{\sin.a}{\sqrt{q\frac{C}{S}}+\sin.\overline{b+x}}$ exceeds unity, or when sin. a is greater than $\sqrt{q\frac{C}{S}}+\sin.\overline{b+x}$.

Now this may easily be by sufficiently enlarging S and diminishing $b+x$. It is indeed frequently seen in fine sailers with all their sails set and not hauled too near the wind.

We remarked above, that the angle of leeway x affects the whole denominator of the fraction which expresses the velocity. Let it be observed that the angle ICL is the complement of LCD, or of b. Therefore, CL : LI, or A:B=1: tan. ICL=1 : cot. b, and B=A $\cdot$ cotan. b. Now A is equivalent to $A'\cdot\cos.^2x$, and thus b becomes a function of x. C is evidently so, being $\sqrt{A^2+B^2}$. Therefore before the value of this fraction can be obtained, we must be able to compute, by our knowledge of the form of the ship, the value of A for every angle x of leeway. This can be done only by resolving her bows into a great number of elementary planes, and computing the impulses on each and adding them into one sum. The computation is of immense labour, as may be seen by one example given by Bouguer. When the leeway is but small, not exceeding ten degrees, the substitution of the rectangular prism of one determined form is abundantly exact for all leeways contained within this limit; and we shall soon see reason for being contented with this approximation. We may now make use of the formula expressing the velocity for solving the chief problems in this part of the seaman's task.

Problem I: To determine the best position of the sails for standing on a given course, when the direction and velocity of the wind and its angle with the course are given.

And first let it be required to determine the best position of the sail for standing on a given course ab, when CE the direction and velocity of the wind, and its angle with the course WCF, are given. This problem has exercised the talents of the mathematicians ever since the days of Newton. In the article PNEUMATICS we gave the solution of one very nearly related to it, namely, to determine the position of the sail which would produce the greatest impulse in the direction of the course. The solution was to place the yard CD in such a position that the tangent of the angle FCD may be one half of the tangent of the angle DCW. This will indeed be the best position of the sail for beginning the motion; but as soon as the ship begins to move in the direction CF, the effective impulse of the wind is diminished, and also its inclination to the sail. The angle DCw diminishes continually as the ship accelerates; for CF is now accompanied by its equal eE, and by an angle ECe, or WCw. CF increases, and the impulse on the sail diminishes, till an equilibrium obtains between the resistance of the water and the impulse of the wind. The impulse is now measured by $CE^2\times\sin.{}^2e$CD instead of $CE^2\times\sin.{}^2$ECD, that is, by EG^2 instead of Eg^2.

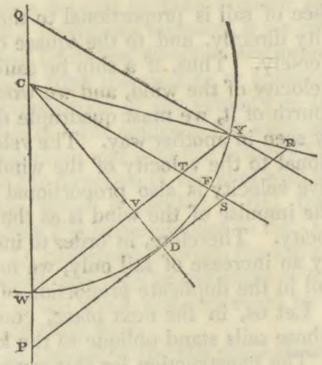
This introduction of the relative motion of the wind renders the actual solution of the problem extremely difficult. It is very easily expressed geometrically: Divide the angle wCF in such a manner that the tangent of DCF may be half of the tangent of DCw, and the problem may be constructed geometrically as follows.

Let WCF (fig. 7.) be the angle between the sail and course. Round the centre C describe the circle WDFY; produce WC to Q, so that CQ$=\frac{1}{3}$WC, and draw QY parallel to CF cutting the circle in Y; bisect the arch WY in D, and draw DC. DC is the proper position of the yard.

Draw the cord WY, cutting CD in V and CF in T; draw the tangent PD, cutting CF in S and CY in R.

It is evident that WY, PR, are both perpendicular to CD, and arc bisected in V and D; therefore (by reason of the parallels QY, CF) 4 : 3=QW : CW,=YW : TW, RP : SP. Therefore PD : PS=2 : 3, and PD:DS=2:1. Q.E.D. But this division cannot be made to the best advantage till the ship has attained its greatest velocity, and the angle w CF has been produced.

Fig. 7



We must consider all the three angles, a, b, and x, as variable in the equation which expresses the value of v, and we must make the fluxion of this equation=0; then, by means of the equation B=A$\cdot$ contan. b, we must obtain the value of b and of $\dot{b}$ in terms of x and $\dot{x}$. With respect to a, observe, that if we make the angle WCF$=p$, we have $p=a+b+x$; and p being a constant quantity, we have $\dot{a}+\dot{b}+\dot{x}=0$. Substituting for a, b, $\dot{a}$, and $\dot{b}$, their values in terms of x and $\dot{x}$, in the fluxionary equation=0, we readily obtain x, and then a and b, which solves the problem.

Let it be required, in the next place, to determine the course and the trim of the sails most proper for plying to windward.

Prob. II. To determine the course and trim of the sails most proper for plying to windward.

In fig. 6, draw FP perpendicular to WC. CF is the motion of the ship; but it is only by the motion PC that she gains to windward. Now CP is=CF$\times$cosin. WCF, or $v\cdot$ cosin. $(a+b+x)$. This must be rendered a maximum, as follows.

By means of the equation which expresses the value of v and the equation B=A$\cdot$ cotan. b, we exterminate the quantities v and b; we then take the fluxion of the quantity into which the expression $v\cdot$ cos. $(a+b+x)$ is changed by this operation. Making this fluxion=0, we get the equation which must solve the problem. This equation will contain the two variable quantities a and x with their fluxions; then make the coefficient of $\dot{x}$ equal to 0, also the coefficient of $\dot{a}$ equal to 0. This will give two equations, which will determine a and x, and from this we get $b=p-a-x$.

Prob. III. To determine the best course and trim of the sails for getting away from a given line of coast.

Should it be required, in the third place, to find the best course and trim of the sails for getting away from a given line of coast CM (fig. 6.), the process perfectly resembles this last, which is in fact getting away from a line of coast which makes a right angle with the wind. Therefore, in place of the angle WCF, we must substitute the angle WCM±WCF. Call this angle e. We must make $v\cdot\cos.(e\pm a\pm b\pm x)$ a maximum. The analytical process is the same as the former, only e is here a constant quantity.

Observations on the preceding problems.

These are the three principal problems which can be solved by means of the knowledge that we have obtained of the motion of the ship when impelled by an oblique sail, and therefore making leeway; and they may be considered as an abstract of this part of M. Bouguer's work. We have only pointed out the process for this solution, and have even omitted some things taken notice of by M. Bezout in his very elegant compendium. Our reasons will appear as we go on. The learned reader will readily see the extreme difficulty of the subject, and the immense calculations which are necessary even in the simplest cases, and will grant that it is out of the power of any but an expert analyst to derive any use from them; but the mathematician can calculate tables for the use of the practical seaman Thus he can calculate the best position of the sails for advancing in a course 90° from the wind, and the velocity in that course; then for 85°, 80°, 75°, &c. M. Bouguer has given a table of this kind; but to avoid the immense difficulty of the process, he has adapted it to the apparent direction of the wind. We have inserted a few of his numbers, suited to such cases as can be of service, namely, when all the sails draw, or none stand in the way of others. Column 1st is the apparent angle of the wind and course; column 2d is the corresponding angle of the sails and keel; and column 3d is the apparent angle of the sails and wind.

M. Bouguer's table for finding the best position of the sails for advancing in any course.

1 *w* CF	2 DCB	3 *w*CD
103°53′	42°30′	61°23′
99 13	40 —	59 13
94 25	37 30	56 55
89 28	35 —	54 28
84 23	32 30	51 53
79 06	30 —	49 06
73 39	27 30	46 09
68 —	25 —	43 —

In all these numbers we have the tangent of *w*CD double of the tangent of DCF.

Inutility of these calculations.

But this is really doing but little for the seaman. The apparent direction of the wind is unknown to him till the ship is sailing with uniform velocity; and he is still uninformed as to the leeway. It is, however, of service to him to know, for instance, that when the angle of the vanes and yards is 56 degrees, the yard should be braced up to 37° 30′, &c.

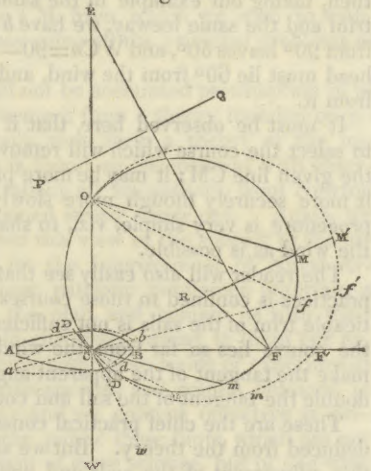
But here occurs a new difficulty. By the construction of a square-rigged ship it is impossible to give the yards that inclination to the keel which the calculation requires.[1] Few ships can have their yards braced up to 37° 30′; and yet this is required in order to have an incidence of 56°, and to hold a course 94° 25′ from the apparent direction of the wind, that is, with the wind apparently 4° 25′ abaft the beam. A good sailing ship in this position may acquire a velocity even exceeding that of the wind. Let us suppose it only one half of this velocity. We shall find that the angle WC*w* is in this case about 29°, and the ship is nearly going 123° from the wind, with the wind almost perpendicular to the sail; therefore this utmost bracing up of the sails is only giving them the position suited to a wind broad on the quarter. It is impossible, therefore, to comply with the demand of the mathematician, and the seaman must be contented to employ a less favourable disposition of his sails in all cases where his course does not lie at least eleven points from the wind.

Let us see whether this restriction, arising from necessity, leaves any thing in our choice, and makes one course preferable to another. We see that there are a prodigious number of courses, and these the most usual and the most important, which we must hold with one trim of the sails; in particular, sailing with the wind on the beam, and all cases of plying to windward, must be performed with this unfavourable trim of the sails. We are certain that the smaller we make the angle of incidence, real or apparent, the smaller will be the velocity of the ship; but it may happen that we shall gain more to windward, or get sooner away from a lee-coast, or any object of danger, by sailing slowly on one course than by sailing quickly on another.

We have seen that while the trim of the sails remains the same, the leeway and the angle of the yard and course remains the same, and that the velocity of the ship is as the sine of the angle of real incidence, that is, as the sine of the angle of the sail and the real direction of the wind.

Let the ship AB (fig. 8.) hold the course CF, with the wind blowing in the direction WC, and having her yards DCD braced up to the smallest angle BCD which the rigging can admit. Let CF be to CE as the velocity of the ship to the velocity of the wind; join FE and draw C*w* parallel to EF; it is evident that FE is the relative motion of the wind, and *w*CD is the relative incidence on the sail.

Fig. 8.



Draw FO parallel to the yard DC, and describe a circle through the points COF; then we say that if the ship, with the same wind and the same trim of the same drawing sails, be made to sail on any other course C*f*, her velocity along CF is to the velocity along C*f* as CF is to C*f*; or, in other words, the ship will employ the same time in going from C to any point of the circumference CFO.

Join *f*O. Then, because the angles CFO, C*f*O are on the same cord CO, they are equal, and *f*O is parallel to *d*C*d*, the new position of the yard corresponding to the new position of the keel *ab*, making the angle *d*C*b*=DCB. Also, by the nature of the circle, the line CF is to C*f* as the sine of the angle CFO to the sine of the angle CO*f*, that is (on account of the parallels CD, OF and C*d*, O*f*), as the sine of WCD to the sine of WC*d*. But when the trim of the sails remains the same, the velocity of the ship is as the sine of the angle of the sail with the direction of the wind; therefore CF is to C*f* as the velocity on CF to that on C*f*, and the proposition is demonstrated.

To determine the best course for avoiding a rock.

Let it now be required to determine the best course for avoiding a rock R lying in the direction CR, or for withdrawing as fast as possible from a line of coast PQ. Draw CM through R, or parallel to PQ, and let m be the middle of the arch C*m*M. It is plain that m is the most remote from CM of any point of the arch C*m*M, and therefore the ship will recede farther from the coast PQ in any given time, by holding the course C*m* than by any other course.

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[1] There are few of the modern men-of-war which cannot have their yards braced up to 27°, instead of 37° 30′. We may assume that most ships will admit of their yards being braced up to 30°; so that the angle of incidence would be 49° 06′, and the course 79° 06′.

This course is easily determined; for the arch C*m*M =360°—(arch CO+arch OM), and the arch CO is the measure of twice the angle CFO, or twice the angle DCB, or twice $\overline{b+x}$, and the arch OM measures twice the angle ECM.

Thus, suppose the sharpest possible trim of the sails to be 35°, and the observed angle ECM to be 70°; then CO+OM is 70°+140° or 210°. This being taken from 360°, leaves 150°, of which the half M*m* is 75°, and the angle MC*m* is 37° 30′. This added to ECM makes EC*m* 170° 30′, leaving WC*m*=72° 30′, and the ship must hold a course making an angle of 72° 30′ with the real direction of the wind, and WCD will be 37° 30′.

This supposes no leeway. But if we know that under all the sail which the ship can carry with safety and advantage she makes 5 degrees of leeway, the angle DC*m* of the sail and course, or $b+x$, is 40°. Then CO+OM=220°, which being taken from 360°, leaves 140°, of which the half is 70°, =M*m*, and the angle MC*m*=35°, and EC*m*=105°, and WC*m*=75°, and the ship must lie with her head 70° from the wind, making 5 degrees of leeway, and the angle WCD is 35°.

The general rule for the position of the ship is, *that the line on shipboard which bisects the angle* b+x *may also bisect the angle* WCM, or make the angle between the course and the line, from which we wish to withdraw, equal to the angle between the sail and the real direction of the wind.

Corollaries.

It is plain that this problem includes that of plying to windward. We have only to suppose ECM to be 90°; then, taking our example in the same ship, with the same trim and the same leeway, we have $b+x=40°$. This taken from 90° leaves 50°, and WC*n*=90—25=65, and the ship's head must lie 60° from the wind, and the yard must be 25° from it.

It must be observed here, that it is not always eligible to select the course which will remove the ship fastest from the given line CM; it may be more prudent to remove from it more securely though more slowly. In such cases the procedure is very simple, viz., to shape the course as near the wind as is possible.

The reader will also easily see that the propriety of these practices is confined to those courses only where the practicable trim of the sails is not sufficiently sharp. Whenever the course lies so far from the wind that it is possible to make the tangent of the apparent angle of the wind and sail double the tangent of the sail and course, it should be done.

The adjustment of the sails supposed in the theory impracticable.

These are the chief practical consequences which can be deduced from the theory. But we should consider how far this adjustment of the sails and course can be performed. And here occur difficulties so great as to make it almost impracticable. We have always supposed the position of the surface of the sail to be distinctly observable and measurable; but this can be hardly affirmed even with respect to a sail stretched on a yard. Here we supposed the surface of the sail to have the same inclination to the keel that the yard has. This is by no means the case; the sail assumes a concave form, of which it is almost impossible to assign the direction of the mean impulse. We believe that this is always considerably to leeward of a perpendicular to the yard, lying between CI and CE, (fig. 6). This is of some advantage, being equivalent to a sharper trim. We cannot affirm this, however, with any confidence, because it renders the impulse on the weather-leech of the sail so exceedingly feeble as hardly to have any effect. In sailing close to the wind, the ship is kept so near that the weather-leech of the sail is almost ready to receive the wind edgewise, and to flutter or shiver. The most effective or drawing sails with a side-wind, especially when plying to windward, are the staysails. We believe that it is impossible to say, with anything approaching to precision, what is the position of the general surface of a staysail, or to calculate the intensity and direction of the general impulse; and we affirm with confidence that no man can pronounce on these points with any exactness. If we can guess within a third or a fourth part of the truth, it is all we can pretend to; and after all, it is but a guess. Add to this, the sails coming in the way of each other, and either becalming them or sending the wind upon them in a direction widely different from that of its free motion. All these points we think beyond our power of calculation, and therefore that it is in vain to give the seaman mathematical rules, or even tables of adjustment ready calculated; since he can neither produce that medium position of his sails that is required, nor tell what is the position which he employs.

This is one of the principal reasons why so little advantage has been derived from the very ingenious and promising disquisitions of Bouguer and other mathematicians, and has made us omit the actual solution of the chief problems, contenting ourselves with pointing out the process to such readers as have a relish for these analytical operations.

The theory itself erroneous,

But there is another principal reason for the small progress which has been made in the theory of seamanship. This is the error of the theory itself, which supposes the impulsions of a fluid to be in the duplicate ratio of the sine of incidence. The most careful comparison which has been made between the results of this theory and matter of fact, is to be seen in the experiments made by the members of the Royal Academy of Sciences at Paris, mentioned in the article Resistance of Fluids. We subjoin another abstract of them in the following table; where column 1st gives the angle of incidence; column 2d gives the impulsions really observed; column 3d the impulses, had they followed the duplicate ratio of the sines; and column 4th the impulses, if they were in the simple ratio of the sines.

Angle of incid.	Impulsion observed.	Impulse as sine.^{2}	Impulse as sine.
90	1000	1000	1000
84	989	989	995
78	958	957	978
72	908	905	951
66	845	835	914
60	771	750	866
54	693	655	809
48	615	552	743
42	543	448	669
36	480	346	587
30	440	250	500
24	424	165	407
18	414	96	309
12	406	43	208
6	400	11	105

Here we see an enormous difference in the great obliquities. When the angle of incidence is only six degrees, the observed impulse is forty times greater than the theoretical impulse; at 12° it is ten times greater; at 18° it is more than four times greater; and at 24° it is almost three times greater

and the deductions from it useless.

No wonder then that the deductions from this theory are so useless and so unlike what we familiarly observe. We took notice of this when we were considering the leeway of a rectangular box, and thus saw a reason for admitting an incomparably smaller leeway than what would result from the laborious computations necessary by the theory. This error in theory has as great an influence on the impulsions of air when acting obliquely on a sail; and the experiments of Mr. Robins and of the Chevalier Borda, on the oblique impulsions of air, are perfectly conformable (as far as they go) to those of the academicians on water. The oblique impulsions of the wind are therefore much more efficacious for pressing the ship in the direction of her course than the theory allows us to suppose; and the progress of a ship plying to windward is much greater, both because the oblique impulses of the wind are more effective, and because the leeway is much smaller, than we suppose. Were not this the case, it would be impossible for a square-rigged ship to get to windward. The impulse on her sails, when close hauled, would be so trifling, that she would not have a third part of the velocity which we see her acquire: and this trifling velocity would be wasted in leeway; for we have seen that the diminution of the oblique impulses of the water is accompanied by an increase of leeway. But we see that in the great obliquities the impulsions continue to be very considerable, and that even an incidence of six degrees gives an impulse as great as the theory allows to an incidence of 40°. We may therefore, on all occasions, keep the yards more square; and the loss which we sustain by the diminution of the very oblique impulse will be more than compensated by its more favourable direction with respect to the ship's keel. Let us take an example of this. Suppose the wind about two points before the beam, making an angle of 68° with the keel. The theory assigns 43° for the inclination of the wind to the sail, and 15° for the trim of the sail. The perpendicular impulse being supposed 1000, the theoretical impulse for 45° is 465. This reduced in the proportion of radius to the sine of 25°, gives the impulse in the direction of the course only 197.

But if we ease off the lee-braces till the yard makes an angle of 50° with the keel, and allows the wind an incidence of no more than 18°, we have the experimented impulse 414, which, when reduced in the proportion of radius to the sine of 50°, gives an effective impulse 317. In like manner, the trim 56°, with the incidence 12°, gives an effective impulse 337; and the trim of 62°, with the incidence only 6°, gives 353.

Hence it would at first sight appear that the angle DCB of 62° and WCD of 6° would be better for holding a course within six points of the wind than any more oblique position of the sails; but it will only give a greater initial impulse. As the ship accelerates, the wind apparently comes ahead, and we must continue to brace up as a ship freshens her way. It is not unusual for her to acquire half or two-thirds of the velocity of the wind; in which case the wind comes apparently ahead more than two points, when the yards must be braced up to 35°, and thus allows an impulse no greater than about 7°. Now, this is very frequently observed in good ships, which, in a brisk gale and smooth water, will go five or six knots close-hauled, the ship's head six points from the wind, and the sails no more than just full, but ready to shiver by the smallest luff. All this would be impossible by the usual theory; and in this respect these experiments of the French Academy give a fine illustration of the seaman's practice. They account for what we should otherwise be much puzzled to explain; and the great progress which is made by a ship close-hauled being perfectly agreeable to what we should expect from the law of oblique impulsions, deducible from these so often-mentioned experiments, while it is totally incompatible with the common theory, should make us abandon the theory without hesitation, and strenuously set about the establishment of another, founded entirely on experiments. For this purpose the experiments should be made on the oblique impulsions of air, on as great a scale as possible, and in as great a variety of circumstances, so as to furnish a series of impulsions for all angles of obliquity. We have but four or five experiments on this subject, viz., two by Mr. Robins, and two or three by the Chevalier Borda. Having thus gotten a series of impulsions, it is very practicable to raise on this foundation a practical institute, and to give a table of the velocities of a ship suited to every angle of inclination and of trim; for nothing is more certain than the resolution of the impulse perpendicular to the sail into a force in the direction of the keel, and a lateral force.

Experiments proper for establishing another.

We are also disposed to think that experiments might be made on a model very nicely rigged with sails, and trimmed in every different degree, which would point out the mean direction of the impulse on the sails, and the comparative force of these impulses on different directions of the wind. The method would be very similar to that for examining the impulse of the water on the hull. If this can also be ascertained experimentally, the intelligent reader will easily see that the whole motion of a ship under sail may be determined for every case. Tables may then be constructed by calculation, or by graphical operations, which will give the velocities of a ship in every different course, and corresponding to every trim of sail. And let it be here observed, that the trim of the sail is not to be estimated in degrees of inclination of the yards; because, as we have already remarked, we cannot observe nor adjust the lateen sails in this way. But, in making the experiments for ascertaining the impulse, the exact position of the tacks and sheets of the sails are to be noted; and this combination of adjustments is to pass by the name of a certain trim. Thus that trim of all the sails may be called 40, whose direction is experimentally found equivalent to a flat surface trimmed to the obliquity 40°.

Having done this, we may construct a figure for each trim similar to fig. 8, where, instead of a circle, we shall have a curve COM′F′, whose chords CF′, *c f′*, &c. are proportional to the velocities in these courses; and by means of this curve we can find the point *m′*, which is most remote from any line CM from which we wish to withdraw: and thus we may solve all the principal problems of the art.

We hope that it will not be accounted presumption in us to expect more improvement from a theory founded on judicious experiments only, than from a theory of the impulse of fluids, which is found so inconsistent with observation, and of whose fallacy all its authors, from Newton to D'Alembert, entertained strong suspicions. Again, we beg leave to recommend this view of the subject to the attention of the Society for the Improvement of Naval Architecture. Should these patriotic gentlemen entertain a favourable opinion of the plan, and honour us with their correspondence, we will cheerfully impart to them our notions of the way in which both these trains of experiments may be prosecuted with success, and results obtained in which we may confide; and we content ourselves at present with offering to the public these hints, which are not the speculations of a man of mere science, but of one who, with a competent knowledge of the laws of mechanical nature, has the experience of several years service in the royal navy, where the art of working ships was a favourite object of his scientific attention.

Recommended to the Society for the Improvement of Naval Architecture.

With those observations we conclude our discussion of the first part of the seaman's task, and now proceed to consider the means that are employed to prevent or to produce any deviations from the uniform rectilineal course which has been selected.

Means employed to prevent or produce deviations from a course.

Here the ship is be considered as a body in free space, convertible round her centre of inertia. For whatever may be the point round which she turns, this motion may always be considered as compounded of a rotation round an axis passing through her centre of gravity or inertia. She is impelled by the wind and by the water acting on many surfaces differently inclined to each other, and the impulse on each is perpendicular to the surface. In order therefore that she may continue steadily in one course, it is not only necessary that the impelling forces, estimated in their mean direction, be equal and opposite to the resisting forces estimated in their mean direction; but also that these two directions may pass through one point, otherwise she will be affected as a log of wood is when pushed in opposite directions by two forces, which are equal indeed, but are applied to different parts of the log. A ship must be considered as a lever, acted on in different parts by forces in different directions, and the whole balancing each other round that point or axis where the equivalent of all the resisting forces passes. This may be considered as a point supported by this resisting force and as a sort of fulcrum: therefore, in order that the ship may maintain her position, the energies or *momenta* of all the impelling forces round this point must balance each other.

Impulses on a ship sailing right before the wind different from those on her when sailing obliquely.

When a ship sails right afore the wind, with her yards square, it is evident that the impulses on each side of the keel are equal, as also their mechanical *momenta* round any axis passing perpendicularly through the keel. So are the actions of the water on her bows. But when she sails on an oblique course, with her yards braced on either side, she sustains a pressure in the direction CI (fig. 5,) perpendicular to the sail. This, by giving her a lateral pressure LI, as well as a pressure CL ahead, causes her to make leeway, and to move in a line C*b* inclined to CB. By this means the balance of action on the two bows is destroyed; the general impulse on the lee-bow is increased; and that on the weather-bow is diminished. The combined impulse is therefore no longer in the direction BC, but (in the state of uniform motion) in the direction IC.

Suppose that in an instant the whole sails are annihilated and the impelling pressure CI, which precisely balanced the resisting pressure on her bows, removed. The ship tends, by her inertia, to proceed in the direction C*b*. This tendency produces a continuation of the resistance in the opposite direction IC, which is not directly opposed to the tendency of the ship in the direction C*b*; therefore the ship's head would immediately come up to the wind. The experienced seaman will recollect something like this when the sails are suddenly lowered when coming to anchor. It does not happen solely from the obliquity of the action on the bows: It would happen to the parallelopiped of fig. 2, which was sustaining a lateral impulsion $B\cdot\sin.^2x$, and a direct impulsion $A\cdot\cos.^2x$. These are continued for a moment after the annihilation of the sail: but being no longer opposed by a force in the direction CD, but by a force in the direction C*b*, the force $B\cdot\sin.^2x$ must prevail, and the body is not only retarded in its motion, but its head turns towards the wind. But this effect of the leeway is greatly increased by the curved form of the ship's bows. This occasions the centre of effort of all the impulsions of the water on the leeside of the ship to be very far forward, and this so much the more remarkably as she is sharper afore. It is in general not much abaft the foremast. Now the centre of the ship's tendency to continue her motion is the same with her centre of gravity, and this is generally but a little before the mainmast. She is therefore in the same condition nearly as if she were pushed at the mainmast in a direction parallel to C*b*, and at the foremast by a force parallel to IC. The evident consequence of this is a tendency to come up to the wind. This is independent of all situation of the sails, provided only that they have been trimmed obliquely.

Griping.

This tendency of the ship's head to windward is called griping in the seaman's language, and is greatest in ships which are sharp forward, as we have said already. This circumstance is easily understood. Whatever is the direction of the ship's motion, the absolute impulse on that part of the bow immediately contiguous to B is perpendicular to that very part of the surface. The more acute, therefore, that the angle of the bow is, the more will the impulse on that part be perpendicular to the keel, and the greater will be its energy to turn the head to windward.

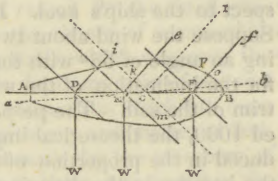
Propriety of the disposition of the sails of a ship.

Thus we are enabled to understand or to see the propriety of the disposition of the sails of a ship. We see her crowded with sails forward, and even many sails extended far before her bow, such as the spritsail, the bowsprit topsail, the fore-topmast staysail, the jib, and flying jib. The sails abaft are comparatively smaller. The sails on the mizenmast are much smaller than those on the foremast. All the staysails hoisted on the mainmast may be considered as headsails, because their centres of effort are considerably before the centre of gravity of the ship: and notwithstanding this disposition, it generally requires a small action of the rudder to counteract the windward tendency of the lee-bow. This is considered as a good quality when moderate; because it enables the seaman to throw the sails aback, and stop the ship's way in a moment, if she be in danger from any thing a-head; and the ship which does not carry a little of a weather helm, is always a dull sailer.

Action of the water and the sails.

In order to judge somewhat more accurately of the action of the water and sails, suppose the ship AB (fig. 9,) to have its sails on the mizenmast D, the mainmast E, and the foremast F, braced up or trimmed alike, and the three lines D *i*, E *e*, F *f*, perpendicular to the sails, are in the proportion of the impulses on the sails. The ship is driven a-head and to leeward, and moves in the path *a*C*b*. This path is so inclined to the line of the keel, that the medium direction of the resistance of the water is parallel to the direction of the impulse. A line CI may be drawn parallel to the lines D *i*, E *e*, F *f*, and equal to their sum: and it may be drawn from such a point C, that the actions on all the parts of the hull between C and B may balance the *momenta* of all the actions on the hull between C and A. This point may justly be called the *centre of effort*, or the *centre of resistance*. We cannot determine this point for want of a proper theory of the resistance of fluids. Nay, although experiments like those of the Parisian Academy should give us the most perfect knowledge of the intensity of the oblique impulses on a square foot, we should hardly be benefitted by them: for the action of the water on a square foot of the hull at *p*, for instance, is so modified by the intervention of the stream of water which has struck the hull about B, and glided along the bow B *op*, that the pressure on *p* is totally different from what it would have been were it a square foot or surface detached from the rest, and presented in the same position to the water moving in the direction *b*C. For it is found, that the resistances given to planes joined so as to form a wedge, or to curved surfaces, are widely different from the accumulated resistances, calculated for their separate parts, agreeably to the experiments of the academy on single surfaces. We therefore do not attempt to ascertain the point C by theory; but it may be accurately determined by the experiments which we have so strongly recommended; and we offer this as an additional inducement for prosecuting them.

Fig. 9.



Centre of effort.

To be determined by experiments.

Draw through C a line perpendicular to CI, that is, parallel to the sails; and let the lines of impulse of the three sails cut in the points *i*, *k*, and *m*. This line *im* may be considered as a lever, moveable round C, and acted on at the points *i*, *k*, and *m*, by three forces. The rotatory momentum of the sails on the mizenmast is $Di \times iC$; that of the sails on the mainmast is $Ee \times kC$; and the momentum of the sails on the foremast is $Ff \times mC$. The two first tend to press forward the arm C*i*, and then to turn the ship's head towards the wind. The action of the sails on the foremast tends to pull the arm C*m* forward, and produce a

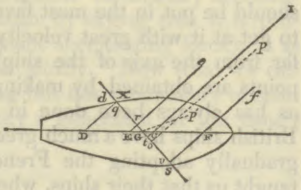
Equilibrium preserved by the position of the sails.

contrary rotation. If the ship under these three sails keeps steadily in her course, without the aid of the rudder, we must have $\mathrm{D}i \times i\mathrm{C} + \mathrm{E}e \times k\mathrm{C} = \mathrm{F}f \times m\mathrm{C}$. This is very possible, and is often seen in a ship under her mizen-topsail, main-topsail, and fore-topsail, all parallel to one another, and their surfaces duly proportioned by reefing. If more sails are set, we must always have a similar equilibrium. A certain number of them will have their efforts directed from the larboard arm of the lever im lying to leeward of CI, and a certain number will have their efforts directed from the starboard arm lying to windward of CI. The sum of the products of each of the first set, by their distances from C, must be equal to the sum of the similar products of the other set. As this equilibrium is all that is necessary for preserving the ship's position, and the cessation of it is immediately followed by a conversion; and as these states of the ship may be had by means of the three square sails only, when their surfaces are properly proportioned, it is plain that every movement may be executed and explained by their means. This will greatly simplify our future discussions. We shall therefore suppose in future that there are only the three topsails set, and that their surfaces are so adjusted by reefing, that their actions exactly balance each other round that point C of the middle line AB, where the actions of the water on the different parts of her bottom in like manner balance each other. This point C may be differently situated in the ship according to the leeway she makes, depending on the trim of the sails; and therefore although a certain proportion of the three surfaces may balance each other in one state of leeway, they may happen not to do so in another state. But the equilibrium is evidently attainable in every case, and we therefore shall always suppose it.

Consequence of destroying it.

It must now be observed, that when this equilibrium is destroyed, as, for example, by turning the edge of the mizen-topsail to the wind, which the seamen call *shivering* the mizen-topsail, and which may be considered as equivalent to the removing the mizen-topsail entirely, it does not follow that the ship will turn round the point C, this point remaining fixed. The ship must be considered as a free body, still acted on by a number of forces, which no longer balance each other; and she must therefore *begin* to turn round a spontaneous axis of conversion, which must be determined in the way set forth in the article ROTATION. It is of importance to point out in general where this axis is situated. Therefore let G (fig. 10.) be the centre of gravity of the ship. Draw the line qGv parallel to the yards, cutting $\mathrm{D}d$ in q, $\mathrm{E}e$ in r, CI in t, and $\mathrm{F}f$ in v. While the three sails are set, the line qv may be considered as a lever acted on by four forces, *viz.* $\mathrm{D}d$, impelling the lever forward perpendicularly in the point q; $\mathrm{E}e$, impelling it forward in the point r; $\mathrm{F}f$, impelling it forward in the point v; and CI, impelling it backward in the point t. These forces balance each other both in respect of progressive motion and of rotatory energy: for CI was taken equal to the sum of $\mathrm{D}d$, $\mathrm{E}e$, and $\mathrm{F}f$; so that no acceleration or retardation of the ship's progress in her course is supposed.

Fig. 10.



But by taking away the mizen-topsail, both the equilibriums are destroyed. A part $\mathrm{D}d$ of the accelerating force is taken away; and yet the ship, by her inertia or inherent force, tends, for a moment, to proceed in the direction $\mathrm{C}p$ with her former velocity; and by this tendency exerts for a moment the same pressure CI on the water, and sustains the same resistance IC. She must therefore be retarded in her motion by the excess of the resistance IC over the remaining impelling forces $\mathrm{E}e$ and $\mathrm{F}f$, that is, by a force equal and opposite to $\mathrm{D}d$. She will therefore be retarded in the same manner as if the mizen-topsail were still set, and a force equal and opposite to its action were applied to G, the centre of gravity, and she would soon acquire a smaller velocity, which would again bring all things into equilibrium; and she would stand on in the same course, without changing either her leeway or the position of her head.

But the equilibrium of the lever is also destroyed. It is now acted on by three forces only, viz. $\mathrm{E}e$ and $\mathrm{F}f$, impelling it forward in the points r and v, and IC impelling it backward in the point t. Make $rv : ro = \mathrm{E}e + \mathrm{F}f : \mathrm{F}f$, and make op parallel to CI and equal to $\mathrm{E}e + \mathrm{F}f$. Then we know, from the common principles of mechanics, that the force op acting at o will have the same momentum or energy to turn the lever round *any* point whatever as the two forces $\mathrm{E}e$ and $\mathrm{F}f$ applied at r and v; and now the lever is acted on by two forces, viz. IC, urging it backwards in the point t, and op urging it forwards in the point o. It must therefore turn round like a floating log, which gets two blows in opposite directions. If we now make $\mathrm{IC} - op : op = to : tx$, or $\mathrm{IC} - op : \mathrm{IC} = to : ox$, and apply to the point x a force equal to $\mathrm{IC} - op$ in the direction IC; we know by the common principles of mechanics, that this force $\mathrm{IC} - op$ will produce the same rotation round any point as the two forces IC and op applied in their proper directions at t and o. Let us examine the situation of the point x.

The force $\mathrm{IC} - op$ is evidently $= \mathrm{D}d$, and op is $= \mathrm{E}e + \mathrm{F}f$. Therefore $ot : tx = \mathrm{D}d : op$. But because, when all the sails were filled, there was an equilibrium round C, and therefore round t, and because the force op acting at o is equivalent to $\mathrm{E}e$ and $\mathrm{F}f$ acting at r and v, we must still have the equilibrium; and therefore we have the momentum $\mathrm{D}d \times qt = op \times ot$. Therefore $ot : tq = \mathrm{D}d : op$, and $tq = tx$. Therefore the point x is the same with the point q.

By shivering the mizen-top-sail.

Therefore, when we shiver the mizen-topsail, the rotation of the ship is the same as if the ship were at rest, and a force equal and opposite to the action of the mizen-topsail were applied at q or at D, or any point in the line $\mathrm{D}q$.

This might have been shown in another and shorter way. Suppose all sails filled, the ship is in equilibrio. This will be disturbed by applying to D a force opposite to $\mathrm{D}d$; and if the force be also equal to $\mathrm{D}d$, it is evident that these two forces destroy each other, and that this application of the force $d\mathrm{D}$ is equivalent to the taking away of the mizen-topsail. But we chose to give the whole mechanical investigation; because it gave us an opportunity of pointing out to the reader, in a case of very easy comprehension, the precise manner in which the ship is acted on by the different sails and by the water, and what share each of them has in the motion ultimately produced. We shall not repeat this manner of procedure in other cases, because a little reflection on the part of the reader will now enable him to trace the *modus operandi* through all its steps.

We now see that, in respect both of progressive motion and of conversion, the ship is affected by shivering the sail D, in the same manner as if a force equal and opposite to $\mathrm{D}d$ were applied at D, or at any point in the line $\mathrm{D}d$. We must now have recourse to the principles established under the article ROTATION.

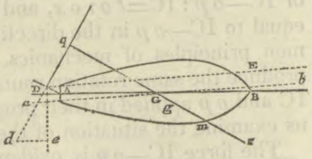
Let p represent a particle of matter, r its radius vector, or its distance $p\mathrm{G}$ from an axis passing through the centre of gravity G, and let M represent the whole quantity of matter of the ship. Then its momentum of inertia is $= \int p \cdot r^2$, (see ROTATION, No. 18.) The ship, impelled in the point D by a force in the direction $d\mathrm{D}$, will begin to turn round a spontaneous vertical axis, passing through a point S of the line $q\mathrm{G}$, which is drawn through the centre of gravity G, perpendicular to the direction $d\mathrm{D}$ of the external force, and the distance GS of this axis from the centre of gravity is $=\frac{\int p\cdot r^2}{M\cdot Gq}$ (see ROTATION, No. 96.), and it is taken on the opposite side of G from q, that is, S and q are on opposite sides of G.

Let us express the external force by the symbol F. It is equivalent to a certain number of pounds, being the pressure of the wind moving with the velocity V and inclination a on the surface of the sail D; and may therefore be computed either by the theoretical or experimental law of oblique impulses. Having obtained this, we can ascertain the angular velocity of the rotation and the absolute velocity of any given point of the ship by means of the theorems established in the article ROTATION.

Action of the rudder.

But before we proceed to this investigation, we shall consider the action of the rudder, which operates precisely in the same manner. Let the ship AB (fig. 11), have her rudder in the position AD, the helm being hard a-starboard, while the ship sailing on the starboard tack, and making leeway, keeps on the course *a b*. The lee surface of the rudder meets the water obliquely. The very foot of the rudder meets it in the direction DE parallel to *a b*. The parts farther up meet it with various obliquities, and with various velocities, as it glides round the bottom of the ship and falls into the wake. It is absolutely impossible to calculate the accumulated impulse. We shall not be far mistaken in the deflection of each contiguous filament, as it quits the bottom and glides along the rudder; but we neither know the velocity of these filaments, nor the deflection and velocity of the filaments gliding without them. We therefore imagine that all computations on this subject are in vain. But it is enough for our purpose that we know the direction of the absolute pressure which they exert on its surface. It is in the direction D*d*, perpendicular to that surface. We also may be confident that this pressure is very considerable, in proportion to the action of the water on the ship's bows, or of the wind on the sails; and we may suppose it to be nearly in the proportion of the square of the velocity of the ship in her course; but we cannot affirm it to be accurately in that proportion, for reasons that will readily occur to one who considers the way in which the water falls in behind the ship.

Fig. 11.



Greatest in a fine sailer.

It is observed, however, that a fine sailer always steers well, and that all movements by means of the rudder are performed with great rapidity when the velocity of the ship is great. We shall see by and by, that the speed with which the ship performs the angular movements is in the proportion of her progressive velocity: For we shall see that the squares of the times of performing the evolution are as the impulses inversely, which are as the squares of the velocities. There is perhaps no force which acts on a ship that can be more accurately determined by experiment than this. Let the ship ride in a stream or tideway whose velocity is accurately measured; and let her ride from two moorings, so that her bow may be a fixed point. Let a small tow line be laid out from her stern or quarter at right angles to the keel, and connected with some apparatus fitted up on shore or on board another ship, by which the strain on it may be accurately measured; a person conversant with mechanics will see many ways in which this can be done.

How to determine it.

Perhaps the following may be as good as any; let the end of the tow-line be fixed to some point as high out of the water as the point of the ship from which it is given out, and let this be very high. Let a block with a hook be on the rope, and a considerable weight hung on this hook. Things being thus prepared, put down the helm to a certain angle, so as to cause the ship to sheer off from the point to which the far end of the tow-line is attached. This will stretch the rope, and raise the weight out of the water. Now heave upon the rope, to bring the ship back again to her former position, with her keel in the direction of the stream. When this position is attained, note carefully the form of the rope, that is, the angle which its two parts make with the horizon. Call this angle a. Every person acquainted with these subjects knows that the horizontal strain is equal to half the weight multiplied by the cotangent of a, or that 2 is to the cotangent of a as the weight to the horizontal strain. Now it is this strain which balances and therefore measures the action of the rudder, or D*e* in fig. 11. Therefore, to have the absolute impulse D*d*, we must increase D*e* in the proportion of radius to the secant of the angle b, which the rudder makes with the keel. In a great ship sailing six miles in an hour, the impulse on the rudder inclined 30° to the keel is not less than 3000 pounds. The surface of the rudder of such a ship contains near 80 square feet. It is not, however, very necessary to know this absolute impulse D*d*, because it is its parts D*e* alone which measures the energy of the rudder in producing a conversion. Such experiments, made with various positions of the rudder, will give its energies corresponding to these positions, and will settle that long disputed point, which is the best position for turning a ship. On the hypothesis that the impulsions of fluids are in the duplicate ratio of the sines of incidence, there can be no doubt that it should make an angle of 54° 44′ with the keel. But the form of a large ship will not admit of this, because a tiller of a length sufficient for managing the rudder in sailing with great velocity has not room to deviate above 30° from the direction of the keel;[1] and in this position of the rudder the mean obliquity of the filaments of water to its surface cannot exceed 40° or 45°. A greater angle would not be of much service, for it is never for want of a proper obliquity that the rudder fails of producing a conversion.

Why a sh misses stays, &c

A ship misses stays in rough weather for want of a sufficient progressive velocity, and because her bows are beat off by the waves; and there is seldom any difficulty in wearing the ship, if she has any progressive motion. It is, however, always desirable to give the rudder as much influence as possible. Its surface should be enlarged (especially below) as much as can be done consistently with its strength, and with the power of the steersman to manage it; and it should be put in the most favourable situation for the water to get at it with great velocity; and it should be placed as far from the axis of the ship's motion as possible. These points are obtained by making the stern-post very upright, as has always been done in the French dockyards. The British ships have a much greater rake; but our builders are gradually adopting the French forms, experience having taught us that their ships, when in our possession, are much more obedient to the helm than our own.—In order to ascertain the motion produced by the action of the rudder, draw from the centre of gravity a line Gq perpendicular to D*d*, (D*d* being drawn through the centre of effort of the rudder). Then, as in the consideration of the action of the sails, we may conceive the line qG as a lever connected with the ship, and impelled by a force D*d* acting perpendicularly at q. The consequence of this will be, an incipient conversion of the ship about a vertical axis passing through some point S in the line qG, lying on the other side of G from q; and we have, as in the former case, $GS=\frac{\int p\cdot r^2}{M\cdot Gq}$.

The acti of the ru der simil to that o the sails, and very great.

Thus the action and effects of the sails and of the rudder are perfectly similar, and are to be considered in the same manner. We see that the action of the rudder, though of a small surface in comparison of the sails, must be very great: For the impulse of water is many hundred times greater than that of the wind; and the arm qG of the lever, by which it acts, is incomparably greater than that by which any of the impulsions on the sails produces its effect; accordingly the ship yields much more rapidly to its action than she does to the lateral impulse of a sail.

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[1] In modern ships the improvements in the tillers will admit of the rudder's being put over so as to make an angle of 54° 44′ with the keel—the angle of maximum advantage assigned to it by theory.

Observe here, that if G were a fixed or supported axis, it would be the same thing whether the absolute force D*d* of the rudder acts in the direction D*d*, or its transverse parts D*e* acts in the direction D*e*, both would produce the same rotation; but it is not so in a free body. The force D*d* both tends to retard the ship's motion and to produce a rotation: It retards it as much as if the same force D*d* had been immediately applied to the centre. And thus the real motion of the ship is compounded of a motion of the centre in a direction parallel to D*d*, and of a motion round the centre. These two constitute the motion round S.

Employed as an example of the motions of conversion.

As the effects of the action of the rudder are both more remarkable and somewhat more simple than those of the sails, we shall employ them as an example of the mechanism of the motions of conversion in general; and as we must content ourselves, in a work like this, with what is very general, we shall simplify the investigation by attending only to the motion of conversion. We can get an accurate notion of the whole motion, if wanted for any purpose, by combining the progressive or retrograde motion parallel to D*d* with the motion of rotation which we are about to determine.

In this case, then, we observe, in the first place, that the angular velocity (see ROTATION, No. 22.) is $\frac{Dh \cdot qG}{\int pr^2}$; and, as was shewn in that article, this velocity of rotation increases in the proportion of the time of the forces' uniform action, and the rotation would be uniformly accelerated if the forces did really act uniformly. This, however, cannot be the case, because, by the ship's change of position and change of progressive velocity, the direction and intensity of the impelling force is continually changing. But if two ships are performing similar evolutions, it is obvious that the changes of force are similar in similar parts of the evolution. Therefore the consideration of the momentary evolution is sufficient for enabling us to compare the motions of ships actuated by similar forces, which is all we have in view at present. The velocity v, generated in any time t by the continuance of an invariable momentary acceleration, (which is all that we mean by saying that it is produced by the action of a constant accelerating force), is as the acceleration and the time jointly. Now what we call the *angular velocity* is nothing but this momentary acceleration. Therefore the velocity v generated in the time t is $= \frac{F \cdot qG}{\int pr^2} t$.

Angular velocity.

The expression of the angular velocity is also the expression of the velocity v of a point situated at the distance 1 from the axis G.

Let z be the space or arch of revolution described in the time t by this point, whose distance from G is $=1$. Then $\dot{z} = v\dot{t} = \frac{F \cdot qG}{\int pr^2} t\,\dot{t}$, and taking the fluent $z = \frac{F \cdot qG}{\int pr^2} t^2$. This arch measures the whole angle of rotation accomplished in the time t. These are therefore as the squares of the times from the beginning of the rotation.

Those evolutions are equal which are measured by equal arches. Thus two motions of 45 degrees each are equal. Therefore because z is the same in both, the quantity $\frac{F \cdot qG}{\int pr^2} t^2$ is a constant quantity, and t^2 is reciprocally proportional to $\frac{F \cdot qG}{\int pr^2}$, or is proportional to $\frac{\int pr^2}{F \cdot qG}$, and t is proportional to $\frac{\sqrt{\int pr^2}}{\sqrt{F \cdot qG}}$. That is to say, the times of the similar evolutions of two ships are as the square root of the momentum of inertia directly, and as the square root of the momentum of the rudder or sail inversely. This will enable us to make the comparison easily. Let us suppose the ships perfectly similar in form and rigging, and to differ only in length L and l; $\int P \cdot R^2$ is to $\int pr^2$ as L^5 to l^5. For the similar particles P and p contain quantities of matter which are as the cubes of their lineal dimensions, that is, as L^3 to l^3. And because the particles are similarly situated, R^2 is to r^2 as L^2 to l^2. Therefore $P \cdot R^2 : p \cdot r^2 = L^5 : l^5$. Now F is to f as L^2 to l^2. For the surfaces of the similar rudders or sails are as the squares of their lineal dimensions, that is, as L^2 to l^2. And, lastly, Gq is to gq as L to l, and therefore $F \cdot Gq : f \cdot gq = L^3 : l^3$. Therefore we have $T^2 : t^2 = \frac{\int P \cdot R^2}{F \cdot Gq} : \frac{\int p \cdot r^2}{f \cdot gq} = \frac{L^5}{L^3} : \frac{l^5}{l^3} = L^2 : l^2$, and $T : t = L : l$.

Times of similar evolutions with similar ships.

Therefore the times of performing similar evolutions with similar ships are proportional to the lengths of the ships when both are sailing equally fast; and since the evolutions are similar, and the forces vary similarly in their different parts, what is here demonstrated of the smallest incipient evolutions is true of the whole. They therefore not only describe equal angles of revolution, but also similar curves.

A small ship, therefore, works in less time and in less room than a great ship, and this in the proportion of its length. This is a great advantage in all cases, particularly in wearing, in order to sail on the other tack close-hauled. In this case she will always be to windward and a-head of the large ship, when both are got on the other tack. It would appear at first sight that the large ship will have the advantage in tacking. Indeed the large ship is farther to windward when again trimmed on the other tack than the small ship when she is just trimmed on the other tack. But this happened before the large ship had completed her evolution, and the small ship, in the mean time, has been going forward on the other tack, and going to windward. She will therefore be before the large ship's beam, and perhaps as far to windward.

We have seen that the velocity of rotation is proportional, *cæteris paribus*, to $F \times Gq$. F means the absolute impulse on the rudder or sail, and is always perpendicular to its surface. This absolute impulse on a sail depends on the obliquity of the wind to its surface. The usual theory says, that it is as the square of the sine of incidence; but we find this not true. We must content ourselves with expressing it by some as yet unknown function φ of the angle of incidence a, and call it φa; and if S be the surface of the sail, and V the velocity of the wind, the absolute impulse is $nV^2S \times \varphi a$. This acts (in the case of the mizen-topsail, fig. 10.) by the lever qG, which is equal to $DG \times \cos. DGq$, and DGq is equal to the angle of the yard and keel; which angle we formerly called b. Therefore its energy in producing a rotation is $nV^2S \times \varphi a \times DG \times \cos. b$. Leaving out the constant quantities n, V^2, S, and DG, its energy is proportional to $\varphi a \times \cos. b$. In order, therefore, that any sail may have the greatest power to produce a rotation round G, it must be so trimmed that $\varphi a \times \cos. b$ may be a maximum. Thus, if we would trim the sails on the foremast, so as to pay the ship off from the wind right a-head with the greatest effect, and if we take the experiments of the French academicians as proper measures of the oblique impulses of the wind on the sail, we will brace up the yard to an angle of 48 degrees with the keel. The impulse corresponding to 48 is 615, and the cosine of 48° is 669. These give a product of 411 435. If we brace the sail to 54·44, the angle assigned by the theory, the effective impulse is 405 274. If we make the angle 45°, the impulse is 408 774. It appears then that 48° is preferable to either of the others. But the difference is inconsiderable, as in all cases of maximum a small deviation from the best position is not very detrimental. But the difference between the theory and this experimental measure will be very great when the impulses of the wind are of necessity very oblique. Thus, in tacking ship, as soon as the headsails are taken aback, they serve to aid the evolution, as is evident: But if we were now to adopt the maxim inculcated by the theory, we should immediately round in the weather-braces, so as to increase the impulse on the sail, because it is then very small; and although we by this means make the yard more square, and therefore diminish the rotatory momentum of this impulse, yet the impulse is more increased (by the theory) than its vertical lever is diminished.—Let us examine this a little more particularly, because it is reckoned one of the nicest points of seamanship to aid the ship's coming round by means of the headsails; and experienced seamen differ in their practice in this manœuvre. Suppose the yard braced up to 40°, which is as much as can be usually done, and that the sail shivers, (the bowlines are usually let go when the helm is put down), the sail immediately takes aback, and in a moment we may suppose an incidence of 6 degrees. The impulse corresponding to this is 400, (by experiment), and the cosine of 40° is 766. This gives 306 400 for the effective impulse. To proceed according to the theory, we should brace the yard to 70°, which would give the wind (now 34° on the weather-bow) an incidence of nearly 36°, and the sail an inclination of 20° to the intended motion, which is perpendicular to the keel. For the tangent of 20° is about $\frac{1}{2}$ of the tangent of 36°. Let us now see what effective impulse the experimental law of oblique impulsions will give for this adjustment of the sails. The experimental impulse for 36° is 480; the cosine of 70° is 342; the product is 164 160, not much exceeding the half of the former. Nay, the impulse for 36°, calculated by the theory, would have been only 346, and the effective impulse only 118 332. And it must be farther observed, that this theoretical adjustment would tend greatly to check the evolution, and in most cases would entirely mar it, by checking the ship's motion a-head, and consequently the action of the rudder, which is the most powerful agent in the evolution; for here would be a great impulse directed almost astern.

A nice point of seamanship.

We were justifiable, therefore, in saying, in the beginning of this article, that a seaman would frequently find himself baffled if he were to work a ship according to the rules deduced from M. Bouguer's work; and we see by this instance of what importance it is to have the oblique impulsions of fluids ascertained experimentally. The practice of the most experienced seamen is directly the opposite to this theoretical maxim, and its success greatly confirms the usefulness of these experiments of the academicians so often praised by us.

We return again to the general consideration of the rotatory motion. We found the velocity $v = \frac{F \cdot qG}{\int pr^2}$. It is therefore proportional, *cæteris paribus*, to qG. We have seen in what manner qG depends on the position and situation of the sail or rudder when the point G is fixed. But it also depends on the position of G. With respect to the action of the rudder, it is evident that it is so much the more powerful, as it is more remote from G. The distance from G may be increased either by moving the rudder farther aft or G farther forward. And as it is of the utmost importance that a ship answer her helm with the greatest promptitude, those circumstances have been attended to which distinguished fine steering ships from such as had not this quality; and it is in a great measure to be ascribed to this, that, in the gradual improvement of naval architecture, the centre of gravity has been placed far forward. Perhaps the notion of a centre of gravity did not come into the thoughts of the rude builders in early times; but they observed that those boats and ships steered best which had their extreme breadth before the middle point, and consequently the bows not so acute as the stern. This is so contrary to what one would expect, that it attracted attention more forcibly; and, being somewhat mysterious, it might prompt to attempts of improvement, by exceeding in this singular maxim. We believe that it has been carried as far as is compatible with other essential requisites in a ship.

Of impor ance to d termine th best place for a shi centre of gravity.

We believe that this is the chief circumstance in what is called the trim of a ship; and it were greatly to be wished that the best place for the centre of gravity could be accurately ascertained. A practice prevails, which is the opposite of what we are now advancing. It is usual to load a ship so that her keel is not horizontal, but lower abaft. This is found to improve her steerage. The reason of this is obvious. It increases the acting surface of the rudder, and allows the water to come at it with much greater freedom and regularity; and it generally diminishes the griping of the ship forward, by removing a part of the bows out of the water. It has not always this effect; for the form of the harping aloft is frequently such, that the tendency to gripe is diminished by immersing more of the bow in the water.

But waving these circumstances, and attending only to the rotatory energy of the rudder, we see that it is of advantage to carry the centre of gravity forward. The same advantage is gained to the action of the after sails. But, on the other hand, the action of the headsails is diminished by it; and we may call every sail a headsail whose centre of gravity is before the centre of gravity of the ship; that is, all the sails hoisted on the bowsprit and foremast, and the staysails hoisted on the mainmast; for the centre of gravity is seldom far before the mainmast.

Suppose that when the rudder is put into the position AD, (fig. 11), the centre of gravity could be shifted to g, so as to increase qG, and that this is done without increasing the sum of the products pr^2. It is obvious that the velocity of conversion will be increased in the proportion of qG to qg. This is very possible, by bringing to that side of the ship parts of her loading which were situated at a distance from G on the other side. Nay, we can make this change in such a manner that $\int pr^2$ shall even be less than it was before, by taking care that every thing which we shift shall be nearer to g than it was formerly to G. Suppose it all placed in one spot m, and that m is the quantity of matter so shifted, while M is the quantity of matter in the whole ship. It is only necessary that $m \cdot gG^2$ shall be less than the sum of the products pr^2, corresponding to the matter which has been shifted. Now, although the matter which is easily moveable is generally very small in comparison to the whole matter of the ship, and therefore can make but a small change in the place of the centre of gravity, it may frequently be brought from places so remote that it may occasion a very sensible diminution of the quantity $\int pr^2$, which expresses the whole momentum of inertia.

A practi of seame in puttin about explained.

This explains a practice of the seamen in small wherries or skiffs, who, in putting about, are accustomed to place themselves to leeward of the mast. They even find that they can aid the quick motions of these light boats by the way in which they rest on their two feet, sometimes leaning all on one foot, and sometimes on the other. And we have often seen this evolution very sensibly accelerated in a ship of war, by the crew running suddenly, as the helm is put down, to the lee-bow. And we heave heard it asserted by very expert seamen, that after all attempts to wear ship (after lying-to in a storm) have failed, they have succeeded by the crew collecting themselves near the weather fore-shrouds the moment the helm was put down. It must be agreeable to the reflecting seaman to see this practice supported by undoubted mechanical principles.

The evolution accelerated by additional matter.

It will appear paradoxical to say that the evolution may be accelerated even by an addition of matter to the ship; and though it is only a piece of curiosity, our readers may wish to be made sensible of it. Let m be the addition, placed in some point m lying beyond G from q. Let S be the spontaneous centre of conversion before the addition. Let v be the velocity of rotation round g, that is, the velocity of a point whose distance from g is 1, and let ϱ be the radius vector, or distance of a particle from g. We have (ROTATION, No. 22.) $v=\frac{F\cdot qg}{\int p\varrho^2+m\cdot mg^2}$. But we know (ROTATION, No. 23.) that $\int p\varrho^2=\int pr^2+M\cdot Gg^2$. Therefore $v=\frac{F\cdot qg}{\int pr^2+M\cdot Gg^2+m\cdot mg^2}$. Let us determine Gg and mg and qg.

Let mG be called z. Then, by the nature of the centre of gravity, $M+m:M=Gm:gm=z:gm$, and $gm=\frac{M}{M+m}z$, and $m\cdot gm^2=\frac{mM^2}{\overline{M+m})^2}z^2$. In like manner, $M\cdot Gg^2=\frac{Mm^2}{\overline{M+m})^2}z^2$. Now $mM^2+m^2M=Mm\times\overline{M+m}$. Therefore $M\cdot Gg^2+m\cdot gm^2=\frac{Mm\times(M+m)}{\overline{M+m})^2}z^2,=\frac{Mm}{M+m}z^2$. Let u be $=\frac{m}{M+m}$, then $M\cdot Gg^2+m\cdot gm^2=Mnz^2$. Also $Gg=nz$, being $=\frac{m}{M+n}z$. Let qG be called c: then $qg=c+nz$. Also let SG be called e.

We have now for the expression of the velocity $v=\frac{F(c+nz)}{\int pr^2+Mnz^2}$, or $v=\frac{F}{M}\times\frac{c+nz}{\frac{\int pr^2}{M}+nz^2}$. But (ROTATION, No. 30.) $\frac{\int pr^2}{M}=ce$. Therefore, finally, $v=\frac{F}{M}\times\frac{c+nz}{ce+nz^2}$. Had there been no addition of matter made, we should have had $v=\frac{F}{M}\times\frac{c}{ce}$. It remains to shew, that z may be so taken that $\frac{c}{ce}$ may be less than $\frac{c+nz}{ce+nz^2}$. Now, if c be to z as ce to z^2, that is, if z be taken equal to e, the two fractions will be equal. But if z be less than e, that is, if the additional matter is placed anywhere between S and G, the complex fraction will be greater than the fraction $\frac{c}{ce}$, and the velocity of rotation will be increased. There is a particular distance which will make it the greatest possible, namely, when z is made $=\frac{1}{n}(\sqrt{c^2+nce}-c)$, as will easily be found by treating the fraction $\frac{c+nz}{ce+nz^2}$, with z, considered as the variable quantity, for a maximum. In what we have been saying on this subject, we have considered the rotation only in as much as it is performed round the centre of gravity, although in every moment it is really performed round a spontaneous axis lying beyond that centre.

The rotation performed round a spontaneous axis.

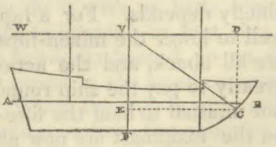
This was done because it afforded an easy investigation, and any angular motion round the centre of gravity is equal to the angular motion round any other point. Therefore the extent and the time of the evolution are accurately defined. From observing that the energy of the force F is proportional to qG, an inattentive reader will be apt to conceive the centre of gravity as the centre of motion, and the rotation as taking place, because the momenta of the sails and rudder, on the opposite sides of the centre of gravity, do not balance each other. But we must always keep in mind that this is not the cause of the rotation. The cause is the want of equilibrium round the point C, (fig. 10), where the actions of the water balance each other. During the evolution, which consists of a rotation combined with a progressive motion, this point C is continually shifting, and the unbalanced momenta which continue the rotation always respect the momentary situation of the point C. It is nevertheless always true, that the energy of a force F is proportional, *cæteris paribus*, to qG, and the rotation is always made in the same direction as if the point G were really the centre of conversion. Therefore the mainsail acts always (when oblique) by pushing the stern away from the wind, although it should sometimes act on a point of the vertical lever through C, which is a-head of C.

These observations on the effects of the sails and rudder in producing a conversion, are sufficient for enabling us to explain any case of their action which may occur. We have not considered the effects which they tend to produce by inclining the ship round a horizontal axis, viz. the motions of rolling and pitching. (See ROLLING and PITCHING.) To treat this subject properly would lead us into the whole doctrine of the equilibrium of floating bodies, and it would rather lead to maxims of construction than to maxims of manœuvre. M. Bouguer's *Traité du Navire* and Euler's *Scientia Navalis* are excellent performances on this subject, and we are not here obliged to have recourse to any erroneous theory.

Different operations of the water on the ship and wind on the sails balance each other.

It is easy to see that the lateral pressure both of the wind on the sails and of the water on the rudder tends to incline the ship to one side. The sails also tend to press the ship's bows into the water, and, if she were kept from advancing, would press them down considerably. But by the ship's motion, and the prominent form of her bows, the resistance of the water to the fore part of the ship produces a force which is directed upwards. The sails also have a small tendency to raise the ship, for they constitute a surface which in general separates from the plumb-line below. This is remarkably the case in the staysails, particularly the jib and fore-topmast staysail. And this helps greatly to soften the ship's bows into the head seas. The upward pressure also of the water on her bows, which we just now mentioned, has a great effect in opposing the immersion of the bows which the sails produce by acting on the long levers furnished by the masts. M. Bouguer gives the name of *point velique* to the point V (fig 12.) of the mast, where it is cut by the line CV ,which marks the mean place and direction of the whole impulse of the water on the bows. And he observes, that if the mean direction of all the actions of the wind on the sails be made to pass also through this

Fig. 12.



point, there will be a perfect equilibrium, and the ship will have no tendency to plunge into the water or to rise out of it; for the whole of the water on the bows, in the direction CV, is equivalent to, and may be resolved into the action CE, by which the progressive motion is resisted, and the vertical action CD, by which the ship is raised above the water. The force CE must be opposed by an equal force VD, exerted by the wind on the sails, and the force CD is opposed by the weight of the ship. If the mean effort of the sails passes above the point V, the ship's bow will be pressed into the water; and if it pass below V, her stern will be pressed down. But, by the union of these forces, she will rise and fall with the sea, keeping always in a parallel position. We apprehend that it is of very little moment to attend to the situation of this point. Except when the ship is right afore the wind, it is a thousand chances to one that the line CV of mean resistance does not pass through any mast; and the fact is, that the ship cannot be in a state of uniform motion on any other condition but the perfect union of the line of mean action of the sails, and the line of mean action of the resistance. But its place shifts by every change of leeway or of trim; and it is impossible to keep these lines in one constant point of intersection for a moment, on account of the incessant changes of the surface of the water on which she floats. M. Bouguer's observations on this point are, however, very ingenious and original.

Chief evolutions described.

We conclude this dissertation by describing some of the chief movements or evolutions. What we have said hitherto is intended for the instruction of the artist, by making him sensible of the mechanical procedure. The description is rather meant for the amusement of the landsman, enabling him to understand operations that are familiar to the seaman. The latter will perhaps smile at the awkward account given of his business by one who cannot hand, reef, or steer.

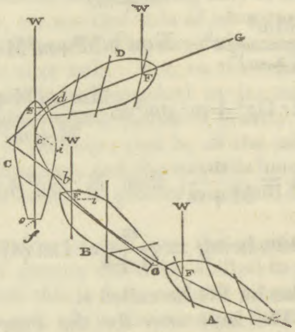
To tack Ship.

The ship must first be kept full, that is, with a very sensible angle of incidence on the sails, and by no means hugging the wind. For as the evolution is chiefly performed by the rudder, it is necessary to give the ship a good velocity. When the ship is observed to luff up of herself, that moment is to be catched for beginning the evolution, because she will by her inherent force continue this motion. The helm is then put down. When the officer calls out helm's a-lee, the fore-sheet, fore-top bowline, jib, and stay-sail sheets forward are let go. The jib is frequently hauled down. Thus the obstacles to the ship's head coming up to the wind by the action of the rudder are removed. If the mainsail is set, it is not unusual to clue up the weather side, which may be considered as a headsail, because it is before the centre of gravity. The mizen must be hauled out, and even the sail braced to windward. Its power in paying off the stern from the wind conspires with the action of the rudder. It is really an aerial rudder. The sails are immediately taken aback. In this state the effect of the mizen-topsail would be to obstruct the movement, by pressing the stern the contrary way to what it did before. It is therefore either immediately braced about sharp on the other tack, or lowered. Bracing it about evidently tends to pay round the stern from the wind, and thus assist in bringing the head up to the wind. But in this position it checks the progressive motion of the ship, on which the evolution chiefly depends. For a rapid evolution, therefore, it is as well to lower the mizen-topsail. Meantime, the headsails are all aback, and the action of the wind on them tends greatly to pay the ship round. To increase this effect, it is not unusual to haul the fore-top bowline again. The sails on the mainmast are now almost becalmed; and therefore when the wind is right a-head, or a little before, the mainsail is hauled round and braced up sharp on the other tack with all expedition. The staysail sheets are now shifted over to their places for the other tack. The ship is now entirely under the power of the headsails and of the rudder, and their actions conspire to promote the conversion. The ship has acquired an angular motion, and will preserve it, so that now the evolution is secured, and she falls off apace from the wind on the other tack. The farther action of the rudder is therefore unnecessary, and would even be prejudicial, by causing the ship to fall off too much from the wind before the sails can be shifted and trimmed for sailing on the other tack. It is therefore proper to right the helm when the wind is right a-head, that is, to bring the rudder into the direction of the keel. The ship continues her conversion by her inherent force and the action of the headsails.

When the ship has fallen off about four points from the wind, the headsails are hauled round, and trimmed sharp on the other tack with all expedition; and although this operation was begun with the wind four points on the bow, it will be six before the sails are braced up, and therefore the headsails will immediately fill. The after sails have filled already, while the head sails were inactive, therefore immediately check the farther falling off from the wind. All sails now draw, for the staysail sheets have been shifted over while they were becalmed or shaking in the wind. The ship now gathers way, and will obey the smallest motion of the helm to bring her close to the wind.

We have here supposed, that during all this operation the ship preserves her progressive motion. She must therefore have described a curve line, advancing all the way to windward. Fig. 13 is a representation of this evolution when it is performed in the completest manner. The ship standing on the course E *a*, with the wind blowing in the direction WF, has her helm put hard a-lee when she is in the position A. She immediately deviates from her course, and describing a curve, comes to the position B, with the wind blowing in the direction WF of the yards, and the square-sails now shiver. The mizen topsail is here represented braced sharp on the other tack, by which its tendency to aid the angular motion (while it checks the progressive motion) is distinctly seen. The main and foresails are now shivering, and immediately after are taken aback. The effect of this on the headsails is distinctly seen to be favourable to the conversion, by pushing the point F in the direction F*i*; but for the same reason it continues to retard the progressive motion. When the ship has attained to the position C, the mainsail is hauled round and trimmed for the other tack. The impulse in the direction F*i* still aids the conversion and retards the progressive motion. When the ship has attained a position between C and D, such that the main and mizen topsail yards are in the direction of the wind, there is nothing to counteract the force of the headsails to pay the ship's head off from the wind. Nay, during the progress of the ship to this intermediate position, if any wind gets at the main or mizen topsails, it acts on their anterior surfaces, and impels the after parts of the ship away from the curve *a b c d*, and thus aids the revolution. We have therefore said, that when once the sails are taken fully aback, and particularly when the wind is brought right ahead, it is scarce possible for the evolution to fail; as soon therefore as the main topsail (trimmed for the other tack) shivers, we are certain that

Fig. 13.



the headsails will be filled by the time they are hauled round and trimmed. The staysails are filled before this, because their sheets have been shifted, and they stand much sharper than the square-sails;[1] and thus every thing tends to check the falling off from the wind on the other tack, and this no sooner than it should be done. The ship immediately gathers way, and holds on in her new course dG.

But it frequently happens, that in this conversion the ship loses her whole progressive motion. This sometimes happens while the sails are shivering before they are taken fully aback. It is evident, that in this case there is little hope of success, for the ship now lies like a log, and neither sails nor rudder have any action. The ship drives to leeward like a log, and the water acting on the lee-side of the rudder checks a little the driving of the stern. The head therefore falls off again, and by and by the sails fill, and the ship continues on her former tack. This is called missing stays, and it is generally owing to the ship's having too little velocity at the beginning of the evolution. Hence the propriety of keeping the sails well filled for some little time before. Rough weather, too, by raising a wave which beats violently on the weather-bow, frequently checks the first luffing of the ship, and beats her off again.

If the ship lose all her motion after the headsails have been fully taken aback, and before we have brought the wind right ahead, the evolution becomes uncertain, but by no means desperate; for the action of the wind on the headsails will presently give her stern-way. Suppose this to happen when the ship is in the position C. Bring the helm over hard to windward, so that the rudder shall have the position represented by the small dotted line of. It is evident, that the resistance of the water to the stern-way of the rudder acts in a favourable direction, pushing the stern outward. In the mean time, the action of the wind on the headsails pushes the head in the opposite direction. These actions conspire therefore in promoting the evolution; and if the wind is right ahead, it cannot fail, but may even be completed speedily, because the ship gathers stern-way, and the action of the rudder becomes very powerful; and as soon as the wind comes on the formerly lee-bow, the action of the water on the now lee-quarter will greatly accelerate the conversion. When the wind therefore has once been brought nearly right ahead, there is no risk of being baffled.

But should the ship have lost all her headway considerably before this, the evolution is very uncertain; for the action of the water on the rudder may not be nearly equal to its contrary action on the lee-quarter; in which case, the action of the wind on the headsails may not be sufficient to make up the difference. When this is observed, when the ship goes astern without changing her position, we must immediately throw the headsails completely aback, and put the helm down again, which will pay off the ship's head from the wind enough to enable us to fill the sails again on the same tack, to try our fortune again; or we must boxhaul the ship in the manner to be described by and by.

Such is the ordinary process of tacking ship; a process in which all the different modes of action of the rudder and sails are employed. To execute this evolution in the most expeditious manner, and so as to gain as much on the wind as possible, is considered as the test of an expert seaman. We have described the process which is best calculated for *ensuring* the movement. But if the ship be sailing very briskly in smooth water, so that there is no danger of missing stays, we may gain more to windward considerably by keeping fast the fore-top bowline and the jib and stay-sail sheets till the square sails are all shivering. For these sails, continuing to draw with considerable force, and balancing each other tolerably fore and aft, keep up the ship's velocity very much, and thus maintain the power of the rudder. If we now let all fly when the square sails are shivering, the ship may be considered as without sails, but exposed to the action of the water on the lee-bow; from which arises a strong pressure of the bow to windward, which conspires with the action of the rudder to aid the conversion. It evidently leaves all that tendency of the bow to windward which arises from leeway, and even what was counteracted by the formerly unbalanced action of these head-staysails. This method lengthens the whole time of the evolution, but it advances the ship to windward. Observe, too, that keeping fast the foretop bowline till the sail shivers, and then letting it go, insures the taking aback of that sail, and thus instantly produces an action that is favourable to the evolution.

The most expert seamen, however, differ among themselves with respect to these two methods, and the first is the most generally practised in the British navy, because the least liable to fail. The forces which oppose the conversion are sooner removed, and the production of a favourable action by the backing of the foretop-sail is also sooner obtained, by letting go the foretop bowline at the first.

Having entered so minutely into the description and rationale of this evolution, we have sufficiently turned the reader's attention to the different actions which co-operate in producing the motions of conversion. We shall therefore be very brief in our description of the other evolutions.

To wear Ship.

When the seaman sees that his ship will not go about head to wind, but will miss stays, he must change his tack the other way; that is, by turning her head away from the wind, going a little way before the wind, and then hauling the wind on the other tack. This is called *wearing* or *veering* ship. It is most necessary in stormy weather with little sail, or in very faint breezes, or in a disabled ship.

The process is exceedingly simple; and the mere narration of the procedure is sufficient for showing the propriety of every part of it.

Watch for the moment of the ship's falling off, and then haul up the mainsail and mizen, and shiver the mizen topsail, and put the helm a-weather. When the ship falls off sensibly (and not before), let go the bowlines. Ease away the fore-sheet, raise the fore tack, and gather aft the weather fore-sheet, as the lee-sheet is eased away. Round in the weather-braces of the fore and main-masts, and keep the yards nearly bisecting the angle of the wind and keel, so that when the ship is before the wind the yards may be square. It may even be of advantage to round in the weather-braces of the main-topsail more than those of the headsails; for the mainmast is abaft the centre of gravity. All this while the mizen-top sail must be kept shivering, by rounding in the weather-braces as the ship pays off from the wind. Then the main-topsail will be braced up for the other tack by the time that we have brought the wind on the weather-quarter. After this it will be full, and will aid the evolution. When the wind is right aft, shift the jib and stay-sail sheets. The evolution now goes on with great rapidity; therefore briskly haul on board the fore and main tacks, and haul out the mizen, and set the mizen-staysail as they will take the wind the right way. We must now check the great rapidity with which the ship comes to the wind on the other tack, by righting the helm before we bring the wind on the beam; and all must be trimmed fore and aft by this time, that the headsails may take and check the coming-to. All being trimmed, stand on close by the wind.

We cannot help losing much ground in this movement. Therefore, though it be very simple, it requires much attention and rapid execution to do it with as little loss of ground as possible. One is apt to imagine at first that it would be better to keep the headsails braced up on the former tack, or at least not to round in the weather-braces so much as is here directed. When the ship is right afore the wind, we should expect assistance from the obliquity of the head-sails; but the rudder being the principal agent in the evolution, it is found that more is gained by increasing the ship's velocity, than by a smaller impulse in the headsails more favourably directed. Experienced seamen differ, however, in their practice in respect of this particular.

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[1] The use of stay-sails has been almost entirely discontinued in the navy for some years. They are still supplied, however, and the fashion of using them will probably return after a time.

To box-haul a Ship.

This is a process performed only in critical situations, as when a rock, a ship, or some danger, is suddenly seen right a-head, or when a ship misses stays. It requires the most rapid execution.

The ship being close-hauled on a wind, haul up the mainsail and mizen, and shiver the top-sails, and put the helm hard a-lee altogether. Raise the fore-tack, let go the head bowlines, and brace about the headsails sharp on the other tack. The ship will quickly lose her way, get stern-way, and then fall off, by the joint action of the headsails and of the inverted rudder. When she has fallen off eight points, brace the aftersails square, which have hitherto been kept shivering. This will at first increase the power of the rudder, by increasing the stern-way; and at the same time it makes no opposition to the conversion which is going on. The continuation of her circular motion will presently cause them to take the wind on their after surfaces. This will check the stern-way, stop it, and give the ship a little headway. Now shift the helm, so that the rudder may again act, in conjunction with the headsails, in paying her off from the wind. This is the critical part of the evolution, because the ship has little or no way through the water, and will frequently remain long in this position. But as there are no counteracting forces the ship continues to fall off. Then the weather-braces of the after sails may be gently rounded in, so that the wind acting on their hinder surfaces may both push the ship a little a-head and her stern laterally in conjunction with the rudder. Thus the wind is brought upon the quarter, and the headsails shiver. By this time the ship has acquired some headway. A continuation of the rotation would now fill the headsails, and their action would be contrary to the intended evolution. They are therefore immediately braced the other way, nearly square, and the evolution is now completed in the same manner with wearing ship.

Some seamen brace all the sails aback the moment that the helm is put hard a-lee, but the after-sails no more aback than just to square the yards. This quickly gives the ship stern-way, and brings the rudder into action in its inverted direction; and they think that the evolution is accelerated by this method.

There is another problem of seamanship deserving of our attention, which cannot properly be called an evolution. This is lying-to. This is done in general by laying some sails aback, so as to stop the head-way produced by others. But there is a considerable address necessary for doing this in such a way that the ship shall lie easily, and under command, ready to proceed in her course, and easily brought under weigh.

To bring-to with the fore or main topsail to the mast, brace that sail sharp aback, haul out the mizen, and clap the helm hard a-lee.

Suppose the fore topsail to be aback; the other sails shoot the ship a-head, and the lee-helm makes the ship come up to the wind, which makes it come more perpendicularly on the sail which is aback. Then its impulse soon exceeds those on the other sails which are now shivering, or almost shivering. The ship stands still awhile, and then falls off, so as to fill the after sails, which again shoot her a-head, and the process is thus repeated. A ship lying-to in this way goes a good deal a-head and also to leeward. If the main topsail be aback, the ship shoots a-head, and comes up till the diminished impulse of the drawing sails in the direction of the keel is balanced by the increased impulse on the main-topsail. She lies a long while in this position, driving slowly to leeward; and she at last falls off by the beating of the water on her weather-bow. She falls off but little, and soon comes up again.

Thus a ship lying-to is not like a mere log, but has a certain motion which keeps her under command. To get under weigh again, we must watch the time of falling off; and when this is just about to finish, brace about briskly, and fill the sail which was aback. To aid this operation, the jib and fore-topmast stay-sail may be hoisted, and the mizen brailed up; or, when the intended course is before the wind or large, back the fore-topsail sharp, shiver the main and mizen topsail, brail up the mizen, and hoist the jib and fore-topmast staysails altogether.

In a storm with a contrary wind, or on a lee shore, a ship is obliged to lie-to under a very low sail. Some sail is absolutely necessary, in order to keep the ship steadily down, otherwise she would kick about like a cork, and roll so deep as to strain and work herself to pieces. Different ships behave best under different sails. In a very violent gale, the three lower stay-sails are in general well adapted for keeping her steady, and distributing the strain. This mode seems also well adapted for wearing, which may be done by hauling down the mizen-staysail. Under whatever sail the ship is brought-to in a storm, it is always with a filled sail, and never with one laid aback. The helm is lashed down hard a-lee; and therefore the ship shoots a-head, and comes up till the sea on her weather-bow beats her off again. Getting under weigh is generally difficult; because the ship and rigging are lofty abaft, and hinder her from falling off readily when the helm is put hard a-weather. We must watch the falling off, and assist the ship by some small headsail. Sometimes the crew get up on the weather fore-shrouds in a crowd, and thus present a surface to the wind.

These examples of the three chief evolutions will enable those who are not seamen to understand the propriety of the different steps, and also to understand the other evolutions as they are described by practical authors. We are not acquainted with any performance in our language, where the whole are considered in a connected and systematic manner. There is a book on this subject in French, called *Le Manœuvrier*, by M. Bourdé de Ville-Huet, which is in great reputation in France.

We offer this account of the subject with all proper respect and diffidence. We do no profess to teach; but by pointing out the defects of the celebrated work of M. Bouguer, and the course which may be taken to remove them, while we preserve much valuable knowledge which they contain, we may perhaps excite some persons to apply to this subject, who, by a combination of what is just in M. Bouguer's theory, with an experimental doctrine of the impulses of fluids, may produce a treatise of seamanship which will not be confined to the libraries of mathematicians, but become a manual for seamen by profession.[1] (B.B.B.)

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[1] There are several good treatises on seamanship in English; but we think the whole topic has become of sufficient importance to deserve still more literary attention than it has yet received; and we are persuaded that a well-digested, and well written marine dictionary, scientific, practical, and popular, if sufficiently copious, and undertaken by a competent hand, would be considered a great boon, not only to seamen, but to the society at large of this essentially maritime country. The most approved works on seamanship in English are the following: Falconer's Marine Dictionary; Darcy Lever's Seamanship; Theory and Practice of Seamanship, by Richard Hall Gower; Griffith's Practical Hints; Nicholson's Seamanship; Steel's Elements and Practice of Rigging, Seamanship, and Naval Tactics. The most recent works on Seamanship with which we are acquainted, are the following: Captain Glascock's Naval Officer's Manual; Lieutenant Martelli's Naval Officer's Guide, and Lieutenant Fordyce's Outlines of Naval Routine. Many useful practical hints may also be derived from the perusal of James's Naval History. The best foreign writers on Seamanship and Tactics, are Pere Hoste, Morogues, Byland, Bourdé, Lescallier, and Grenier.

The foregoing article having been written by the celebrated Professor John Robison, it has been thought proper to reprint it exactly as it left his hands, with the addition of one or two notes explanatory of circumstances which the lapse of time has rendered obscure. This course has been adopted chiefly out of deference to the high authority of the author, which must render it a measure of questionable propriety to retouch, or otherwise alter, or try to improve, an essay which, at the time it was written, must have been considered as complete. But the interests of the readers of this Encyclopædia have also, it is believed, been considered in this matter, since any additions or interpolations made in an article composed with the care which marks every thing from the pen of Professor Robison, might so materially have altered the texture of the fabric, as to divest it of much of its beauty as well as utility. We have, indeed, the means of knowing that the article, as it stands, has been of extensive practical utility; and every admirer of simple, and at the same time vigorous writing, clear and straight to the purpose, must be well pleased to know that no attempt has been made to improve a style which is matchless.

At the same time it is manifest, upon a moment's reflection, that even the most general view of such an art as Seamanship, written more than forty years ago, cannot possibly include many things which it is material should be adverted to. This science, as it may now fairly be called, has greatly advanced within that period. With the improvements which have been made in most other departments of industry and knowledge, the public are more or less familiar, and great pains have been taken throughout this work to extend that familiarity by such popular explanations as shall not only be intelligible to general readers, but be useful to those whom pleasure or business inclines to go deeper. But the art or science of Seamanship, call it which we please, has certainly been too much kept out of sight of late years; and it is the purpose of this Appendix to supply, in a brief space, the deficiency complained of by many persons, whose habits entirely unfit them for gaining the knowledge for themselves, and yet, who are perfectly competent to understand, as well as to appreciate, the value of such information, when stated in clear language.

Most other sciences may be studied with effect in the closet. An amateur astronomer, for example, or a chemist, furnished with good instruments, and having confidence in the skill and good faith of the leaders in the particular walk of knowledge to which his taste inclines him, may, by adopting their results, pursue the same paths with almost equal profit, and perhaps with more pleasure than those who take all the labour, and incur all the responsibility. But there is no royal road of this sort, by which an amateur sailor can investigate the results of seamanship, the mysteries of which, to be fully understood, must be studied afloat, at sea, in all weathers, and in every climate.

All the world, however, knows that the results of nautical skill and exertion are not the same as they used to be. A voyage to India and back, in former times, occupied a couple of years, or more; it is now currently done in nine months, even by ordinary merchant vessels, including the time taken to unload and reload their cargoes. In former days, the scurvy struck down half the crew of every ship which made a long voyage, and was even fearfully prevalent in the navy; now the disease is almost unknown. The numbers of all kinds of ships afloat have enormously increased, and the war of the elements by which they were formerly assailed is no less violent than it was; but assuredly a far smaller proportion of vessels are now driven on shore than were formerly wrecked. The comforts, too, of travelling by sea, in the articles of provisions and water, are all essentially improved; and, finally, the security, as well as the happiness of all persons on board, whether passengers or crew, has been marvellously augmented by the general establishment of a better system of discipline than was known in bygone days; whilst many old manipulations of seamanship are so modified by new contrivances, that if old Benbow, or even Kempenfelt, were to arise from the dead, he would scarcely know how to handle his ship.

It may not be without use, and it certainly must be interesting, to those who have not studied such things personally, to see by an example how scientific seamanship is made to triumph over that groping and blundering method of navigating ships which is technically known by the name of the "rule of thumb." If we take a globe, and trace on it the shortest route, by sea, to India, and then fancy that such must be the best course to follow, we shall be very much mistaken. And yet this is very much what our ancestors actually did, till time, and repeated trials, and multitudinous failures, gradually taught them where to seek for winds, and how to profit by them when found. According to the "rule of thumb" sailing, a ship had only to steer from England to Madeira, pass the Canaries and Cape de Verds, and then to make a direct course to the Cape, and thence to India. On trial, however, this experiment always failed; for on getting near the equator, a series of calms and squalls put a stop to this straight-line scheme, and the mariners of old were then forced to toil along the coast of Africa, or were driven towards that of the Brazils, and very often they came back in utter hopelessness. Now-a-days, the exact spot where the north-east trade wind, which prevails in the northern Atlantic, ought to be parted with; in what district the calms and variables are most easily managed; over what degree of longitude on the equator the ship should pass; and, finally, in what place the south-east trade wind of the southern Atlantic is to be found, and how it is to be made most use of when found; are all matters of such familiarity to the really qualified navigator, that they scarcely occupy his thoughts, but are acted upon as matters of course, and, unless some unforeseen accident occurs, absolutely ensure the success of his voyage. The line he follows, however, is by no means the straight one which an ill-informed person would naturally have chalked out for him to follow, ignorant of the impossibility of pursuing it.

The modern navigator, by not seeking to husband the south-east trade wind too much, but by freely "flanking" through it, sweeps past the coast of Brazil, and by boldly dashing down into pretty high south latitudes, is certain, or almost certain, of finding there such a vein of westerly wind, as amply compensates for the apparent roundabout he has made in his course. In like manner, after passing the Cape, which to the old navigators was truly a "Cabo de tormentos," instead of vainly trying to reach India, by steering straight through the Mozambique channel, the scientific navigator, disregarding the increase of distance, maintains his position in a high latitude, and sails resolutely along a parallel of latitude, with the wind in his poop, till he has obtained such a degree of easting, that, on hauling up to the northward, and making for the south-east trade wind, he enters that mysterious aërial current on such terms as ensure his making it serve his purpose. If, however, he be timid or impatient by nature, and not duly instructed by experience, he will be very apt to haul up too soon to the northward, from not liking to run, as it appears, so far past his port. The consequence will be, that when he encounters the south-east trade-wind, he will find, that instead of its being fair, it is blowing in his teeth, and he will have to run back again to the southward to borrow a little more easting from the westerly breezes which prevail there.

Be it observed, however, that the above instructions would lead a seaman into great error, were he to make the rule absolute; for, at certain seasons of the year, that is, when the sun is far to the north of the line, and the south-west monsoon blowing in the Indian ocean, his course from the

Cape to India would lead him between Madagascar and the main land of Africa; and so he would sail across the equator, and enter the Bay of Bengal with a flowing sheet. At other seasons, so far from having a flowing sheet on reaching India, he may have to beat up the bay, "hank for hank," unless he has knowledge enough to know at which side to enter it, and skill enough,—for it requires a good deal,—to know how to profit by the land and sea breezes of the coasts respectively of Coromandel and of Pegu.

In short, not to swell this example too far, the truly scientific navigator, possessed of the requisite nautical instruments, (the most important of which we propose to speak of by and by), by which means he may at all times be certain of his place, may almost command a fair wind at every stage of his voyage, and thus secure his passage within a certain number of days; though, in his way, he will have had to vary his course a hundred times from that which, at first sight, might have been thought the best, merely because, on the map, it seemed the shortest. The old proverb, indeed, which warns us that the longest way about is often the shortest way home, has perhaps its amplest illustration in the practice of modern seamanship; but, let it be always borne in mind, that this is true only when all the varying circumstances of time and place are duly taken into account, and so appropriated as to give to the ship those advantages of fair wind and moderate weather, without which no voyage can be securely or speedily made. This branch of seamanship, therefore, more than any other, requires for its successful exercise a singular combination of the widest generalizations in theory, with the most minute and specific disintegrations of scientific research in practice. In the Indian seas especially, the whole history of the winds, examined without some theoretical clue, is a mass of confusion; and yet the profoundest meteorological science would inevitably prove not only useless, but absolutely dangerous to the navigator who should trust to it alone, without the aid of local information, and of the improvements of modern art.

These remarkable improvements are due to the spread of knowledge over the sea, as well as over the land; and it is proposed here, to examine a few of the causes which have led to such valuable results in the practice of seamanship, as they will all be found to fall readily under that great head. For detailed practical information, of a kind which might be useful to a sailor in the actual working of a ship, we must of course refer to the precise heads which treat professedly of these things, such as Anchors, Astronomy, Cables, Capstan, Navigation, Rope, Ship-building, Steam-Vessels, and so forth, the purpose of this Appendix to the article Seamanship being merely to point out, in a very general, but by no means superficial manner, the most important improvements which have been introduced afloat since the preceding article was written.

It will not be expected that much should be said here of the mighty revolution in nautical affairs brought about by the introduction of steam; for that subject demands, and has received the fullest attention in its proper place. We shall merely observe, that steam does not essentially interfere with seamanship proper, almost all the manipulations of which remain as before; whilst steam navigation, in spite of its boasted contempt of wind and tide, is still obliged to borrow so much from seamanship to complete its success, that without its aid it would often be useless, and even dangerous in the highest degree. We shall take occasion as we go along, to point out some of the most remarkable occasions in which the old system of seamanship proper is essential to the method by steam; merely remarking at present, that nearly all that branch of our subject which relates to navigation, that is, to the method by which a ship's place is determined at sea, the proper course shaped, and the different ports of the world recognised and made use of, remains the same. Latitudes and longitudes, and the variation of the compass, are evidently just as important to a steam vessel as to a sailing one; and though winds and currents are not quite so essential, every one who has made a steam voyage of any length, is aware how materially its celerity depends upon a knowledge of and due attention to these particulars. It is one of the chief points of a seaman's duty to know where to find a fair wind, and where to fall in with a favourable current; but the obligation, if not equally binding on a steam navigator, is almost so, when his voyage is a long one. The most remarkable occasions on which steam has the advantage over sails are, in a calm, and when the wind is directly ahead. In a calm, a sailing ship is utterly helpless, and must stand stock still; with a wind in her teeth, if it blow hard, she can do nothing, or does worse than nothing, drifts away from her point. There is another important occasion on which a steam vessel, if properly handled, has a wonderful advantage over an ordinary ship, and we advert to it, first, because we do not remember to have seen it mentioned before; and, secondly, because it involves some considerations of true seamanship, which it is the business of this Appendix to dwell on.

We allude to the formidable danger of a lee shore, in a gale of wind, when we shall suppose the weather to be such that a ship and a steam vessel are both obliged to anchor, and that from the anchor not holding, or the insufficient strength of the cables, there is risk of their being forced on the shore. In this predicament, we have heard of a steam vessel, by the mere agency of her steam, not exerted to any great extent, either keeping her cable slack, or very materially relieving it from the strain produced by the wind. But even supposing her stock of fuel expended, or that her machinery had got out of order, she may still be looked upon as a ship with her masts cut away, which, we may explain to unprofessional readers, is the most favourable condition for a ship to be in, under such dangerous circumstances. It may be asked, and with great reason, why, if this be so, should not the ship when in danger of driving on the rocks, also get rid of her masts, by cutting them away, and so place herself in as favourable a position as the steamer, on the lee shore? To this we answer, that the operation of cutting away the masts is always a very serious one, and, like the amputation of a limb to a labouring man, is not to be resorted to till the last extremity. Besides, it is often a matter of doubt, which is the last moment of safety, and the first of extreme danger; and as the commander of the ship may not have had experience of such critical cases, he may, and too often does, hesitate to dismember his vessel, till the anchor comes so rapidly home, that cutting away the masts will not stop her headlong way amongst the breakers; and then it is too late. The steam vessel, however, is *already*, and at all times, in the best condition for anchoring on a lee shore. We ought here to mention to our unnautical readers, in what consists the advantage of cutting away the masts, when a ship is in this situation, and is in danger, from the violence of the wind, of being drifted on the rocks. It is well known that the mere hull of a ship, placed with the bow to the wind, offers but a small resistance to the wind, compared to what is presented by the masts, yards, ropes, and sails; for though the sails be furled, they are generally, on such occasions, but clumsily handed, and hold much wind. The form of a ship's bow is equally adapted, or nearly so, to passing through the air as through the water, and the area offered by it to the wind is very small, compared to that which the "top hamper," as it is called, presents. Let any one in a gale of wind on board ship take hold of the smallest rope, the signal haulyards, for example, and he will find it requires a considerable exertion of his strength to prevent its being blown out of his grasp, and in proportion as the rope is large, so is the violence of the wind upon it. And when the immense number, and great length of the whole ropes of a ship are taken into account, to say nothing of the resistance of the lower masts and top-masts, and the yards, however sharply braced to the wind, we shall be satisfied that the resistance aloft is many fold greater than that which the hull alone offers to the wind. Accordingly, the prodigious additional security which is imparted to a ship on a lee shore by cutting away the masts, is well known to practical seamen. This conviction, resting on the ever energetic mind of Nelson, though within a few minutes of his last breath, was the true source of the last order he ever gave, "Hardy, anchor the fleet."

Whilst speaking of the comparative merits of steam vessels and ordinary ships under a stress of weather, it may be mentioned, that as steamers are furnished with very reduced masts and yards, they are in the most favourable position for making sail in a gale of wind, should sailing then be possible. In other words, a sea-going steamer, though comparatively much undermasted, is enabled, in a storm, to spread quite as much canvas as could be carried with advantage, in a sailing ship of her size, at that particular moment. It must be remembered, that the sailing vessel, in order to be able to make way in fine weather, is obliged at all times to carry with her, and to expose permanently aloft, an extent of masts and yards which is very detrimental to her progress in bad weather; whilst, on the other hand, the steamer stows away her fine weather power under hatches in her coal boxes, till the time returns when it can be used with advantage.

To return to the improvements introduced into the art of seamanship by the skill and science of late years, we may begin by adverting to the remarkable advantages which have been gained by the extensive use of iron on board ship.

In the year 1808, Captain Brown of the navy proposed the use of iron cables and rigging; but it was not till 1811 that the cables were fairly tried. They have since been used universally, and no greater boon was ever bestowed upon the sea service. The original cost of a chain cable is not much more than that of a hempen one, whilst its durability is greater, in a ratio which cannot be stated in figures. The security afforded by it is vastly greater; for it is exposed to none of the deteriorating causes which render a hempen cable, after much use, comparatively so little trust-worthy. The alternate wetting and drying, which saps the strength of a hempen cable, has no effect on one of iron. The friction against rocks, especially against coral, is often fatal to a hemp cable in a few minutes; but the same friction, after weeks of hard use, only slightly polishes a few links of the chain. In tropical countries, therefore, the introduction of chain cables has increased the security of ships at anchor tenfold; but in every climate their advantage is immense. Nor does this advantage consist solely in their strength and durability, for they are managed with much more facility, occupy far less space, and are coiled away with little, or it may be said, no trouble at all; for as they are hove in, they fall quietly into, and adjust themselves, in a box or case near the hatchway, from which they are drawn up when wanted with comparatively small labour. To those who remember the toil and trouble of "forming a bend" in the cable tier, the wet and the dirt, and the noise made by the numbers of men required to coil it away, these advantages will not be considered as small ones.

Several adaptations have been found necessary in consequence of the use of chain cables. The hawse holes require to be filled with strong cases, or tubes of iron; and a most ingenious and powerful stopper has been contrived by the late great and good Sir Thomas Hardy, (the ablest seaman we probably ever had in this country of seamen), by which the cable can at any time be prevented from running out, whatever be the strain upon it. This stopper consists of a large swan-necked bar of tough iron, which embraces the cable as it comes up the hatchway, having one of the ends of the curve fixed to the beams of the lower deck, by means of a powerful bolt, whilst to the other end is attached a tackle, also worked on the lower deck, by which this curved stopper can be drawn tight, and the chain pressed so firmly in its embrace, against the angle of the hatchway, that however quickly it may have been running out, or whatever strain may be brought on it, the cable is arrested almost immediately.

Iron cables require a peculiar but easily-learned description of management. They cannot, for example, be used in deep water, without some modification; for their weight, added to that of the anchor, is so great, that the labour of heaving up becomes prodigious. To remedy this evil, and yet to profit by the security which belongs to rendering invulnerable that part of the cable most exposed to friction by rocks, a device was suggested by admiral the Honourable George Elliot, which having been found to answer the purpose, is now generally adopted. An eye, with a thimble in it, is formed at the end of a hempen cable, and to this is shackled, in the usual way, one of the lengths of the chain. The outer end of this length of chain being then shackled to the anchor, the cable may be used in any depth of water, with nearly as much security as if it were made of iron from end to end, and with only the inconvenience arising from the additional weight of one length of chain. Another device has lately been introduced, which many seamen prefer. This consists of three-tapered tails of small chain, shackled to the main one, by which it can be spliced with ease and security to the hempen cable, with the strands of which it is "married" in the usual way. One advantage of chain cables is, that a ship may often lie at single anchor, without risk of fouling the anchor. If the scope of chain be too short, the tides strong, and the ground either of sand or of smooth and hard materials, there will be nearly the same risk of fouling the anchor as with a hempen cable; but if the scope be long, the tides not very impetuous, and, above all, if the ground consist of mud, there is scarcely any chance of this troublesome and dangerous accident happening. It may be proper to explain, that "fouling the anchor" means the entanglement of the cable with its flukes, or other parts, by which its power of holding the ground is destroyed, or so materially lessened, that when a strain is brought on it, the anchor slides along the bottom, and consequently the ship is no longer held firmly.

Any one who looks at an anchor will perceive that it consists of three principal parts, lying at right angles to one another. 1st, The arms or *flukes*, which form a sort of half-moon, from the *crown* or middle point of which springs; 2d, the *shank*, a long, straight, and very strong bar of iron, firmly welded to the crown at one end; whilst the other is passed through, and is firmly, grasped by the 3d part, viz., a stout beam of wood, called the *stock*. The end of the shank, which projects several inches beyond the stock, is fitted with a strong shackle, (formerly with a ring, when hemp only was used), to which the chain is attached. As long as the cable pulls the anchor by means of this shackle at the end of the shank, the anchor does its duty, and resists the effort to move it along the ground; and if the bottom be soft, the strain of the cable has even the effect of making the bill, or point of the lower fluke bury itself more and more deeply. The purpose of the stock, or long wooden beam which crosses the shank, is to force the anchor to assume its proper position, or that best adapted to its digging one of its flukes into the ground. This important purpose is effected by the tendency which the stock has to lie flat, that is, horizontally on the ground; a position, it will be observed, necessarily implying that one of the flukes is up, and the other buried beneath the surface of the bottom; so that if, by accident, the anchor, when first let go from the ship's bows, should rest on the ground with one end of the stock sticking up, and the other down, which would bring the flukes flat, or horizontally on the bottom, a position in which they would have no hold whatever, a slight strain on the cable puts all to rights, by tumbling the anchor over, so as to bring the stock into its true position, namely, flat on the ground, and of course the flukes upright. This tendency is the obvious consequence of the stock being so much longer across than the flukes are, which naturally causes the anchor to tumble over into its right position, whenever the stock is not lying flat, as it ought always to do.

For many years after the introduction of chain cables, hempen messengers were used to heave them in; now chains are almost universally used, and a great expense saved. The messenger is the endless rope which passes round the capstan, and being attached to the cable by what are well called nippers, draws in the cable along with it as the capstan is hove round. Iron nippers, too, must soon become universal. Chain slings for the lower yards have long been in use, and of late years chain topsail sheets, and chain ties, have been introduced, as well as chain gammoning for the bowsprit, and chain bobstays, which are great improvements.

Attempts are now making, and we feel convinced that they will ere long succeed, to introduce iron *wire* rigging, which we consider as stronger and better than chain, because less dependent on the accidental quality, and careless manufacture of a single part. And here we cannot help remarking, how strange it is that the plan of making iron bridges of wire, so successfully adopted in Switzerland, France, and elsewhere abroad, should not yet have found such favour in England as to be fairly tried. The noble bridge of Freyburg in Switzerland, is several hundred feet wider than the Menai bridge, and though it consists of but one span, it is equally strong, if not stronger, and has cost not a fifth part of the money. We do not think wire will answer for running rope; but for standing rigging it may, we conceive, be most usefully substituted for hemp.

The use of iron ballast, instead of dirty shingle, is also a recent, but valuable improvement, and though the first cost is greater, it very soon overpays itself. Iron ballast was first officially established in the navy about the year 1796.

The next most important use of iron is in a department of seamanship which is by no means to be lightly treated of, we mean the watering and provisioning of ships. The introduction of iron tanks into the navy and merchant service has in many ships doubled, and in all very greatly increased, the quantity of water which can be carried to sea; whilst the quality has been improved in a manner, of the extent and blessing of which no one can form an idea, unless he carries in his recollection the filthy stuff which it was so often the lot of seamen to drink in bygone days. The following statement shews, in a rough way, the gain of stowage.

The cask called a butt occupies about 35 cubic feet of space in a ship's hold, and this space, if it were entirely filled with water, would contain 217 gallons. A butt, however, actually holds only 108 gallons, so that one-half of the space is lost by the thickness, and by the form of the cask, which is the worst possible for stowage, so far as room is concerned. An iron tank, of the largest kind at present made for ships of war, is called a four-feet cube, though it measures about an inch more in its external dimensions, and occupies 68 cubic feet of space. This area, if entirely filled with water, would contain 424 gallons, but it actually holds 400, which is only 24 gallons less than the space could possibly contain. In other words, by using casks, you lose eight-seventeenths, or nearly a half, of the stowage room, whilst by using tanks you lose only one-seventeenth.

A farther increase in the stowage of water is gained by having iron tanks made either of a wedge, or of a flat form, to suit the curve of the ship's hold, or to enter spaces too low to receive cubical tanks.

A single example of the change which took place in a line-of-battle ship, will shew the gain effected by employing iron tanks instead of casks. The Melville, of 74 guns, when fitted with casks, stowed, of water, 47,624 gallons, or $212\frac{1}{2}$ tons. But when iron tanks were substituted, she stowed 88,232 gallons, or 394 tons, or about four-fifths more water. Thus, if the Melville, with a crew say of 600 men, at a gallon of water each per day, could keep the sea for only 80 days, or not quite *three* months, if it were kept in casks, she might carry, at full allowance, 147 days water, or very nearly *five* months, if it were stowed in iron tanks.

We have recently heard of some ships in which the bread, and other dry provisions, were stowed in iron tanks, with great advantage, not only in respect to stowage, but in preserving the provisions from decay. In hot and damp climates this becomes a primary consideration; and we know of a ship of war which, during the long and arduous campaign against the Burmese, by keeping her dry provisions in tanks, effectually excluded from the air, preserved the whole of her bread, flour, pease, cocoa, and rice, in the most perfect condition; whilst in most of the other vessels a large proportion of all the dry provisions were either decayed and rendered useless, or were eaten up by weavels and cockroaches, in spite of every care, greatly to the inconvenience of the public service.

This recalls to our recollection the preserved meats, soups, and vegetables, in cylindrical tin cases, first devised, we believe, by M. Appert, a Frenchman, and now in general use at sea. These meats are expensive, no doubt, but in the long run they often prove not so costly as live stock, because they eat and drink nothing. In all her Majesty's ships, these preserved meats have long been supplied to the sick; and we are of opinion it would be sound economy to serve them out once or twice a-week to the ship's companies generally.

The next most material change for the better, to which it is our duty to advert, in speaking of seamanship in the most extensive sense of that word, relates to the manner in which all ships are now navigated from port to port, and to and from the most distant parts of the globe, not only with far greater celerity, but with much greater safety than formerly. This truly wonderful improvement which has of late years been introduced into the art of seamanship, in shortening voyages, and adding to their security, as well as certainty, is due, mainly, first, to the superior knowledge of the persons in charge of ships; secondly, to the improved quality, lower cost, and greatly increased number of scientific instruments and astronomical tables, now in the hands of every seamanlike officer; thirdly, to the numbers, accuracy, and cheapness of the charts of almost all the navigable regions of the globe; and, lastly, to the more extensive and correct knowledge of the phenomena of the winds, weather, currents, and tides of the ocean. To these vast helps, which every sailor may now avail himself of, almost mechanically, there may be added others which those only can profit by, who, to long experience, add a taste for science, which not only sharpens the observation, but enables an expert navigator to appropriate to the purposes of his voyage, the thousand and one variations to which the elements are subject, but which no books, no rules, nor even talents, can effectually teach the mere seaman how to apply. Nothing, indeed, is more difficult in the practice of this branch of seamanship, than removing from the mind of an old sailor erroneous impressions as to fact, even when substantial means of correction are lying on his table. The truth is, the navigable world is so wide, the phenomena of nature so grand and varied, that until we are schooled by actual experience, we have not the means of grasping a sufficient number of observations at once, to enable us to generalise them into a practical shape, in the complicated art of seamanship.

In the first rank of modern instruments used at sea, stands the Sextant, not the old wooden quadrant of our grandfathers, and even some of our fathers in the art, but the brass sextant of Troughton, Dollond, or Cary, divided to ten seconds, and capable of taking lunar distances with precision. With such an instrument in his hands, and with such a nautical almanac as ours now is, there is no magician in fairy tale, who could cope with a well-practised seaman in the performance of miracles. What human feat, we will ask, can exceed in wonder the exact determination of a ship's place in the midst of a boundless ocean, a thousand miles from land? This marvellous quality of exactness, or rather, we should say, of infallibility, within certain appreciable limits, distinguishes the Sextant from all other nautical instruments. Its operations are connected with those of the sun, moon, and stars, and, by the nature of its construction, partake of their certainty; whereas the Chronometer, which stands the next in order of importance, is essentially a fallible instrument, and, though eminently useful in the navigation branch of seamanship, and much more nice in its determinations, can never be depended on as the Sextant can. These two instruments are admirable allies, but neither is sufficient, if used without the other, to meet the wants of modern navigation. A Chronometer may, and often does, change its rate, and thus it may deceive, instead of instructing, the mariner, without his having any suspicion of its misleading him, and though the chances of its doing so without detection are much lessened, by adding two or three more chronometers, still there never can be any certainty in the results. On the other hand, the errors of a Sextant lie all within the reach of detection and appreciation. They cannot, it is true, theoretically speaking, be fully corrected, yet they may be sufficiently compensated for in practice, which is all the seaman need care about. A single illustration will make this plain, even to those who have not attended to such subjects.

The longitude is found by measuring with a Sextant the angular distance between the moon and a star; and if the instrument used were perfectly correct in all its adjustments, true in its centering and its graduations, and the distance were properly observed, the result would be quite correct. But experience proves that every instrument, even after all the adjustments have been made as carefully as possible, does, in fact, measure the angle either too great or too small; and, consequently, the longitude which results from it will inevitably be too far east or too far west. The manner in which this evil is got rid of, is as follows. If the ship be in west longitude, and star observed lie to the *eastward* of the moon, and the sextant measures the angular distance *greater* than the truth, the resulting longitude will be less than the truth. If another star be now observed, lying to the *westward* of the moon, and the same instrument is used, the distance will, as before, be measured *greater* than the truth, but the resulting longitude will in this case be just as much *greater* than the truth, as the first result was *less;* but the mean of the two will of course be near the true longitude. By using a Sextant in this manner, and by taking a sufficient number of observations on both sides of the moon, when the distances are nearly the same, so close an approximation may be made to the true longitude, that not only may the ship's place be found near enough to steer by, but the errors in the rates of the Chronometers on board may be ascertained, and a fresh departure be taken, with nearly as much confidence as if a well-known headland had been seen. For all short voyages, such as those between port and port in the same country, Chronometers may be pretty confidently reckoned on, since the chances of their varying from their previously ascertained rates, in the course of a few days, are proportionally small. In like manner, the intermediate short runs made by the agency of the Chronometers, between lunar and lunar taken at sea, may be relied upon in practice.

Our neighbours the French, who are excellent navigators, use the reflecting and repeating circle much more than we do; but we have no hesitation in recommending the Sextant as much the superior instrument of the two for real work. Theoretically, no doubt, the circle is more perfect; but it has disadvantages which, after very long experience, we confidently affirm, render it less useful to a seaman than the sextant. In the first place, its weight, and above all, the surface it offers to the wind, render it more fatiguing to use, especially in bad weather. In the next place, its radius being much shorter than that of a sextant, the divisions on the limb are far less easily read off; a serious objection to the use of a circle at night, when every practised seaman knows that the best work in lunars is always done. If Troughton's circle with three verniers be used, which implies six readings for every complete observation, the labour is highly irksome; but even if the repeating circle be used, the risk of error, by the nicety of the manipulations, and the uncertainty of the adjustments, are, we have always found, an overmatch for the simplicity of the single reading off at the end. In short, we are sure that under the troublesome variety of circumstances which are to be encountered at sea, a well practised navigator, with a sextant in his hand, will do twice as much good work in a given time, as he could do with any description of circle which we have had the good fortune to use. On shore, indeed, the circle may often be used with greater effect; but our present purpose is to treat of seamanship.

The next in order of importance in the list of nautical instruments, after the Sextant, is the Chronometer; an instrument to which modern seamanship is indebted for very great service. We are old enough to remember when Chronometers were not only not in general use, but were rarely employed except on voyages expressly scientific. It is difficult to describe the degree of mortification, we may almost call it grief and indignation, with which practical men, skilled in the use of such instruments as we have been describing, and fully aware of their importance in adding to the security of ships, and shortening voyages, witnessed the contempt, or at least the neglect with which they were treated by those most interested in their general adoption. They saw vessels fitted up with every other description of costly equipments, with accommodations of the most showy description, and stores of all kinds in profusion, while neither a Sextant nor a solitary Chronometer ever formed, except accidentally, a part of their provision. If the captain *happened* to know any thing about such matters (for he was not required to do so), and knowing how advantageous they were to the success of his voyage, asked to be supplied with them, he was told "that he might provide himself with these instruments if he liked it;" and if the poor man could not afford to purchase them, the ship, however valuable, was actually allowed to sail away without the most important part of her nautical equipment. Can any absurdity, or, we might almost add, any crime, equal this? We could relate several instances, some of which have fallen under our own knowledge, and others we know to be well authenticated, of ships, and all their crews, passengers, and cargo, being lost, demonstrably so, merely from the want of a Chronometer, which, by costing the owners forty or fifty pounds, might have saved them as many thousands. Some owners are influenced by a petty spirit of economy, ill understood; but by far the greater number are misguided by their ignorance. Happy should we feel could we persuade the owners of ships, and those who insure them, to see that their best interest lies in providing the vessels, in the safety of which they are so deeply interested, with proper scientific instruments, and, as a necessary concomitant, securing the services of commanders really competent to use these instruments in a seamanlike manner. The importance of all such enlarged considerations has of late years been gradually making its way, to the great improvement of seamanship; for the owners of ships have begun to find out, less from any scientific knowledge of the matter, than from the mere instinct of gain, that an attention to this branch of a ship's outfit contributes to their pecuniary profit, and that if it is really worth while to provide Sextants and Chronometers, it is not less so to place them in hands trained to their use. Thus the standard of the characters of commanders of vessels is raised in proportion as their scientific acquirements are advanced, and, in the end, the whole community is benefited, by the increased security, expedition, and profits of commercial enterprise.

When enumerating the scientific instruments which have been introduced into the art of seamanship, we must not forget the Marine Barometer; an instrument, the principle of which, so long well known on shore, has only very lately been adapted to sea uses. This adaptation is accomplished in the simplest way imaginable, by merely contracting the throat of the tube which holds the mercury, at some convenient point of its length, in such a degree, that the oscillations of the fluid which the motions of the vessel would otherwise cause, are so much checked, that the height of the column can be observed, if not quite as accurately as on land, at least with sufficient precision to give the seaman indications of changes in the winds and weather.

We must repeat once more that it is not our purpose to write a complete treatise on seamanship, but merely to give a sketch of the most material advances which have been made since the Encyclopædia was first published, in this thoroughly practical science. It will be enough, therefore, to mention that the use of the barometer at sea consists in giving the seaman information, before hand, of the changes likely to take place in the direction as well as force of the wind; or, which is often fully as useful, to let him know that, in spite of appearances to the contrary, there will be no change. Cases intelligible to unprofessional persons may easily be furnished by any seaman's memory. We remember once, rounding the Cape of Good Hope, on a voyage from China, in a crazy bark, short-handed and ill-found, but with a fair wind, and the weather so moderate that every sail could be carried with advantage. To all appearance, squally, and perhaps stormy, weather was coming on; so that, had we not possessed a barometer, ordinary nautical prudence would have induced us to shorten sail before night, and thus we should have lost the charming fair wind which was co-operating with the current to sweep us rapidly across the bank of Lagulhas. But as the mercury indicated a continuance of fine weather, we carried on, sent the people to bed, rounded the Cape in safety, and reached the trade winds in time to accomplish a successful voyage to St. Helena and home. Nearly in the same region, and under circumstances very similar, we were once grievously tempted to trust rather to appearances than to the more substantial assurances of the barometer, and on the approach of night to make more sail instead of taking it in. As the darkness began, however, the confidence and pride of personal experience gave way to the warnings of the instrument. The sails were reefed, and every thing made snug for a breeze, greatly to the surprise of the sailors, who saw no cause for these precautions. Towards midnight a gale came on, which, had it not been anticipated, would speedily have taken in our sails for us, by blowing them from the yards; and the success of the voyage in this case also was chiefly due to the barometer.

Without dwelling further on this tempting branch of the subject of seamanship, we may venture to give one practical recommendation, which may possibly prove useful both to the owners and commanders of ships. It is, that as much responsibility as possible should always be made to rest on those instrumental parts of the equipment which science, and an adequate experience of its application, show to be really useful. Thus, we would have the owner of a ship, free, and even generous, in his supply of sextants, chronometers, barometers, and charts, to his captain, sure that, if he be chosen for his capacity, the paltry cost of such supply will, in the end, be repaid fifty fold. On the other hand, a commander so confided in, should study to use such means of instruction, as not abusing them. The captain should be possessed of a certain knowledge of their principles, in order to have that degree of faith in their application to practice, without which they may well prove worse than none at all. We have known some ships totally lost, and many voyages doubled in duration, merely by the ignorant misapplication of a figure, or of an algebraic sign. But if the captain knows the proper use of his instruments, he should trust to them, as he is himself trusted by his employers; and by resting upon them that responsibility which they are far more able to bear than he can be, however extensive his experience, he will make out his voyage in safety, and learn, by degrees, not only to feel, but to act on the belief of the uniformity of the laws of nature, in the midst of the wildest apparent confusion.

We had almost forgotten to mention, amongst the modern improvements in seamanship, the immense advantage of correct charts. To any one accustomed to use such charts as are now on board even the worst found ships, the sight of an old "sea map" is enough to make his hair stand on end. In the first place, on looking at the dangers which really exist, but which are omitted in the old charts, he wonders how ships in those times ever escaped destruction; and in the next, he finds the sea so thickly covered with rocks, and shoals, and those vague "vigias," now known to have no existence, that his admiration is great of the boldness of those mariners who could sail on at all during the night.

The government of most civilized countries having taken up this matter in earnest, and sent their surveyors abroad, like geographical missionaries, the world has been put in possession of charts of all those harbours, coasts, and seas which are most frequented, and so accurate is the construction of their maps, that ships duly provided with nautical instruments need scarcely ever incur the danger of running ashore, except by stress of weather, or experience any difficulty in finding safe passages amongst the most complicated sand banks, coral reefs, or any other description of submarine dangers, the terror and bane of old navigation.

It would lead us beyond our limits were we to go into further detail, in order to point out the various minor improvements which have been introduced into the practice of navigation; though we feel strongly tempted to describe the scientific remedies, for example, which have been applied to the steering compass by Professor Barlow, to correct the local attraction caused by the great additional quantity of iron that has lately been put on board all ships. For a similar reason, want of room, we must omit all mention of the improved methods of constructing ships, stowing their holds, making their masts, and, generally, the improved mode of rigging, fitting out, and working ships. These details being all parts of the same course of improvement, would enter naturally into an express treatise on seamanship, but are much too voluminous for this place.

There are two topics, however, on which we must be allowed to touch for a moment, before bringing this Appendix to a close. One is, the improved discipline of the British navy, and the consequent amelioration in the character of all the seamen of the country. The other is, the change in the armament of the ships of war, and the improvement in the training of our seamen to the duties required by this change. Both of these points have so material an influence on the prosperity of the country, and have become so completely part and parcel of the seamanship upon which its glory as a nation depends, that on this occasion we cannot pass them over in silence.

There can be no good seamanship without discipline, for it is as essential to the correct working of a ship that there should be a well-understood subordination established on board, as it is to the correct going of a clock that all its wheels and pinions should be made to fit, and be so placed as to work properly into one another. To carry on this illustration, it may be said, that whilst the mainspring of naval discipline is a sense of duty, even this strong motive would not be enough to produce the desired results, without the intermediate agency of an organised system of discipline, the object of which is, to assign to each person on board a specific set of duties, all which shall contribute to the main purpose; and, thus, as far as may be possible, to arrange and condense the energies of the whole into one course of uniform action, subject to the will of a supreme directing authority, who is responsible to the country at large.

In strictness, this well defined system of discipline belongs only to the naval department of seamanship, but in a great measure it also applies, by transmission, to the merchant service, where it works by the joint agency of custom, example, and the several interests of the parties concerned. So large a mass of the seamen of the country are employed in the navy, and so many naval officers are employed in the merchant service in peace; and as seamen, by the very nature of their lives, are perpetually changing from one service to another, a kind of amalgamation insensibly takes place, and thus the discipline established on board our ships of war, under the sanction of official authority and long established usage, pervades, more or less, the whole profession of the sea. In this view of the matter, the improved discipline of the navy has an important bearing on the well-being of the country, in all those relations connected with our insular situation; just as it might, by no strained analogy, be said, that the education, discipline, and fixed doctrines of the Established Church, have a salutary influence on the religious interests of the country, into whatever number of sects the population may be nominally divided.

The details of this branch of our subject might, we think, easily be made very interesting, but neither our space, nor the purpose of this Appendix, will admit of its being done here. We must content ourselves then, with saying that of late years great pains have been taken to raise the moral character of seamen by education, and by teaching them the advantages of sober and orderly habits, to beget a feeling of self-respect, which is at the root of all good discipline. Religious instruction, gently applied, and without any of that high-pressure cant, of which the sailor, of all mortals, has most abhorrence, has been most beneficially introduced. Light general reading has become general afloat, as well as elementary instruction; and there cannot be a doubt that the seamen are in consequence more correct in their moral conduct. The whole system of punishments, too, has been much modified; for in place of the lash which, at one time, regulated everything, a desire to prevent crime, and to lead the sailors to act from principle, have been substituted with great effect. In fact, when such a spirit as we have just alluded to, however engendered, pervades the captain, officers, and petty officers, the sailors, forming the mass of the crew, readily fall into the same current of duty, and all goes on cheerfully. The power of using corporal punishment exists still, and that it ever must exist in the navy, is the opinion of every person well-informed on the subject, and who knows the character of seamen and the duties which are required of them on board a man-of-war. There are no persons more fully convinced of this necessity than the sailors themselves, or who are more sensible that, under the wise and benevolent modifications now officially established in the navy, it is by far the most effective, and at the same time the most gentle, method of preserving order amongst those refractory subjects who unfortunately are to be found in every ship. Without the power of occasional corporal punishment, we conscientiously believe, it would be quite impossible to restrain such persons within any bounds of decency, or to prevent them from becoming a curse to those about them, whilst their lawless habits would unsettle the arrangements of the best regulated ship in the fleet, and, in the end, render her, instead of a bulwark to defend the country, a source of national weakness and dishonour.

Since the peace of 1815, all the maritime nations of the world have been gradually increasing the size of their ships of war, and adding to their weight of metal. Recently, too, the use of shells has been introduced afloat; a measure of questionable policy on the part of that nation which commenced it, but which we, and others, are of course obliged to adopt. The shells are not, as heretofore, fired from mortars only, but are thrown from the long guns used in ordinary warfare in projecting solid shot. How far this new weapon may modify the seamanship of naval engagements we are not prepared to say. In the mean time, great pains have been taken to train a large body of seamen gunners, including of course a proportion of highly-educated officers of all ranks; whilst guns of the most approved calibre for shell practice, have been placed on board every ship in the navy. The establishment of this new system of exercise, through the agency of an express gunnery department of instruction, and the manner in which it has been enforced in all our ships, have produced a marked effect on the habits and character of the seamen throughout the fleet.

Before closing it may be expected that we should say something of the probable influence of steam navigation on naval warfare; and we do not shrink from committing ourselves by an opinion on this point, though it be one much disputed amongst professional men. Our notion is, that the introduction of steam will make no difference whatever in the result of any contest in which we shall be engaged, however the means may be modified thereby. The battle must still be fought, as it always has been, and ever must be fought, by large bodies of disciplined men, properly led, and properly armed; and the victory, as formerly, will be decided in favour of those who have the best national spirit to urge them on, or who, being equal in this respect, bring the greatest number into the field. Line-of-battle ships, in this view of the subject, are merely convenient vehicles in which warriors are brought, hand to hand, to settle their differences by hard fighting. Steam will enable them either to come together more quickly, or to avoid coming together at all, as the case may be; but neither steam, nor any other mechanical agency, will ever dispense with the moral agency of trained men, by whose conduct and courage alone the issue of all wars must be determined. We have heard it suggested, and we think with not less probability than ingenuity, that steamers in war will take the same place in fleets that cavalry have long done in armies. It is a very important place, no doubt, but it is not one which decides the eventual fate of the war; *that* is always the work of the infantry. The cavalry protect the flanks, and otherwise help the infantry to get into action with that of the enemy opposed to them, and when these are broken, they cut in upon them and do much execution. In like manner, armed steamers will guard the edges of fleets, tow three-deckers into action, and, when the enemy is discomfitted, will come in with desperate effect to reap the iron harvest. Still we contend, that the great battle which decides the fate of empires, must ever be fought by men, that is, by numerous bodies of disciplined men acting together, duly led, and fighting under the influence of national sentiment. It is impossible to impart this sentiment to machinery; and though we do not deny that, occasionally, a steamer, armed with guns of enormous calibre, may grievously annoy a line-of-battle ship in a calm, or under some other untoward circumstances, we are fully satisfied that by proper arrangements, every sailing ship may be so armed and worked, that the moral and physical agents on board of her will prove an overmatch for that power which relies, for its superiority, on its mechanical machinery alone. We have no doubt, too, that ere long steam engines will find a place on board all large ships of war (high-pressure engines of course); for the absurd and totally unsubstantial prejudice against this modification of steam power will, in the event of a war, if not long before, give way to the prodigious convenience in the way of stowage, and other advantages, which point out the expediency of its use in all sea-going vessels without exception. To what extent ships of war may require to be fitted with steam power, is a question which must depend on circumstances that cannot be foreseen; but that, eventually, they must have, within themselves, some such means of locomotion, besides what they may borrow from tug boats, we hold to be quite certain. (B T.)

SEARCH-Warrant, in *Law*, a kind of general warrant issued by justices of peace or by magistrates of towns, for searching all suspected places for stolen goods. In Scotland this was often done formerly; and in some English law-books there are precedents requiring the constable to search all such suspected places as he and the party complaining shall think convenient; but such practice is condemned by Lord Hale, Mr Hawkins, and the best authorities both among the English and the Scotch lawyers. However, in case of a complaint, and oath made of goods stolen, and that the party suspects that those goods are in a particular house, and shows the cause of such suspicion, the justice may grant a warrant to search not only that house, but other suspected places, and to attach the goods, and the party in whose custody they are found, and bring them before him or some other justice, to give an account how he came by them, and to abide such order as to law shall appertain. This warrant should be directed to the constable or other public officer, who may enter a suspected house and make search.

SEATON, a town in the hundred of Colyton, in the county of Devon, 150 miles from London. It consists chiefly of one street, and stands on the sea-shore, in a very pleasant but secluded situation. It is much resorted to as a sea-bathing place during the summer months; and there is a considerable fishery carried on from hence. It has a parish church and an Independent chapel. The population amounted in 1821 to 1745, and in 1831 to 1803, taken at a period of the year when there is no occasional residence.

Seaton-Carew, a township in the parish of Stranton, in the county of Durham, in the ward of Stockton, two miles from Hartlepool, seven from Stockton, and 256 from London. It stands close to the sea-shore, near the influx of the river Tees into the sea. It is well adapted for sea-bathing, which has caused an increase in the number of the houses. The chief occupation of the inhabitants is that of fishing. Their number amounted in 1821 to 704, and in 1831 to 736; but it has much increased in the last seven years.

SEBACIC Acid, so called because it is procured from fat.

SEBASTIANO, called *Del Piombo*, from an office in the lead-mines given him by Pope Clement VII., was an eminent Venetian painter, born in the year 1485. He was first a disciple of old Giovanni Bellino; continued his studies under Giorgione; and having attained an excellent manner of colouring, went to Rome, where he insinuated himself into the favour of Michel Angelo. He has the reputation of being the first who invented the art of preparing plaster-walls for oil-painting; but he was so slow and lazy in his work, that other hands were often employed to finish what he had begun. He died in 1547.

SEBASTIAN, St, a considerable and strongly fortified city of Spain, the capital of the province of Guipuscoa. It is built on a tongue of land projecting into the sea. The north point of the mountain Orgullo, being the high land of St Sebastian, is about three miles to the west of Port Passage, on which is built the castle of Mota, which serves as a guide on one side, as the light-house does on the other entrance to the bay, which is a very narrow strait, not admitting through it more than two vessels at a time; but the bay, when entered, is secure for vessels furnished with good ground-tackle, which sunken rocks make very necessary.

For the protection of vessels trading with the town, there are piers, within which ships of 300 tons may enter at low water; but when the tide is out they lie dry on a hard bottom.

The city is defended by strong works on the land side, and has only two gates. St Sebastian is better built than most Spanish towns, the streets being wide, straight, and well paved. The houses, also, are large and well built. The town contains, besides warehouses, about 700 houses, three parish churches, five monasteries, a hospital, and about 12,000 or 13,000 inhabitants. The plaza, or square, is a very fine object.

This place was the seat of the Guipuscoa Society, one of the largest trading associations in Spain, which formed a junction with the Manilla Company; and these had almost a monopoly of the trade with Caraccas in the western colonies of Spain, and with the Philippine Islands in the East Indies. It was then a port of vast commercial importance, having, besides those branches, a considerable share of the export trade of wool. At that period there were large establishments for making ropes and cables, many anchor-smiths and nail-smiths, and such other occupations as are connected with the equipment of ships; but political circumstances have changed and much diminished the commerce of this place.

The important position of this place has drawn upon it much of the calamity of war. In former times it had been frequently besieged and occupied by opposing parties. It was treacherously seized by the French in 1808, and was occupied by them till 1813. When the battle of Vittoria had been gained by the Duke of Wellington on the 21st of June, a way was opened for the British army to attack this city, into which the French had thrown a powerful garrison, who defended it with great bravery and skill. The British army invested the place, and attempted to storm it on the 25th July; but having been repulsed, they besieged it in regular form, and with the loss of many lives it was stormed and carried on the 31st of August. During the assault the town was set on fire and nearly destroyed; and a scene of misery was exhibited to the unfortunate people, in the rage of the storming soldiery, as well as in the progress of the flames, which will long be recollected with horror by the wretched sufferers. The city was, however, speedily rebuilt, and commerce gradually returned. The civil war in some measure centred here, it being the chief point by which the queen's party received their supply of warlike stores from England. Its trade has, however, received a most disastrous check. The castle of Mota is in lat. 43. 19. N., and long. 1. 59. W.

SEBESE, or Pulo Bicie, a small island in the Straits of Sunda. Long. 105. 27. E. Lat. 5. 50. S.

SEBSVAR, a town of Khorassan, in Persia, 180 miles north-west of Herat. It was taken in 1381 by Timur, who made a cruel example of the inhabitants who revolted from his yoke, burying alive ten thousand of their number.

SEBURAI, Seburæi, a name which the Jews give to such of their rabbin or doctors as lived and taught some time after the finishing of the Talmud.

SECALE, Rye. See Agriculture.

SECANT, in *Geometry*, a line that cuts another, or divides it into parts.

SECANT, in *Trigonometry*, denotes a right line drawn from the centre of a circle, which, cutting the circumference, proceeds till it meets with a tangent to the same circle.

SECEDERS, a numerous body of Presbyterians, who have withdrawn from the communion of the Established Church in Scotland.

In order that the causes from which the Secession originated may be clearly understood, we shall introduce an account of that important event by a brief sketch of the previous history of the Scottish church.

James I. after his accession to the English throne, entertained an ardent desire to form the Church of Scotland as much as possible upon the model of that in England; and his son Charles, with the assistance of Archbishop Laud, endeavoured to carry the design into execution, by establishing canons for ecclesiastical discipline, and introducing a liturgy into the public service of the church. Great numbers of the clergy and laity of all ranks took the alarm at what they justly considered as a bold and dangerous innovation; and after frequent applications to the throne, they at last obtained the royal proclamation for a free parliament and General Assembly. The Assembly met in 1638, and began their labours with a repeal of all the acts of the six preceding parliaments, which had favoured the introduction of Episcopacy. They condemned the liturgy, together with every branch of the hierarchy. They cited all the Scottish bishops to their bar, and after having excommunicated nine of them, and deposed five from their episcopal office, they restored kirk-sessions, presbyteries, and synods, provincial as well as national. These proceedings were ratified by the parliament which met in 1640. The law of patronage, however, was in full force for several years after this period; but great care was taken that no minister should be obtruded on the people contrary to their inclination; and in 1649 patronage was abolished altogether, as an oppressive grievance.

The restoration of Charles II. in 1660, produced a total change in the state of ecclesiastical affairs in Scotland. All that the General Assembly had done from 1638 to 1650 was rendered null and void; the covenants were pronounced to be unlawful, Episcopacy was restored, and the king was declared to be the supreme head of the church in all matters civil and ecclesiastical. During this period, under the sway of Lauderdale and his associates, the Presbyterians were not only subjected to fines, imprisonment, and exile, but numbers of them were publicly executed, for their adherence to their political and religious principles.

At the memorable era of the Revolution, the affairs of the church underwent a complete change. The first parliament which met after that event abolished prelacy and the king's supremacy in ecclesiastical affairs. They ratified the Westminster Confession of Faith, together with the Presbyterian form of church government and discipline, "as agreeable to the word of God, and most conducive to the advancement of true piety and godliness, and the establishment of peace and tranquillity within these realms." That same parliament abolished patronage, and vested the election of ministers in the heritors and elders, with the consent of the congregation.

At the first General Assembly held after the Revolution, a most conciliatory spirit was manifested, and a wide door of admission into the national church was opened to the episcopal ministers, on the most lenient terms. Great multitudes of the conforming clergy were thus induced, for the sake of the benefice, to transfer their respect and obedience from the bishop to the presbytery, and were received into ministerial communion on merely acknowledging "that the church government, as now settled by law, is the only government of this church." The admission of these time-servers into the church laid the foundation of those measures which ultimately led to the secession.[1]

In the reign of Queen Anne, the true Protestant religion was ratified and established, together with the Presbyterian form of church government and discipline; and the unalterable continuance of both was declared to be an essential condition of the union of the two kingdoms in all time coming. In 1712, the law respecting patronage was revived, in resentment, it has been said, of that warm attachment which the Church of Scotland discovered to the family of Hanover; and about the same period the imposition by the government, of the oath of abjuration, was a fertile source of discord and strife, both among ministers and people. This oath was regarded with great jealousy, and was peculiarly obnoxious to the Presbyterian clergy, both because its avowed design was the security of the Church of England, and because it seemed to imply an approbation of diocesan Episcopacy, with the ceremonies of that church, and a recognition of the queen's supremacy in matters of religion. About a third part of the clergy, including the founders of the Secession Church, positively refused to swear this offensive oath; though they were enjoined to do so on pain of ejection from their churches, and of paying an exorbitant fine. A train of events which followed in rapid succession soon made it manifest that the dominant party in the Scottish church were, if not hostile, at least indifferent, to the most important doctrines of religion, and ready to sacrifice the liberties of the people at the shrine of civil authority. This charge was proved beyond the possibility of contradiction, by their conduct towards the presbytery of Auchterarder in the year 1717, with regard to what has since been denominated the Auchterarder Creed, by their vindictive proceedings against the twelve minsters known by the name of "Marrow Men," who endeavoured to check the progress of error by the diffusion of sound doctrine, along with their condemnation of the doctrines of the book entitled the Marrow of Modern Divinity, in the years 1720–21, and especially by the leniency of their dealings with Professor Simpson of Glasgow, who, though found guilty of teaching a system of deism rather than Christian theology, in his prelections to the students of divinity, received no higher censure than simple suspension.

For some time after the revival of patronage in 1712, the severity of the law was greatly mitigated by the general disinclination, on the part both of ministers and patrons, to avail themselves of its provisions in opposition to the feelings of the people; but this state of things was speedily changed. After the lapse of a few years, patrons no longer hesitated to avail themselves of their legal rights, and ministers were no longer disinclined to accept of presentations when given contrary to the wishes of the congregation. But on the part of the people acts of resistance became more frequent and more obstinate, though they were almost uniformly unsuccessful; for the ruling party among the clergy were firm in their resolution that the law of patronage should be carried into effect. They found themselves, however, placed in circumstances of peculiar difficulty; for not only were the people loud in their remonstrances against violent settlements, but a considerable party of the ministers themselves espoused the popular side, and not only strenuously opposed the intrusion of ministers upon congregations, but obstinately refused to carry into effect the decisions of the Assembly. To obviate this difficulty, in 1729 they appointed a committee of their own number to meet and ordain the obnoxious presentee; and for a period of twenty years this expedient was resorted to in cases where the presbytery proved refractory. The excitement of the people, and their resistance to the yoke of patronage, continued to increase; violent settlements prevailed in every part of the country; and in some cases the popular feeling was so strong, that it was deemed necessary to employ an armed force to carry into effect the decisions of the church-courts. At the meeting of the Assembly in 1730, there were no fewer than twelve cases of appeals on the part of congregations against the intrusion of obnoxious ministers; but the dominant party were so determined to crush all opposition to their enactments, that they not only dismissed these appeals, but solemnly enacted, at this meeting of the Assembly, that henceforward no reasons of dissent "against the determination of church judicatures" should be entered on the record. The Assembly of 1731 followed closely in the footsteps of its predecessor. By the law of patronage it was provided, that if the patron suffered six months to elapse without exercising his right of presentation, the presbytery to which the vacant parish belonged was empowered to take steps for its settlement. The presbyteries in these cases frequently gave the people the right of choosing their ministers; and with the view of destroying this last remnant of popular election, an overture was laid before the Assembly of 1731, proposing, that when the right of appointment devolved upon presbyteries, the power of election in vacant parishes should belong only to the elders and Protestant heritors, and, in royal burghs, to the elders, magistrates, and town-council. This overture was transmitted to the different presbyteries, that, according to the regulations of the barrier act, their opinion respecting it might be given at next meeting of the Assembly; and though a great majority of those presbyteries from whom reports were received, expressed disapprobation of the measure, the supporters of the overture obtained a majority of the Assembly of 1732 in its favour.[1]

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[1] For a description of their character, see Burnet, vol. i. p. 158, folio edition.

Among the opponents of the measures of the Assembly in 1732, Mr Ebenezer Erskine, minister at Stirling, held a prominent place. His talents and learning, his faithfulness in the discharge of his ministerial duties, and his intrepidity and zeal in the popular cause, had secured to him the respect and esteem of his brethren, as well as extensive influence among the people. In the various important questions which had been agitated after his entrance into the ministry, the abjuration oath, the controversy respecting the Marrow of Divinity, and the process carried on against Professor Simpson, he had shown himself an active and fearless opponent of the measures pursued by the ruling party in the church. He was not only one of those who signed the representation of grievances laid before the Assembly in 1732, but being a member of Assembly that year, he spoke and protested against its rejection. Being at that time moderator of the synod of Perth and Stirling, he opened the meeting at Perth, on the 10th of October following, with a sermon from Psalm cxviii. 22, in the course of which he remonstrated against the act of the preceding Assembly with regard to the settlement of ministers, alleging that it was contrary to the word of God and the established constitution of the church. These statements gave great offence to several members of synod, and after the court was constituted, and a new moderator chosen, a formal complaint was lodged against him, for uttering several offensive expressions in his sermon.[2] Many of the members declared that they heard him utter nothing but sound and seasonable doctrine; but his accusers insisting on their complaint, obtained the appointment of a committee of synod, to collect what were called the offensive expressions, and to lay them before the next diet in writing. This was done accordingly, and Mr Erskine having been heard in reply to the charges made against him, a keen debate of three days ensued, and at last the synod, by a majority of six votes, found Mr Erskine censurable for some expressions in his sermon, "tending to disquiet the peace of the church, and impugning several acts of Assembly, and proceedings of church judicatories." Against this sentence Mr Erskine protested and appealed to the General Assembly. But in spite of his protest and appeal, the synod proceeded in the cause, and agreed to "rebuke Mr Erskine, and admonish him to behave orderly for the future;" and they at the same time appointed the "presbytery of Stirling to inquire anent his after behaviour at their privy censures, and report to the next synod." Mr Erskine not appearing when called upon, the synod resolved that he should be rebuked at their next meeting in April. All attempts at accommodation proving fruitless, the Assembly which met in May 1733 affirmed the sentence of the synod, and appointed Mr Erskine to be rebuked and admonished at the bar of the Assembly. Mr Erskine, however, declared that he could not submit in silence to the rebuke and admonition, and presented a written protest, to the effect, that as the Assembly had found him censurable, and had rebuked him for doing what he conceived to be agreeable to the word of God and the standards of the church, he should be at liberty to teach the same truths, and to testify against the same or similar evils, on every proper occasion. To this protest Messrs William Wilson, minister at Perth, Alexander Moncrieff, minister at Abernethy, and James Fisher, minister at Kinclaven, gave in a written adherence, under the form of instrument. The Assembly having refused to permit the protest to be read, the four protesters left the paper on the table and withdrew, intending to return to their respective charges, and act agreeably to their protest, as circumstances might require. Here the matter would in all probability have terminated, as at this period none of the four entertained any intention of a formal separation from the national church. But an overruling Providence had ordered it otherwise. The court had proceeded to a different business, when the protest, which had fallen from the table, was accidentally picked up by a minister, who, perusing the contents of it, rose with great indignation, and called the attention of the Assembly to the insult which had been offered to their authority.[3] The protest being read, a great uproar ensued, and the Assembly ordered their officer to summon the four brethren to appear at the bar of the court next day. They obeyed the citation, and a committee was appointed to retire with them in order to persuade them to withdraw their paper. The committee having reported that their persuasions had produced no effect on the minds of the brethren, the Assembly ordered them to appear before the Commission in August following, and retract their protest; and if they should not comply, and testify their sorrow for their conduct, the Commission was empowered to suspend them from the exercise of their ministry, and in case of their acting contrary to the sentence of suspension, the Commission should proceed to a higher censure.

The Commission met in August accordingly, and the four ministers still adhering to their protest, were suspended from the exercise of their office. At the meeting in November, addresses were received from a number of presbyteries and synods, recommending lenity and forbearance towards the suspended ministers, and many members of the Commission strenuously supported the same view. The question, however, was put, "Proceed immediately to inflict a higher censure," or "Delay the same till March;" and the votes being equal on both sides, Mr John Gowdie, the moderator, one of the ministers of Edinburgh, gave his casting vote to proceed to a higher censure. At this stage of the proceedings the Commission proposed certain terms of accommodation, which the suspended ministers, after mature deliberation, declared they could not conscientiously accept. The Commission, therefore, on the 16th of November 1733, passed sentence upon them; loosing their relation to their respective charges, declaring their churches vacant, and prohibiting all ministers of the Church of Scotland from employing them in any ministerial function.

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[1] Reports were received from forty-nine presbyteries; six approved of the overture without alteration, twelve on condition that certain important amendments were introduced, while thirty-one gave it their unqualified condemnation. Eighteen presbyteries gave in no report.

[2] The persons who took the lead in moving for investigation were, Messrs Adam Ferguson, minister at Logierait; James Mercer, minister at Aberdalgie; James Mackie, minister at Forteviot, afterwards at St Ninians; and the Laird of Glendoig, ruling elder.

[3] It is stated by Mr Adam Gibb, that the person who picked up Mr Erskine's protest was Mr James Nasmith, minister at Dalmeny.

The sentence being intimated to them, they protested that their ministerial office and relation to their respective charges should be held as valid as if no such sentence had passed; that they were now obliged to make a *secession* from the prevailing party in the ecclesiastical courts; and that it should be lawful for them to preach the gospel, and discharge all the duties of the pastoral office, according to the word of God, and the principles and constitution of the Church of Scotland.

The Secession properly commenced at this date. Accordingly the ejected ministers declared in their protest, that they were laid under the disagreeable necessity of seceding, not from the principles and constitution of the Church of Scotland, to which they expressed their steadfast adherence, but from the present church-courts, which had thrown them out from ministerial communion. In the new and trying circumstances in which they were placed, they conducted themselves with great caution and prudence. A few weeks after their expulsion from the national church, they met, according to previous appointment, at Gairney Bridge, a small village in the neighbourhood of Kinross, on the 5th of December 1733. Having spent the whole of that and the greater part of the succeeding day in prayer and pious conference, they finally resolved to constitute themselves into a presbytery, under the designation of *the Associate Presbytery*. This presbytery, at its first formation, consisted only of the four ejected ministers; for though Messrs Ralph Erskine and Thomas Mair were present at this interesting meeting, they were merely spectators. Anxious, however, to avoid every thing like rashness or precipitancy, and cherishing a solemn impression of the responsibility attached to their conduct, in the remarkable circumstances in which they were placed, the seceding ministers resolved to hold their meetings chiefly for prayer and religious conference, and to defer proceeding to any judicial acts till they should see whether the ecclesiastical courts would retrace their steps. They considered it necessary, however, to publish a Testimony to the doctrine, worship, and government of the Church of Scotland, and a statement of the grounds of their secession from the national church. This has been since known by the name of the Extrajudicial Testimony.

In the Assembly which met in May 1734, a conciliatory spirit was manifested by the ruling party; the agitated state of popular feeling, and the knowledge that the Seceders had many friends among the clergy themselves, disposed them to make some concessions to prevent the spread of disaffection. When the commission-book was examined, there were some reservations made in the approval of its proceedings; the act of 1730, forbidding church-courts to record dissents and protests, and the act of 1732, respecting the settlement of vacant parishes, were repealed; the Commission was appointed to petition his majesty and the parliament for the repeal of the patronage act; and they authorized the Synod of Perth and Stirling to receive the ejected ministers into the communion of the church, and restore them to their respective charges, but with this express direction, that the "synod should not take upon them to judge of the legality or formality of the former procedure of the church judicatories in relation to this affair, or either approve or censure the same." But as the appearances of reformation which had been exhibited were, in the opinion of the four seceding brethren, dictated merely by a calculating worldly policy, and by no real regard for the cause of truth, after solemn and repeated deliberation, they were unanimously of opinion that, in existing circumstances, it was their duty to remain in a state of separation, till they should see unequivocal and decided evidence that the cause of defection was in reality abandoned. Having prepared a statement of the reasons of their refusal, and the terms upon which they were willing to return to the Established Church, they published it some time before the meeting of Assembly 1735. The proceedings of the Assemblies of 1735 and 1736 seemed to the seceding ministers fully to justify the opinion which they had formed respecting the measures proposed in the preceding Assembly, and to dispel, for the time at least, all hopes of a re-union with the Established Church; and they now considered it "full time to proceed to the exercise of the powers with which they were intrusted by the Head of the church, for the vindication of His truths and ordinances, and for the relief of the Christian people, by supplying them with sermon."[1] They now prepared what they termed an Act, Declaration, and Testimony to the doctrine, worship, government, and discipline of the Church of Scotland, and condemning the numerous instances of defection from these, both in former and in the present times. Some time after this, having received the accession of Messrs Ralph Erskine of Dunfermline, Thomas Mair of Orwell, Thomas Nairn of Abbotshall, and James Thomson of Burntisland, the Associate Presbytery now consisted of eight members. Numerous applications for sermon having been received from all parts of the country,[2] and the seceding ministers having now renounced all hopes of a re-union with the church, resolved to adopt measures for extending and perpetuating the benefits of the Secession; and accordingly Mr Wilson of Perth, a person of great ability and learning, was chosen professor of divinity, and intrusted with the education of candidates for the ministry.[3] These measures necessarily produced a complete separation between them and the Established Church. The Assembly of 1739 declared the refractory ministers worthy of deposition; but, from motives of expediency, delayed giving sentence against them till next year, when they were all deposed, and ordered to be ejected from their churches. In some places, such as Stirling and Perth, the seceding ministers were forcibly excluded from their usual places of worship the first Sabbath after the decision of the Assembly, while in others, such as Dunfermline and Burntisland, they continued to occupy their pulpits for at least two years after sentence of deposition was pronounced against them. All of them, however, continued to discharge the duties of the ministry in their respective congregations, who still adhered to them, erected places of worship for them, and provided for their support. Meanwhile cases of violent settlements of ministers increased throughout the country, and the opposition was frequently so formidable, and popular excitement so great, as to render the attendance of a guard of soldiers necessary at ordinations. These contests had of course a powerful influence in increasing the adherents of the seceding ministers. New accessions were made to them from all quarters. Some even of the probationers of the Established Church placed themselves under their superintendence, and their theological hall was in such a flourishing condition that, in the year 1741, it was attended by a greater number of students than any of the Scottish universities except Edinburgh.[1]

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[1] Testimony of the United Associate Synod, p. 52.

[2] During the years 1737–38, upwards of seventy petitions for sermon were laid on the table of the presbytery.

[3] Mr Wilson devoted the months of March, April, and May, to his course of theological tuition. He not only read his lectures, but conducted the whole business of the class, in the Latin language.

The numbers of the seceding ministers continuing rapidly to increase, a new arrangement was adopted on the 11th of October 1744, by which they were formed into three presbyteries, under one synod. The first meeting of the Associate Synod was held at Stirling on the first Tuesday of March 1745, at which period it had under its inspection about thirty settled congregations and sixteen vacancies in Scotland, besides several congregations in Ireland. The Seceders, in common with the great body of the religious Presbyterians in Scotland, both clergy and laity, entertained great veneration for the national covenants; and as the practice of public covenanting had, for a considerable period, been neglected in Scotland, they expected that the revival of it would have a powerful effect in advancing the work of reformation. An overture to this purpose had been deliberately prepared by a committee of presbytery, which, after various amendments and enlargements, was finally adopted by the presbytery at Stirling, on the 23d of December 1743. And on the 28th of the same month, which was observed as a day of solemn fasting and humiliation, the confession of sins was read, and the engagement to duties subscribed by fifteen ministers, in the presence of a numerous assembly. And when the presbytery met at Edinburgh, on the 14th of February 1744, they enacted that the renewing of the covenant should be the term of ministerial and Christian communion. An unhappy controversy now, however, arose respecting the religious clause of some burgess-oaths, which, it was alleged, was utterly inconsistent with the oath of the covenants and with the Secession Testimony.[2] One party insisted that no Seceder should be allowed to swear this oath, while the other urged the exercise of mutual forbearance. So sharp was the contention between them, that at the meeting of synod in April 1747, after several long and stormy discussions, an entire separation took place between the contending parties. Never, perhaps, was the truth of Father Paul's remark more strikingly verified, "In verbal contentions, the smallness of the difference often nourishes the obstinacy of the parties." Those who condemned the swearing of the burgess oath as sinful, and inconsistent with the Secession Testimony, were called "Antiburghers," and the other party, who contended that it should be declared not to be a term of communion, were designated "Burghers." The latter made various attempts to bring about a reconciliation with the opposing party, by proposing a meeting for prayer and friendly conference, but without success. And the "Antiburghers" not only refused to agree to the proposal, but, after several previous steps, went the length of passing sentence of deposition and excommunication, with all due formality, on Messrs Ebenezer and Ralph Erskine, James Fisher, and the other ministers who had adopted the opposite views respecting the swearing of the burgess oath. Each party claimed to itself the name and lawful constitution of the Associate Synod; but, for the sake of distinction, the Burghers were termed the Associate, and the Antiburghers the General Associate Synod. A furious controversy raged between them for a number of years, and, both from the pulpit and the press, the one party indulged in invectives against the other. In the course of time, however, this hostility subsided; a feeling of cordiality gradually gained ground; and, after a separation of nearly eighty years, the two bodies were again united into one.

These divisions among the Seceders afforded an excellent opportunity to the dominant party in the national church to have regained their lost influence with the people; but, instead of availing themselves of it to check the progress of the Secession, they only became more resolute in enforcing the law of patronage. The doctrine which they taught at this time in their pulpits, it has been said, "could neither be called Christian nor heathen, but was a compound of both;" and all petitions for the redress of grievances, and all resistance to their arbitrary decrees, were silenced by the strong arm of power. "The language of the majority in Assemblies at this time," says the late Sir Henry Moncrieff,[3] "universally was, that the secession from the church, instead of increasing, was on the decline, and that the superior character and talents of the established clergy were gradually weakening its resources, and would ultimately exhaust them. Experience has not verified these sanguine expectations. At the distance of a few years after Dr Robertson retired, the people, disgusted with unsuccessful processes before the Assembly, relinquished the plan of their predecessors, and came seldom to the Assembly with appeals from the sentences of the inferior courts appointing the settlement of presentees whom they resisted. But they began to do more quietly, or with less observation than formerly, what was not less unfriendly to the establishment. In ordinary cases, they now leave the church-courts to execute their sentences without opposition, and set themselves immediately to rear a meeting-house, which very frequently carries off a large portion of the inhabitants of the parish." This state of comparative quiescence was not, however, produced without long and severe struggles; and for many years the disputes in the church-courts respecting the settlements of ministers were incessant. In the year 1751, an unpopular minister having been presented to the church and parish of Inverkeithing, the presbytery of Dunfermline refused to proceed with his settlement, and the synod of Fife, who were next appointed to ordain him, proved equally refractory. The affair was brought before the Assembly of 1752, and they peremptorily enjoined the presbytery of Dunfermline to proceed with the ordination of the presentee, and ordered all the members of presbytery to attend on that occasion. Six ministers who absented themselves from conscientious scruples were brought to the bar of the Assembly. One of their number, Mr Thomas Gillespie, minister of Carnock, was immediately deposed, and three others were afterwards suspended. Mr Gillespie, notwithstanding this sentence, continued to discharge his ministerial duties, and a few years afterwards he and Mr Thomas Boston of Oxnam and Mr Collier formed themselves into a presbytery, and became the founders of that numerous and respectable body of dissenters entitled the Synod of Relief.

When such proceedings were systematically carried on in the courts of the Established Church, it is not to be wondered at that the spirit of disaffection should continue to spread among its members, and that the numbers of the Seceders rapidly increased, in spite of the strife that prevailed among themselves at this period. Not only did the Associate Synods steadily extend their influence in Scotland by the accessions which they were constantly making to the number of their adherents, but they sent preachers to England, to Ireland, and even to America, and erected a considerable number of Secession congregations in these countries. The controversy respecting the burgess-oath gradually exhausted itself; but towards the close of the eighteenth century, both synods were disturbed by an angry discussion respecting the power of the magistrate in matters of religion, and the obligation of the national covenant upon posterity. In 1796 the synod commenced their revision of the Testimony, a business of no small importance and difficulty, as this document "consisted of two hundred octavo pages, and included all the controversial points in divinity and church-government which had been discussed in this country for successive generations." During the progress of this laborious work, which lasted for a period of nearly eight years, considerable dissatisfaction was expressed by a small minority; and when at length the revision was brought to a close in May 1804, and the Introduction, Narrative, and Testimony, as corrected and enlarged, were adopted by the synod as the term of admission for those who shall apply for joining in communion with them, five ministers, Messrs Whytock, Aitken, Chalmers, Hog, and M'Crie, protested against the decision, and, after various ineffectual attempts at accommodation, left the body, and formed themselves into a distinct presbytery.

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[1] Letter from Mr R. Erskine to Mr Whitefield, dated the 10th of April 1741.

[2] The following is the clause referred to: "I protest before God and your Lordships, that I profess and allow with my heart the true religion presently professed within this realm, and authorized by the laws thereof; and I shall abide thereat, and defend the same, to my life's end, renouncing the Roman religion called papistry."

[3] Appendix to Life of Dr Erskine, by Sir H. Moncrieff Wellwood, Bart., p. 464.

Nearly about this period a fierce controversy was carried on in the Associate or Burgher Synod respecting the same subject, which was under consideration for a considerable time, and various controversial publications issued from the press respecting it. At length, in April 1797, the synod by a majority agreed to the following motion. "That whereas some parts of the standard books of this synod have been interpreted as favouring compulsory measures in religion, the synod hereby declare that they do not require an approbation of any such principle from any candidate for license or ordination; and whereas a controversy has arisen among us respecting the nature and kind of the obligation of our solemn covenants on posterity, whether it be entirely of the same kind upon us as upon our ancestors who swore them, the synod hereby declare, that while they hold the obligation of our covenants upon posterity, they do not interfere with that controversy which has arisen respecting it, and recommend it to all their members to suppress that controversy, as tending to gender strife, rather than godly edifying." Notwithstanding this decision, the ferment which had been excited by the discussion on this subject rather increased than abated, and the question was again brought under the notice of the synod in September 1799. After a lengthened discussion, it was decided by a large majority, that "the synod adjourn the further discussion of this question till a future meeting, and in the mean time appoint a committee to draw up a synodical address to the people of their charge, expressive of their adherence to the doctrine, worship, discipline, and government of the Church of Scotland." Against this decision several members protested, and two of them, Messrs Willis and Hyslop, declared in their protest, that as the synod had refused to reverse their former act, they would no longer acknowledge their authority. In consequence of this declaration their names were erased from the roll, and shortly afterwards they, along with Mr Watson, minister of Kilpatrick, constituted themselves into a distinct presbytery, and became the founders of that body which is ordinarily known by the appellation of the Original Burgher Synod. An attempt was made by these separatists to obtain possession of the property belonging to the synod, by alleging that they had abandoned the principles which their predecessors in the Secession had always maintained. An appeal to the courts of law was made on this point, in the case of the Associate congregation in Perth. Mr Jervie, one of the ministers of this congregation, joined the Original Burgher Synod, while his colleague Mr Aikman continued in connection with the Associate Synod. The congregation were also divided in sentiment, and each party claimed the exclusive possession of the manse and place of worship. After a long and expensive litigation, in the course of which the process was carried from the inferior courts to the House of Lords, and thence remitted back to the Court of Session, it was ultimately decided that the defenders had not departed from the original standards and principles of the association, and that the pursuers had separated from the congregation to which they belonged, without any assignable cause, and without any fault on the part of the Associate Synod. They had, therefore, no right to disturb the defenders in the possession of their property. The question was one of great importance, and the principle laid down in this instance as the ground of judgment, has been since regarded as the settled law of the country in all similar cases.

No other event of much importance occurred in the history of the Secession Church, till the period when the two great branches of which it was composed were again happily united into one. A junction had previously taken place between the Burgher and Antiburgher ministers in America, Nova Scotia, and Ireland. For a number of years an amicable feeling had gradually gained ground among the ministers and people connected with both branches of the Secession, and their intercourse in bible, missionary, and other religious societies tended powerfully to strengthen the feeling of mutual regard. From the moment that the proposal of a junction was made, both synods entered on the matter with cordiality and zeal. The religious public generally took considerable interest in the movement. The town councils of Glasgow and Paisley abolished the religious clause of the oath which had occasioned the strife, and the Convention of Royal Burghs unanimously recommended its entire abolition, for the express purpose of removing any obstacles that might obstruct the progress of this desirable event. At length the articles of union having been agreed upon and sanctioned by both synods, and all the necessary preliminaries settled, the union was completed on the 8th of September 1820, in Bristo Street church, Edinburgh, the spot where, seventy-three years before, the separation had taken place.

All the ministers of the Associate Synod became members of the United Synod; but Professor Paxton, and other nine ministers of the General Associate or Antiburgher Synod, refused to concur in the union, and soon after formed a junction with Professor Bruce, Dr M'Crie, and other members of the Constitutional Associate Presbytery, who withdrew from the Antiburgher body in 1806.

Since the period of the union the Secession Church has continued rapidly to increase in numbers and strength, and the extraordinary controversy which is at present agitating the whole country has brought the Seceders much more prominently into view than during any preceding era of their church. The question respecting the power of the magistrate in religious affairs had frequently been discussed among Seceders themselves, but of late years it has become a matter of national interest. The founders of the Secession Church doubtless approved of the interference of the civil magistrate in matters of religion; but they appear to have changed their opinions on this subject at no distant period after their secession from the Established Church, as appears from the language of the Associate presbytery as early as 1743, in their answers to Mr Nairn: "If true religion became a part of the civil constitution, it inevitably follows that the church became a part of the state, which doctrine, as it is absurd in itself, lays a plain foundation for Erastianism, overturning the distinction betwixt the kingdom of our Lord Jesus Christ and the kingdoms of this world." The same sentiments were expressed by the Reverend Adam Gibb in his Display of the Secession Testimony, published in 1774, and by the Antiburgher Synod in the revision of their Testimony. This explicit condemnation of the connection between church and state was one of the principal grounds of the separation of Professor Bruce and Dr M'Crie from the Antiburgher Synod; and the refusal of the Burgher Synod to reverse the act which made this subject a matter of forbearance, was the sole reason why Messrs Willis, Hyslop, and others, renounced their connection with that body. The controversy slumbered during a period of about thirty years from this date; but about the year 1829 it was again resumed, and since that time has increased to such a degree, that the harmony between churchmen and dissenters has been broken up, and the hopes which were formerly cherished of a re-union between the Secession and the Establishment have, for the present at least, been completely extinguished. Proposals were made in 1834, for a union between the Secession and the Synod of Relief, and the measure is still under the consideration of both churches. In the mean time the most friendly intercourse is maintained between them, and, from the harmonious feeling manifested on the subject, in all probability the union will ere long be consummated.

The exposition of ecclesiastical polity, which is given under the article PRESBYTERIAN, applies to the constitution of the United Associate Synod. They have lay-elders, kirk-sessions, and presbyteries; but instead of a General Assembly, they meet in synod once a year, the synod being their supreme court. They have the same standards and the same confession as the Established Church. They believe that the Holy Scriptures are the sole criterion of truth, and the only rule of faith and manners; and that "the Supreme Judge by which all controversies of religion are to be determined, and all the decrees of councils, opinions of ancient writers, doctrines of men and private spirits, are to be examined, and in whose sentence we are to rest, can be no other than the Holy Spirit speaking in the Scriptures." They are fully persuaded, however, that the standards of the Church of Scotland exhibit a just and consistent view of the meaning and design of the Holy Scriptures with regard to doctrine, worship, government, and discipline. They therefore hold the Westminster Confession of Faith, the Larger and Shorter Catechisms, as expressive of the sense in which they understand the Scriptures; and they so far differ from the dissenters in England, that they hold these standards to be not only articles of peace, and a test of orthodoxy, but as a bond of union and fellowship. They consider a simple declaration of adherence to the Scriptures as too equivocal a proof of unity in sentiment, because Arians, Socinians, and Arminians make such a confession of their faith, while they retain sentiments which, they (the Seceders) apprehend, are subversive of the great doctrines of the gospel. They believe that Jesus Christ is the only King and Head of the Church, which is his body; that it is his sole prerogative to enact laws for the government of his kingdom, which is not of this world; and that the church is not possessed of a legislative, but only of an executive power, to be exercised in explaining and applying to their proper objects and ends those laws which Christ has published in the Scriptures. Those doctrines which they teach relative to faith and practice are exhibited at great length in an explanation of the Westminster Assembly's Shorter Catechism, by way of question and answer, composed chiefly by the late Mr Fisher of Glasgow, and published by desire of the synod. They catechise their hearers publicly, and visit them from house to house once every year.

In many of their congregations they celebrate the Lord's Supper four times, in the remainder twice in the year; and they examine their young people strictly concerning their knowledge of the principles of religion previously to their admission to that sacrament. They will permit none to partake of the ordinance of the Lord's Supper who are ignorant of the principles of the gospel, or who are scandalous and immoral in their lives. They condemn private baptism, nor will they admit those who are grossly ignorant and profane to be sponsors for their children. They never accept a sum of money as a commutation for any offence; and those of the delinquents who do not submit to adequate censure are publicly declared to be fugitives from discipline, and are expelled the society. They condemn all clandestine and irregular marriages, nor will they marry any person unless the banns of marriage have been regularly proclaimed in the parish church.

Believing that the people have a natural right to choose their own pastors, the settlement of their ministers always proceeds upon a popular election, and the candidate who is elected by the majority of the communicants is ordained among them. Convinced that a charge of souls is a trust of the greatest importance, they carefully watch over the morals of their students, and direct them to such a course of reading and study as they judge most proper to qualify them for the profitable discharge of the pastoral duties. At the ordination of their ministers, they use a formula nearly of the same kind with that of the Established Church, which their ministers are bound to subscribe when called to it; and if any of them teach doctrines contrary to the Scriptures or the Westminster Confession of Faith, they are sure to be expelled from their communion. It must be noticed, however, that they are not required to approve of any thing in the standards of the church which teaches compulsory or persecuting and intolerant principles in religion.

The education of candidates for the ministry has always been reckoned a matter of the greatest importance by the Secession Church. The course of study is very nearly the same as that adopted by the Establishment. Students, before being admitted to the Theological Hall, must attend at least three years at one of the universities; and the course of preparatory study required of them includes Latin, Greek, Logic, Moral Philosophy, and Mathematics; a knowledge of Hebrew is also required, so that they may be enabled to enter on the critical study of the Old Testament Scriptures as soon as they commence their course of theology. The study of natural philosophy may be deferred till after commencing the study of divinity; but students must produce the certificate of the professor of that science, and be examined as to their proficiency in it, either before admission to the Divinity Hall, or immediately after their first session in it. And it is strongly recommended to them to attend also such classes as they may have access to for the study of geology, chemistry, and other branches of physical science. Students who have a view to the Christian ministry are examined by the presbyteries at the close of each session, that their proficiency may be ascertained, and that they may be prevented from advancing to the higher branches of study till they have acquired a competent knowledge of those which precede them. During the whole course of the student's education, his improvement in personal religion is kept steadily in view. Before he is encouraged to prosecute preparatory studies, strict inquiry is made into his piety, as well as his talents and capability of acquirement; his progress in personal religion as well as in literature is constantly watched over; and he cannot be admitted into the Divinity Hall till he is a member in full communion with the Secession Church.

The Secession has four professors of divinity, each giving instruction in one great department of theological science, or explanatory of the duties of the Christian ministry. 1. The professor of biblical literature, whose duty it is to give a course of lectures on the history, evidence, and interpretation of the sacred books; to direct the reading of the students, and to examine them on these subjects; to read to them portions of the original Scriptures critically, and to require from them explicatory and critical exercises. 2. The professor of exegetical theology, who gives lectures and conducts examinations on one or more of the books of the

Old Testament, the gospel history, the Acts of the Apostles, and one or more of the doctrinal epistles; and who also gives a view of the divine dispensations, as these are detailed in the Holy Scriptures. The course of the present professor embraces a critical exposition of the principal prophecies of the Messiah, the doctrines of Jesus Christ, and the Epistles to the Romans, Galatians, and Hebrews. 3. The professor of systematic theology. 4. The professor of pastoral theology and ecclesiastical history, whose duty it is to explain the qualifications of the ministerial character, and the duties of the pastoral office; and to give instruction in all the services which, as teachers or rulers in the church, ministers are called upon to perform, such as conducting the public devotions of the church, the composition and delivery of pulpit discourses, ministerial visitation of families, public catechising, visitation of the sick, the government and discipline of the church, giving also an abstract of ecclesiastical history. The term of study is five years, and the duration of the annual session two months; and it is rendered imperative on students to attend the whole time. They are usually from five to six hours a day in the classroom. For the first and second sessions of their attendance at the hall, they are committed to the care of the professor of biblical literature and exegetical theology, and the professors of systematic and pastoral theology during the last three years of their course. During the vacation the students are under the superintendence of their respective presbyteries, who meet and converse with them as to their progress in their studies, and hear and criticise their trial discourses. The examinations and exercises prescribed on trials for license and ordination are much the same as in the Established Church.

The Secession has produced a respectable proportion of authors distinguished in various departments of literary pursuit. To say nothing of living authors, the works of Dr Jamieson, the profound and ingenious author of the Scottish Dictionary, and of several learned defences of some of the fundamental principles of religion, entitle him to a place among the distinguished men of his age and country; and the writings of the founders of the Secession, and of Lawson, Dick, Belfrage, Pollock, and others, are well known and highly esteemed in religious and literary circles.

The United Associate Synod now comprehends twenty-two presbyteries, composed of 361 congregations, exclusive of missionary stations both at home and abroad. The following statement will show the regular and steady progress which it has made during the period of one hundred and six years which has elapsed since its origin.

"When the Associate Presbytery was first constituted by the fathers of the Secession, on the 6th of December 1733, the number of the brethren who took this important step amounted only to *four*.

"When the General Assembly pronounced sentence of deposition on the members of the Associate Presbytery on the 15th of May 1740, their number had increased to *eight*.

"Five years after this, when the Associate Presbytery constituted itself into a synod, on the first Tuesday of March 1745, the number of ministers amounted to *twenty-six*.

"When the division occasioned by the burgess oath controversy took place, on the 9th of April 1747, the number had increased to *thirty-two*.

"When the re-union was accomplished, on the 5th of September 1820, the number of ministers belonging to the two synods that were united on that occasion amounted to *two hundred and sixty-two*.

"Since that event took place a period of nineteen years has elapsed, and the number of ordained ministers who are members of the United Associate Synod amounts at the present period to *three hundred and fifty-seven*, being an increase, since the re-union, of nearly *one hundred* ministers."

From accurate returns made by the different congregations, it has been ascertained that the population connected with the Secession Church, including young and old, amounts to 261,345; the number of communicants is 126,070; the sabbath-schools and classes, 716; the number of scholars, 37,612. The average number of persons connected with each congregation is 730, the average number of communicants is 349. The stipends of the ministers vary from L.70 to L.450. The average paid to each minister, exclusive of sacramental expenses, is L.131. In the country, in addition to the stipend, the minister is generally furnished with a dwelling-house. None of the ministers have or ever had a legal bond securing their incomes.

Annual amount of stipends in Secession Church..	L.47,315
Annual allowance for the poor..........................	4,011
Collected for missions by congregational associations	11,042
Annual allowance for sacramental expenses..........	3,610
Annual collection for synod fund..........................	760
Total amount collected annually by the Secession Church..	66,728[1]

A considerable number of missionaries and catechists are maintained in Canada, Jamaica, and other places, either by the synod or by individual congregations in connection with the Secession Church; and many congregations, particularly in the larger towns, support one or more local missionaries at their own expense.

The Presbyterian Synod of Ireland in connection with the United Associate Synod comprehends nine presbyteries and 134 congregations. Proposals are at present making for a union between this body and the Synod of Ulster. The Synod of Nova Scotia contains five presbyteries and twenty-four congregations.

Associate Synod of Original Seceders. This body separated from the Antiburgher Synod in 1806, and formed themselves into a distinct presbytery, called at first *The Constitutional Associate Presbytery*; but after their junction with the few ministers who refused to accede to the union of the Burghers and Antiburghers in 1820, they assumed the name of *The Associate Synod of Original Seceders.* This body now extends to four presbyteries, comprehending thirty-six congregations. They have a professor of divinity of their own, and, with the exception of their opinion respecting the interference of the magistrate in religious matters, they are identical in their leading principles with the United Associate Synod. The late Dr M'Crie, the able and learned biographer of Knox and Melville, was a minister of this body.

Original Burgher Associate Synod. In our history of the Secession Church we gave a brief statement of the controversy which led to the separation of this body from her communion. They extended latterly to four presbyteries, including forty-two congregations. A short time ago, however, they made a formal application to be received into the communion of the Established Church. The proposal met with a favourable reception from the General Assembly, and at the meeting of the Burgher Synod in 1839 a majority of the members agreed to accept of the terms offered by the Assembly, and have accordingly returned into the bosom of the national church. The minority seem as yet not to have determined as to the course which they will pursue.

(Mackerrow's History of the Secession Church; Brown's History of the Secession Church; Testimony of the United Associate Synod; Fraser's Lives of Ebenezer and Ralph Erskine; Ferrier's Memoirs of the Rev. W. Wilson; Moncrieff's Life of Dr Erskine.) (B. Q.)

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[1] These, and a variety of other interesting details, will be found in Mackerrow's valuable History of the Secession Church.

SECHELLES, a cluster of high, rocky, and, generally speaking, barren islands, in the Indian Ocean, only three of which are inhabited. Cotton is the only product. There are twelve smaller islands, and as many islets or rocks, besides the larger ones. They abound in turtle, oysters, and particularly cocoa-nuts, which are imported by the inhabitants of the Mauritius. There are six decked vessels which belong to the inhabitants. Lat. 4. to 5. S.

SECKENDORF, Guy Louis de, a very learned German, descended from an ancient and noble family, was born at Aurach, in Franconia, in 1626. He was a good linguist, learned in law, history, and divinity, and is said to have been a tolerable painter and engraver. He was honourably employed by several of the German princes; and died counsellor of state to Frederick III., elector of Brandenburg, and chancellor of the university of Halle, in 1692. He wrote many books, particularly a history and defence of the Lutheran religion, in Latin, in two volumes folio, Frankfort, 1602.

SECKER, Thomas, a learned and respectable prelate of the Church of England, was born in 1693, at a village called Sibthorn, in the vale of Belvoir, in Nottinghamshire. His father was a Protestant dissenter, a pious, virtuous, and sensible man, who, having a small paternal fortune, followed no profession. His mother was the daughter of Mr Brough, a substantial gentleman farmer of Shelton, in the same county. He received his education at several private schools and academies in the country, being obliged, by various accidents, to change frequently his masters.

Notwithstanding this disadvantage, he had at the age of nineteen not only made considerable progress in Greek and Latin, and read the best writers in both languages, but had acquired a knowledge of French, Hebrew, Chaldaic, and Syriac, had learned geography, logic, algebra, geometry, conic sections, and gone through a course of lectures on Jewish antiquities and other points, preparatory to the critical study of the Bible. He had been destined by his father for orders amongst the dissenters. With this view, during the latter years of his education, his studies were chiefly turned towards divinity, in which he had made such advances, that by the time he was twenty-three he had carefully read a great part of the Scriptures, particularly the New Testament, in the original, and the best comments upon it; Eusebius's Ecclesiastical History, the Apostolical Fathers, Whiston's Primitive Christianity, and the principal writers for and against ministerial and lay conformity. But though the result of these inquiries was a well-grounded belief of the Christian revelation, yet not being at that time able to decide on some abstruse speculative doctrines, nor to determine absolutely what communion he should embrace, he resolved, like a wise and honest man, to pursue some profession, which should leave him at liberty to weigh those things more maturely in his thoughts, and not oblige him to declare or teach publicly opinions which were not yet thoroughly settled in his own mind.

In 1716, therefore, he applied himself to the study of physic, and after gaining all the medical knowledge he could, by reading the usual preparatory books, and attending the best lectures during that and the following winter in London, in order to improve himself farther, he went to Paris in January 1719. There he lodged in the same house with the celebrated anatomist Mr Winslow, whose lectures he attended, as he did those of the materia medica, chemistry, and botany, at the King's Gardens. He saw the operations of surgery at the Hôtel Dieu, and attended also for some time M. Gregoire the accoucheur, but without any design of ever practising that or any other branch of surgery. Here he became acquainted with Mr Martin Benson, afterwards bishop of Gloucester, one of the most agreeable and virtuous men of his time, with whom he quickly became connected, and not many years afterwards was united by the strictest bonds of affinity as well as affection.

During the whole of Mr Secker's continuance at Paris, he kept up a constant correspondence with Mr Joseph Butler, afterwards bishop of Durham, with whom he became acquainted at the academy of Mr Jones, which was kept first at Gloucester, and afterwards at Tewkesbury. Mr Butler having been appointed preacher at the Rolls on the recommendation of Dr Clarke, and of Mr Edward Talbot, son of Bishop Talbot, he now took occasion to mention his friend Mr Secker, without Secker's knowledge, to Mr Talbot, who promised, in case he chose to take orders in the Church of England, to engage the bishop his father to provide for him. This was communicated to Mr Secker in a letter from Mr Butler about the beginning of May 1720. He had not at that time come to any resolution of quitting the study of physic; but he began to foresee many obstacles to his pursuing that profession; and having never discontinued his application to theology, his former difficulties with regard to conformity and some other doubtful points had gradually lessened, as his judgment became stronger and his reading and knowledge more extensive. It appears also from two of his letters still extant, written from Paris to a friend in England, both of them prior to the date of Mr Butler's letter above mentioned, that he was greatly dissatisfied with the divisions and disturbances which at that particular period prevailed among the dissenters.

In this state of mind Mr Butler's unexpected proposal found him; and he was therefore very well disposed to take it into consideration. After deliberating on the subject of such a change for upwards of two months, he resolved at length to embrace the offer, and for that purpose quitted France about the beginning of August 1720.

On his arrival in England, he was introduced to Mr Talbot, with whom he cultivated a close acquaintance; but it was unfortunately of very short duration; for in the month of December that gentleman died of the small-pox. This was a great shock to all his friends, who had justly conceived the highest expectations of him, but especially to an amiable lady whom he had lately married, and who was very near sinking under so sudden and grievous a stroke. Mr Secker, besides sharing largely in the common grief, had peculiar reason to lament an accident that seemed to put an end to all his hopes; but he had taken his resolution, and he determined to persevere. It was some encouragement to him to find that Mr Talbot had, on his death-bed, recommended him, together with Mr Benson and Mr Butler, to his father's notice. Thus did that excellent young man, for he was but twenty-nine when he died, by his nice discernment of character and his considerate good nature, provide most effectually for the welfare of that church from which he himself was so prematurely snatched away; and at the same time raised up, when he least thought of it, the truest friend and protector to his wife and unborn daughter, who afterwards found in Mr Secker all that tender care and assistance which they could have hoped for from the nearest relation.

It being judged necessary by Mr Secker's friends that he should have a degree at Oxford, and having been informed, that if he should previously take the degree of doctor of physic at Leyden, it would probably help him in obtaining the other, he went and took his degree there in March 1721; and, as part of his exercise for it, he composed and printed a dissertation *De Medicina Statica*, which is still extant, and is thought by the gentlemen of that profession to be a sensible and learned performance. In April the same year, he entered himself a gentleman commoner of Exeter College, Oxford; after which he obtained the degree of bachelor of arts, in consequence of the chancellor's recommendatory letter to the convocation.

He now spent a considerable part of his time in London, where he quickly gained the esteem of some of the most learned and ingenious men of those days, particularly of Dr

Clarke, rector of St James's, and the celebrated Dean Berkeley, afterwards bishop of Cloyne, with whom he every day became more delighted and more closely connected. He paid frequent visits of gratitude and friendship to Mrs Talbot, widow of Mr Edward Talbot, by whom she had a daughter five months after his decease. With her lived Mrs Catharine Benson, sister of Bishop Benson, whom in many respects she greatly resembled. She had been for several years Mrs Talbot's inseparable companion, and was of unspeakable service to her at the time of her husband's death, by exerting all her courage, activity, and good sense, of which she possessed a large share, to support her friend under so great an affliction, and by afterwards attending her sickly infant with the utmost care and tenderness.

Bishop Talbot being in 1721 appointed to the see of Durham, Mr Secker was in 1722 ordained deacon by him in St James's church, and not long afterwards priest in the same place, where he preached his first sermon on 28th of March 1723. The bishop's domestic chaplain was at that time Dr Rundle, a man of warm fancy and very brilliant conversation, but apt sometimes to be carried, by the vivacity of his wit, into indiscreet and ludicrous expressions, which created him enemies, and, upon one occasion, produced disagreeable consequences. With him Mr Secker was soon afterwards associated in the bishop's family, and both were taken down by his lordship to Durham in July 1723.

In the following year the bishop gave Mr Secker the rectory of Houghton-le-Spring. This preferment putting it in his power to fix himself in the world in a manner agreeable to his inclinations, he soon afterwards made a proposal of marriage to Mrs Benson, which being accepted, they were married by Bishop Talbot in 1725. At the earnest request of both, Mrs Talbot and her daughter consented to live with them, and the two families from that time became one.

About this time Bishop Talbot also gave preferments to Mr Butler and Mr Benson, whose rise and progress in the church are here interwoven with the history of Mr Secker. In the winter of 1725–26, Mr Butler first published his incomparable sermons; of which, as Dr Beilby Porteous and Dr Stinton inform us, Mr Secker took pains to render the style more familiar, and the author's meaning more obvious; yet they were by many called obscure. Mr Secker gave his friend the same assistance in that noble work the Analogy of Religion Natural and Revealed.

He now gave up all the time he possibly could to his residence at Houghton, applying himself with alacrity to all the duties of a country clergyman, and supporting an useful and respectable character throughout. Here he would have been content to live and die; here, as he has often been heard to declare, he spent some of the happiest hours of his life; and it was no thought or choice of his own that removed him to a higher and more conspicuous situation. But Mrs Secker's health, which now began to decline, and was thought to be injured by the dampness of the situation, obliged him to think of exchanging it for a more healthy one. Accordingly, an exchange was made through the friendly interposition of Mr Benson, with Dr Finney, prebendary of Durham, and rector of Ryton; and Mr Secker was instituted to Ryton and the prebend on the 3d of June 1727. For the two following years he lived chiefly at Durham, going every week to officiate at Ryton, and spending there two or three months together in the summer.

In July 1732 he was appointed chaplain to the king; for which favour he was indebted to Dr Sherlock, who having heard him preach at Bath, had conceived the highest opinion of his abilities, and had thought them well worthy of being brought forward into public notice. From that time an intimacy commenced between them, and he received from that great prelate many solid proofs of esteem and friendship.

His month of waiting at St James's happened to be August, and on Sunday the 27th of that month he preached before the queen, the king being then abroad. A few days afterwards, her majesty sent for him into her closet, and held a long conversation with him, in the course of which he took an opportunity of mentioning to her his friend Mr Butler. He also, not long after this, on Mr Talbot's being made lord chancellor, found means to have Mr Butler effectually recommended to him for his chaplain. The queen likewise appointed him clerk of her closet; and from this situation he rose, as his talents became more known, to those high dignities which he afterwards attained.

Mr Secker now began to have a public character, and to stand high in the estimation of those who were allowed to be the best judges of merit. He had already given proofs of abilities that plainly indicated the eminence to which he must one day rise as a preacher and a divine; and it was not long before an opportunity offered of placing him in an advantageous point of view. Dr Tyrrwhit, who succeeded Dr Clarke as rector of St James's in 1729, found that preaching in so large a church endangered his health. Bishop Gibson, his father-in-law, therefore proposed to the crown that he should be made residentiary of St Paul's, and that Mr Secker should succeed him in the rectory. This arrangement was so acceptable to those in power, that it was entered into without any difficulty. Mr Secker was instituted rector on the 18th of May 1733; and in the beginning of July went to Oxford to take his degree of doctor of laws, not being of sufficient standing for that of divinity. On this occasion it was that he preached his celebrated Act Sermon, on the advantages and duties of academical education, which was universally allowed to be a masterpiece of sound reasoning and just composition. It was printed at the desire of the heads of houses, quickly passed through several editions, and is now to be found in the second collection of Occasional Sermons, published by himself in 1766.

It was thought that the reputation he acquired by this sermon contributed not a little towards that promotion which very soon followed its publication. For in December 1734, he received a very unexpected notice from Bishop Gibson, that the king had fixed on him for the see of Bristol. Dr Benson was about the same time appointed to the see of Gloucester, as was Dr Fleming to that of Carlisle; and the three new bishops were all consecrated together in Lambeth chapel, on the 19th of January 1734–1735, the consecration sermon being preached by Dr Thomas, afterwards bishop of Winchester.

The honours to which Dr Secker was thus raised in the prime of life did not in the least abate his diligence and attention. He drew up, for the use of his parishioners, an admirable course of Lectures on the Church Catechism, and not only read them once every week on the usual days, but also every Sunday evening, either at the church or one of the chapels belonging to it.

The sermons which he, at the same time, composed, were truly excellent and original. His faculties were now in their full vigour, and he had an audience to speak before which rendered the utmost exertion of them necessary. In 1737, he succeeded to the see of Oxford, on the promotion of Dr Potter to that of Canterbury, then vacant by the death of Archbishop Wake. In 1750, he was installed dean of St Paul's, for which he gave in exchange the rectory of St James's and his prebend of Durham. Having now more leisure both to prosecute his own studies and to encourage those of others, he gave Dr Church considerable assistance in his First and Second Vindication of the Miraculous Powers, against Mr Middleton; and he was of equal use to him in his Analysis of Lord Bolingbroke's Works. About the same time began Archdeacon Sharp's controversy with the followers of Mr Hutchinson, which

Second || Second Sight.

was carried on to the end of the year 1755. Bishop Secker, we are told, read over all Dr Sharp's papers, amounting to three volumes octavo, and corrected and improved them throughout. But the ease which this change of situation gave him was soon disturbed by a heavy and unexpected stroke, namely, the loss of his three friends, Bishops Butler, Benson, and Berkeley, who were all cut off within the space of one year.

On the death of Archbishop Hutton, he was promoted to the see of Canterbury, and was confirmed at Bow-church, on the 21st of April 1758. He had never once throughout his whole life asked preferment for himself, nor shown any unbecoming eagerness for it; and the use he made of his newly-acquired dignity very clearly showed, that rank, and wealth, and power, had no other charms for him, than as they enlarged the sphere of his active and industrious benevolence.

For more than ten years, during which Dr Secker enjoyed the see of Canterbury, he resided constantly at his archiepiscopal house at Lambeth. A few months before his death, the dreadful pains he felt had compelled him to think of trying the Bath waters; but that design was stopped by the fatal accident which put an end to his life. His Grace had been for many years subject to the gout, which, in the latter part of his life, returned with more frequency and violence, and did not go off in a regular manner, but left the parts affected for a long time very weak, and was succeeded by pains in different parts of the body. About a year and a half before he died, after a fit of the gout, he was attacked with a pain in the arm, near the shoulder, and having continued about twelve months, a similar pain seized the upper and outer part of the opposite thigh, and the arm soon became easier.

On Saturday the 30th of July 1768, he was seized, as he sat at dinner, with a sickness at his stomach. He recovered before night; but the next evening, while his physicians were attending, and his servants raising him on his couch, he suddenly cried out that his thigh-bone was broken. The shock was so violent, that the servants perceived the couch to shake under him, and the pain so acute and unexpected, that it overcame the firmness he so remarkably possessed. He lay for some time in great agony; but when the surgeons arrived, and discovered with certainty that the bone was broken, he was perfectly resigned, and never afterwards asked a question about the event. A fever soon ensued. On Tuesday he became lethargic, and continued so until about five o'clock on Wednesday afternoon, when he expired with great calmness, in the seventy-fifth year of his age. On examination, the thigh-bone was found to be carious about four inches in length, and at nearly the same distance from its head. The disease took its rise from the internal part of the bone, and had so entirely destroyed its substance, that nothing remained at the part where it was broken but a portion of its outward integument; and even this had many perforations, one of which was large enough to admit two fingers, and was filled with a fungous substance arising from within the bone. There was no appearance of matter about the caries, and the surrounding parts were in a sound state. It was apparent that the torture which he underwent during the gradual corrosion of this bone must have been inexpressibly great.

SECOND, in *Geometry*, *Chronology*, and other sciences, the sixtieth part of a prime or minute, whether of a degree or of an hour.

SECOND, in *Music*, one of the musical intervals, being only the difference between any sound and the next nearest sound, whether above or below it.

SECOND SIGHT, in Gaelic called *Taisch*, is a mode of seeing superadded to that which nature generally bestows. This gift or faculty, which is neither voluntary nor constant, is in general rather troublesome than agreeable to the possessors of it, who are chiefly to be found among the inhabitants of the Highlands of Scotland, those of the Western Isles, of the Isle of Man, and of Ireland. It is an impression made either by the mind upon the eye, or by the eye upon the mind, by which things distant or future are perceived, and seen as if they were present. A man on a journey far from home falls from his horse; another, who is perhaps at work about the house, sees him bleeding on the ground, commonly with a landscape of the place where the accident befalls him. Another seer, driving home his cattle, or wandering in idleness, or musing in the sunshine, is suddenly surprised by the appearance of a bridal ceremony, or funeral procession, and counts the attendants or mourners, of whom, if he knows them, he relates the names, but if he knows them not, he can describe the dresses. Things distant are seen at the instant they happen.

Second Sight.

Of things future, Johnson says that he knows no rule pretended to for determining the time between the sight and the event; but we are informed by Mr Grose, that in general the time of accomplishment bears some relation to the time of the day in which the impressions are received. Thus visions seen early in the morning, which seldom happens, will be much sooner accomplished than those appearing at noon; and those seen at noon will take place in a much shorter time than those happening at night. Sometimes the accomplishment of the latter does not fall out within a year or more.

These visions are not confined to solemn or important events, nor is it true, as is commonly reported, that to the second sight nothing is presented but phantoms of evil. The future visit of a mountebank or a piper, a plentiful draught of fish, the arrival of common travellers, or, if possible, still more trifling matters than these, are foreseen by the seers. A gentleman told Dr Johnson, that when he had once gone far from his own island, one of his labouring servants predicted his return, and described the livery of his attendant, which he had never worn at home, and which had been, without any previous design, occasionally given him.

Dr Beattie of Aberdeen gives the following account of this imaginary gift. The Highlands of Scotland are a picturesque but a melancholy country. Long tracts of mountainous desert, covered with dark heath, and often obscured by misty weather; narrow valleys, thinly inhabited, and bounded by precipices resounding with the fall of torrents; a soil so rugged, and a climate so dreary, as in many parts to admit neither the amusements of pasturage nor the labours of agriculture; the mournful dashing of waves along the friths and lakes that intersect the country; the portentous noises which every change of the wind and every increase or diminution of the waters is apt to raise in a lonely region full of echoes and rocks and caverns; the grotesque and ghastly appearance of such a landscape by the light of the moon; objects like these diffuse a gloom over the fancy, which may be compatible enough with occasional and social merriment, but cannot fail to tincture the thoughts of a native in the hour of silence and solitude. If these people, notwithstanding their reformation in religion, and more frequent intercourse with strangers, do still retain many of their old superstitions, we need not doubt but in former times they must have been much more enslaved to the horrors of imagination, when beset with the bugbears of Popery and Paganism. Most of their superstitions are of a melancholy cast. That of Second Sight, by which some are still supposed to be haunted, is considered by themselves as a misfortune, on account of the many dreadful images it is said to obtrude upon the fancy. It is said that some of the Alpine regions do likewise lay claim to a sort of second sight. Nor is it wonderful, that persons of a lively imagination, immured in deep solitude, and surrounded with the stupendous scenery of clouds, precipices, and torrents, should dream, even when they think themselves awake, of those few striking ideas with which their lonely lives are diversified; of corpses, funeral processions, and other subjects of terror; or of marriages, the arrival of strangers, and such like matters of more agreeable curiosity.

Let it be observed, also, that the ancient Highlanders of Scotland had hardly any other way of supporting themselves than by hunting, fishing, or war, professions which are continually exposed to fatal accidents; and hence, no doubt, additional horrors would often haunt their solitude, and a deeper gloom overshadow the imagination even of the hardiest native.

A treatise on this subject was published in the year 1762, in which many tales were told of persons whom the author believed to have been favoured, or haunted, with these illuminations; but most of the tales were trifling and ridiculous, and the whole work betrayed, on the part of the compiler, the most extreme credulity.

That any of these visionaries are apt to be swayed in their declarations by sinister views, we will not say; but this may be alleged with confidence, that none but ignorant people pretend to be gifted in this way; and in them it may be nothing more, perhaps, than short fits of sudden sleep or drowsiness, attended with lively dreams, and arising from some bodily disorder, the effect of idleness, low spirits, or a gloomy imagination. For it is admitted, even by the most credulous Highlanders, that as knowledge and industry are propagated in their country, the second sight disappears in proportion; and nobody ever laid claim to the faculty who was much employed in the intercourse of social life.[1] Nor is it at all extraordinary that one should have the appearance of being awake, and should even think one's self so, during those fits of dozing; that they should come on suddenly, and while one is engaged in some business. The same thing happens in persons much fatigued, or long kept awake, who frequently fall asleep for a moment, or for a long space, while they are standing, or walking, or riding on horseback. Add but a lively dream to this slumber, and take away the consciousness of having been asleep, and a superstitious man may easily mistake his dream for a waking vision; which, however, is soon forgotten when no subsequent occurrence recalls it to his memory, but which, if it shall be thought to resemble any future event, exalts the poor dreamer into a Highland prophet. This conceit makes him more recluse and more melancholy than ever, and so feeds his disease, and multiplies his visions, which, if they are not dissipated by business or society, may continue to haunt him as long as he lives, and which, in their progress through the neighbourhood, receive some new tinctures of the marvellous from every mouth that promotes their circulation. As to the prophetical nature of this second sight, it cannot be admitted at all. That the Deity should work a miracle in order to give intimation of the frivolous things of which these tales are composed, the arrival of a stranger, the nailing of a coffin, or the colour of a suit of clothes; and that these intimations should be given for no end, and to those persons only who are idle and solitary, who speak Gaelic, or who live among mountains and deserts; is like nothing in nature or providence that we are acquainted with, and must therefore, unless it were confirmed by satisfactory proof, be rejected as absurd and incredible.

To these objections Dr Johnson replies, that by presuming to determine what is fit and what is beneficial, they presuppose more knowledge of the universal system than man has attained, and therefore depend upon principles too complicated and extensive for our comprehension; that there can be no security in the consequence when the premises are not understood; that the second sight is only wonderful because it is rare, for, considered in itself, it involves no greater difficulty than dreams, or perhaps than the regular exercise of the cogitative faculty; that a general opinion of communicative impulses, or visionary representations, has prevailed in all ages and among all nations; that particular instances have been given, with such evidence as neither Bacon nor Bayle has been able to resist; that sudden impressions, which the event has verified, have been felt by more than own or publish them; that the second sight of the Hebrides implies only the local frequency of a power which is nowhere totally unknown; and that where we are unable to decide by antecedent reason, we must be content to yield to the force of testimony. By the pretension to second sight, no profit was ever sought or gained. It is an involuntary affection, in which neither hope nor fear are known to have any part. Those who profess to feel it do not boast of it as a privilege, nor are considered by others as advantageously distinguished. They have no temptation to feign, and their hearers have no motive to encourage the imposture.

SECT, a collective term, comprehending all those who follow the doctrines and opinions of some famous divine, philosopher, or other person.

SECTION, in general, denotes a part of a divided thing, or the division itself. Such, particularly, are the subdivisions of a chapter, called also *paragraphs* and *articles*. The mark of a section is §.

Section, in *Geometry*, denotes a side or surface of a body or figure cut off by another, or the place where lines, planes, and the like, cut each other.

SECTOR, in *Geometry*, is a part of a circle comprehended between two radii and an arc of the circle.

Sector is also a mathematical instrument, of use in finding the proportion between quantities of the same kind; as between lines and lines, surfaces and surfaces, &c. whence the French call it the *compass of proportion*. The great advantage of the sector above the common scales is, that it is made so as to fit all radii and all scales. By the lines of chords, sines, &c. upon the sector, we have lines of chords, sines, &c. to any radius between the length and breadth of the sector when open.

The sector is supposed to have been invented by Guido Baldo, or Ubaldo, about the year 1568. The first printed account of it was in 1584, by Gaspar Mordente, at Antwerp, who says that his brother, Fabricius Mordente, invented it in 1554. Treatises on its use have been written by Daniel Specle at Strasburg in 1589; also by Thomas Hood at London in 1598, and by Lewin Hulse at Frankfort-on-the-Maine in 1603, who says that it was invented long before by Justus Byrgius. But the honour of the invention was claimed by Galileo, who wrote on its use in 1607, and by Balthasar Capra of Milan. There are also treatises on it by our countrymen Gunter, Forster, and others.

Before the invention of logarithms, practical men were more easily contented with approximate solutions than they are at present. Now, however, any question that can be resolved by the sector can be about as readily answered by the smallest table of logarithms, and with perfect certainty, as far as the table extends. Hence it is that the sector is not much used, although it is commonly reckoned one of a complete set of mathematical instruments.

For treatises on its use, see Bion on Mathematical Instruments, translated by Stone; Robertson's Treatise on Mathematical Instruments; and Adams's Geometrical Essays.

Any one possessing a sector will easily understand its theory and use from the 14th problem of the fifth section of our treatise on GEOMETRY, where it is taught how to find a fourth proportional to three given lines.

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[1] This, however, is denied by Johnson, who affirms that the islanders of all degrees, whether of rank or understanding, universally admit it; except the ministers, who, according to him, reject it, in consequence of a system, against conviction. He affirms, too, that in 1773, there was in the Hebrides a second-sighted gentleman, who complained of the terrors to which he was exposed.

SECTOR of a Sphere is the solid generated by the revolution of the sector of a circle about one of its radii; the other radius describing the surface of a cone, and the circular arc a circular portion of the surface of the sphere of the same radius. Hence the spherical sector consists of a right cone, and of a segment of the sphere having the same common base with the cone. The solid content will therefore be found by multiplying the base or spherical surface by the radius of the sphere, and taking one third of the product.

SECTOR of an Ellipse or Hyperbola, is the space contained by any two semidiameters, and the arc of the curve between them.

Astronomical SECTOR, or Equatorial SECTOR, an instrument for taking the difference of right ascensions and declinations of such stars as, on account of their great difference of declinations, will not pass through a fixed telescope. There is an instrument of this kind in the observatory at Greenwich, and it is described in Vince's Practical Astronomy.

Zenith SECTOR, an instrument employed in extensive trigonometrical surveys. Its use is to determine with great accuracy the zenith distances of stars whose declinations differ but little from the latitude of an observer. A very fine instrument of this kind, constructed by Ramsden, is now using in the trigonometrical survey of Britain, and is fully described and figured in the Transactions of the Royal Society of London for 1803.

SECULAR, that which relates to affairs of the present world, in which sense the word stands opposed to *spiritual* and *ecclesiastical.*

SECULAR is more peculiarly used for a person who lives at liberty in the world, not shut up in a monastery, nor bound by vows, or subjected to the particular rules of any religious community; in which sense it stands opposed to *regular.* The Catholic clergy are divided into secular and regular; of which the latter are bound by monastic rules, the former not.

SECULAR Games, in *Antiquity,* solemn games held among the Romans once in an age.

These games lasted three days and as many nights, during which time sacrifices were performed, and theatrical shows exhibited, with combats and sports in the circus. The occasion of these games, according to Valerius Maximus, was to stop the progress of a plague. Valerius Publicola was the first who celebrated them at Rome, in the year of the city 245. The whole world was invited by a herald to a feast which they had never seen before, nor ever should see again. Some days before the games began, the quindecemviri, in the Capitol and in the Palatine temple, distributed to the people purifying compositions of various kinds. Thence the populace passed to Diana's temple on the Aventine Mount, with wheat, barley, and oats, as an offering. After this whole nights were spent in devotion to the Destinies. When the time of the games was fully come, the people assembled in the Campus Martius, and sacrificed to Jupiter, Juno, Apollo, Latona, Diana, the Parcæ, Ceres, Pluto, and Proserpine. On the first night of the feast, the emperor, with the quindecemviri, caused three altars to be erected on the banks of the Tiber, which were sprinkled with the blood of three lambs, and then proceeded to regular sacrifice. A space was next marked out for a theatre, which was illuminated with innumerable flambeaux and fires. Here they sung hymns, and celebrated all kinds of sports. On the day afterwards, having offered victims at the Capitol, they went to the Campus Martius, and celebrated sports in honour of Apollo and Diana. These lasted until next day, when the noble matrons, at the hour appointed by the oracle, went to the Capitol to sing hymns to Jupiter. On the third day, which concluded the solemnity, twenty-seven boys, and as many girls, sung, in the temple of Palatine Apollo, hymns and verses in Greek and Latin, to recommend the city to the protection of those deities whom they designed particularly to honour by their sacrifices. The inimitable *Carmen Seculare* of Horace was composed for this last day, in the Secular Games celebrated by Augustus.

It has been much disputed whether these games were held every hundred or every hundred and ten years. Valerius Antius, Varro, and Livy, are quoted in support of the former opinion. In favour of the latter may be produced the quindecemviral registers, the edicts of Augustus, and the words of Horace in the secular poem, "Certus undenos decies per annos."

It was a general belief, that the girls who bore a part in the song should be soonest married; and that the children who did not dance and sing at the coming of Apollo should die unmarried, and at an early period of life.

SECULARIZATION, the act of converting a regular person, place, or benefice, into a secular one. Almost all the cathedral churches were anciently regular, that is, the canons were religious; but they have been since secularized. For the secularization of a regular church, there is required the authority of the pope, that of the prince, the bishop of the place, the patron, and even the consent of the people. Religious that want to be released from their vow, obtain briefs of secularization from the pope.

SECUNDRA, a town of Hindustan, in the province of Agra, and district of Furrukabad, forty-four miles north-east from Agra. Long. 78. 21. E. Lat. 27. 45. N. It is also a town of Delhi, in the district of Merat, twenty-eight miles south-east from the city of Delhi. Long. 77. 34. E. Lat. 28. 38. N. Likewise a town in the province of Agra, district of Etaweh, on the Jumna, forty-seven miles from the town of Etaweh. Long. 79. 35. E. Lat. 26. 23. N.

SECUNDUS, JOANNES NICOLAIUS, an elegant writer of Latin poetry, was born at the Hague in the year 1511. His descent was from an ancient and honourable family in the Netherlands; and his father Nicolaus Everardus, who was born in the neighbourhood of Middleburg, seems to have been high in the favour of the Emperor Charles V., as he was employed by that monarch in several stations of considerable importance. We find him first a member of the grand parliament or council of Mechelen, afterwards president of the states of Holland and Zealand at the Hague, and lastly holding a similar office at Mechelen, where he died on the 5th of August 1532, aged seventy.

These various employments did not occupy the whole of Everardus's time. Notwithstanding the multiplicity of his business, he found leisure to cultivate letters with great success, and even to act as preceptor to his own children, who were five sons and three daughters. They all took the name of Nicolaii from their father; but on what account our author was called Secundus is not known. It could not be from the order of his birth, for he was the youngest son. Perhaps the name was not given him till he became eminent; and then, according to the fashion of the age, it might have arisen from some pun, such as his being *Poetarum nemini Secundus.* Poetry, however, was by no means the profession which his father wished him to follow. He intended him for the law, and, when he could no longer direct his studies himself, placed him under the care of Jacobus Valeardus. This man is said to have been every way well qualified to discharge the important trust which was committed to him; and he certainly gained the affection of his pupil, who, in one of his poems, mentions the death of Valeardus with every appearance of unfeigned sorrow. Another tutor was soon provided; but it does not appear that Secundus devoted much of his time to legal pursuits. Poetry, and the sister arts of painting and sculpture, had engaged his mind at a very early period; and the imagination, on which these lay hold, can with difficulty submit to the dry study of musty civilians. Secundus is said to have written verses when but ten years old; and from the vast quantity which he left behind him, we have reason to conclude that such writing constituted his principal employment. He found time, however, to carve figures of all his own family, of his mistresses, of the Emperor Charles V., of several eminent personages of those times, and of many of his intimate friends; and in the last edition of his works, published by Scriverius, at Leyden, 1631, there is a print of one of his mistresses with this inscription around it: *Vatis amatoris Julia sculpta manu.*

Secundus having nearly attained the age of twenty-one, and being determined, as it would seem, to comply as far as possible with the wishes of his father, quitted Mechelen, and went to France, where, at Bourges, a city in the Orleannois, he studied the civil law under the celebrated Andreas Alciatus. Alciatus was one of the most learned civilians of that age; but that which undoubtedly endeared him much more to our author, was his general acquaintance with polite literature, and more particularly his taste in poetry. Having studied a year under this eminent professor, and taken his degrees, Secundus returned to Mechelen, where he remained only a very few months. In 1533 he went into Spain with warm recommendations to the Count of Nassau and other persons of high rank; and soon afterwards he became secretary to the cardinal archbishop of Toledo, in a department of business which required no other qualifications than what he possessed in a very eminent degree, a facility in writing with elegance the Latin language. It was during his residence with this cardinal that he wrote his *Basia*, a series of wanton poems, of which the fifth, seventh, and ninth *carmina* of Catullus seem to have given the hint. Secundus was not, however, a servile imitator of Catullus. His expressions seem to be borrowed rather from Tibullus and Propertius; and in the warmth of his descriptions he surpasses every thing that has been written on similar subjects by Catullus, Tibullus, Propertius, C. Gallus, Ovid, or Horace.

In 1535 he accompanied the Emperor Charles V. to the siege of Tunis, but gained few laurels as a soldier. The hardships which were endured at that memorable siege were but little suited to the soft disposition of a votary of Venus and the muses; and upon an enterprise which might have furnished ample matter for an epic poem, it is remarkable that Secundus wrote nothing which has been deemed worthy of preservation. Having returned from his martial expedition, he was sent by the cardinal to Rome to congratulate the pope upon the success of the emperor's arms, but was taken so ill on the road, that he was not able to complete his journey. He was advised to seek, without a moment's delay, the benefit of his native air; and that happily recovered him.

Having now quitted the service of the archbishop of Toledo, Secundus was employed in the same office of secretary by the bishop of Utrecht; and so much had he hitherto distinguished himself by the classical elegance of his compositions, that he was soon called upon to fill the important post of private Latin secretary to the emperor, who was then in Italy. This was the most honourable office to which our author was ever appointed; but before he could enter upon it, death put a stop to his career of glory. Having arrived at Saint Amand, in the district of Tournay, in order to meet, upon business, with the bishop of Utrecht, he was, upon the 8th of October 1536, cut off by a violent fever, in the very flower of his age, not having quite completed his twenty-fifth year. He was interred in the church of the Benedictines, of which his patron the bishop was abbot; and his near relations erected to his memory a marble monument, with a plain Latin inscription.

The works of Secundus have gone through several editions, of which the best and most copious is that of Scriverius already mentioned. It consists of, 1. Julia, eleg. lib. i.; 2. Amores, eleg. lib. ii.; 3. Ad Diversos, eleg. lib. iii.; 4. Basia, styled by the editor *incomparabilis et divinus prorsus liber*; 5. Epigrammata; 6. Odarum liber unus; 7. Epistolarum liber unus; 8. Epistolarum liber alter, heroico carmine scriptus; 9. Funerum liber unus; 10. Sylvæ et Carminum fragmenta; 11. Poemata nonnulla fratrum; 12. Itineraria Secundi tria; 13. Epistolæ totidem, soluta oratione. Of these works it would be superfluous in us to give any character, after the ample testimonies prefixed to them by Lelius Greg. Gyraldus, the elder Scaliger, Theodore Beza, and others equally celebrated in the republic of letters, who all speak of them as excellent.

SECUTORES, a species of gladiators among the Romans, whose arms were a helmet, a shield, and a sword or a leaden bullet. They were armed in this manner, because they had to contend with the retiarii, who were dressed in a short tunic, and bore a three-pointed lance in their left hand, and a net in their right. The retiarius attempted to cast his net over the head of the secutor; and if he succeeded, he drew it together and slew him with his trident; but if he missed his aim, he immediately betook himself to flight, till he could find a second opportunity of entangling his adversary with his net. He was pursued by the secutor, who endeavoured to despatch him in his flight.

Secutores was also a name given to such gladiators as took the place of those that were killed in the combat, or who engaged the conqueror. This post was usually taken by lot.

SEDAN, an arrondissement of the department of the Ardennes, in France, extending over 278 square miles, divided into four cantons and eighty-two communes, with, in the year 1836, 63,233 inhabitants. The capital is the fortified city of the same name, situated on the river Meuse. It is celebrated for its cloth manufactures, especially those of black; and it has also some considerable establishments for making cannon, muskets, and other arms, as well as other kinds of hardware, and china. In the same year its population amounted to 13,719. It was the birthplace of the celebrated Turenne. Long. 4. 52. 31. E. Lat. 49. 22. 29. N.

SEDAN-CHAIR is a covered vehicle for carrying a single person, being suspended by two poles, and borne by two men, who are hence denominated *chairmen*. They were first introduced into London in 1634, when Sir Sanders Duncomb obtained the sole privilege to use, let, and hire a number of the said covered chairs for fourteen years.

SEDASIER, a town of Hindustan, in the province of Mysore, and district of Coorg. In 1799 the troops of Tippoo Sultan were here defeated by the British. It is seven miles north-west of Periapatam.

SEDBERGH, a town in the wapentake of Staincliff and Ewcross, in the west riding of the county of York, 271 miles from London. It is situated on the borders of Westmoreland, at the foot of the Houghill Fells. It has a market, which is held on Thursday. The population amounted in 1821 to 4483, and in 1831 to 4711.

SEDHOUT, a district in the Balaghaut ceded territories, situated principally between the fourteenth and fifteenth degrees of north latitude. It lies immediately within the Eastern Ghauts. It is a rocky and mountainous region, indifferently cultivated, but interspersed with fertile valleys. The chief river is the Pennar, and the principal town is Odegherry. The fortress of Sedhout, the capital of the above district, was taken by Meer Jumla about the year 1650. At this period Sedhout and the adjoining district were celebrated for their diamond mines, which, however, are no longer worked.

SEDITION, among civilians, is used for a factious commotion of the people, or an assembly of a number of citizens without lawful authority, tending to disturb the peace and order of society. This offence is of different kinds. Some seditions more immediately threaten the supreme power, and the subversion of the present constitution of the state; others tend only towards the redress of private grievances. Among the Romans, therefore, it was variously punished, according as its end and tendency threatened greater mischief. (See lib. i. *Cod. de Seditiosis*, and *Mat. de Crimin.* lib. ii. n. 5, *De Læsa Majestate.*) In the punishment, the authors and ringleaders were justly distinguished from those who, with less wicked intention, joined and made part of the multitude.

The same distinction holds in the law of England and in that of Scotland. Some kinds of sedition in England amount to high treason, and come within the statute 25 Edward III. as levying war against the king. And several seditions are mentioned in the Scotch acts of parliament as treasonable (Bayne's Crim. Law of Scotland, p. 33, 34). The law of Scotland makes riotous and tumultuous assemblies a species of sedition. But the law there, as well as in England, is now chiefly regulated by the riot act, made 1 Geo. I.; only it is to be observed, that the proper officers in Scotland to make the proclamation thereby enacted are sheriffs, stewards, and bailies of regalities, or their deputies; magistrates of royal boroughs, and all other inferior judges and magistrates; high and petty constables, or other officers of the peace, in any county, stewartry, city, or town. In that part of the island, the punishment of the offence is any thing short of death which the judges, in their discretion, may appoint.

SEDATIVES, in *Medicine*, a general name for such medicines as weaken the powers of nature, such as blood-letting, cooling salts, purgatives, and the like.

SE-DEFENDENDO, in *Law*, is a plea used for him who is charged with the death of another, by alleging that he was under a necessity of doing what he did in his own defence; as that the other assaulted him in such a manner, that if he had not done what he did, he must have been in hazard of his own life.

SEDLEY, Sir Charles, an English poet and wit, the son of Sir John Sedley of Aylesford in Kent, was born about the year 1639. At the restoration he came to London to join the general jubilee, and commenced wit, courtier, poet, and gallant. He was so much admired, that he became a kind of oracle among the poets; which made King Charles tell him, that nature had given him a patent to be Apollo's viceroy. The productions of his pen were some plays, and several delicately tender amorous poems, in which the softness of the verses was so exquisite, as to be called by the Duke of Buckingham Sedley's witchcraft. Less pleasing opinions, however, have been expressed by others. "There were no marks of genius or true poetry to be descried," say the authors of the *Biographia Britannica;* "the art wholly consisted in raising loose thoughts and lewd desires, without giving any alarm; and so the poison worked gently and irresistibly. Our author, we may be sure, did not escape the infection of his own art, or rather was first tainted himself before he spread the infection to others." A very ingenious writer, however, speaks much more favourably of Sir Charles Sedley's writings. "He studied human nature," says Langhorn in his Effusions, "and was distinguished for the art of making himself agreeable, particularly to the ladies; for the verses of Lord Rochester, beginning with, *Sedley has that prevailing gentle art*, so often quoted, allude not to his writings, but to his personal address." But whilst he thus grew in reputation for wit and in favour with the king, he became poor and debauched; his estate was impaired, and his morals were corrupted. One of his frolics, however, being followed by an indictment and a heavy fine, Sir Charles took a more serious turn, applied himself to business, and became a member of parliament, in which he was a frequent speaker. We find him in the House of Commons in the reign of James II., whose attempts upon the constitution he vigorously withstood; and he was very active in bringing about the Revolution. This was thought more extraordinary, as he had received favours from James. But that prince had taken a fancy to Sir Charles's daughter, though it seems she was not very handsome, and, in consequence of his intrigues with her, he created Miss Sedley countess of Dorchester. This honour, so far from pleasing, greatly shocked Sir Charles. However libertine he himself had been, yet he could not bear the thoughts of his daughter's dishonour; and with regard to her exaltation, he only considered it as rendering her more conspicuously infamous. He therefore conceived a hatred for the king, and from this, as well as other motives, readily joined to dispossess him of the throne. A witty saying of Sedley's, on this occasion, is recorded. "I hate ingratitude," said Sir Charles; "and therefore, as the king has made my daughter a countess, I will endeavour to make his daughter a queen;" meaning the Princess Mary, married to the Prince of Orange, who dispossessed James of the throne at the Revolution. He lived till the beginning of Queen Anne's reign, and his works were printed in two vols. 8vo, 1719.

SEDRE Passage, a narrow channel of the Eastern Seas, on the north coast of Sumatra, between Pulo Nancy and King's Point.

SEDUCTION is the act of tempting and drawing aside from the right path, and comprehends every endeavour to corrupt any individual of the human race. This is the import of the word in its largest and most general sense; but it is commonly employed to express the act of tempting a virtuous woman to part with her chastity.

The seducer of female innocence practises the same stratagems of fraud to get possession of a woman's person, that the swindler employs to get possession of his neighbour's goods or money; yet the law of honour, which pretends to abhor deceit, and which impels its votaries to murder every man who presumes, however justly, to suspect them of fraud, or to question their veracity, applauds the address of a successful intrigue, though it be well known that the seducer could not have obtained his end without swearing to the truth of a thousand falsehoods, and calling upon God to witness promises which he never meant to fulfil.

The law of honour is indeed a very capricious rule, which accommodates itself to the pleasures and conveniences of higher life; but the law of the land, which is enacted for the equal protection of high and low, may be supposed to view the guilt of seduction with a more impartial eye. Yet for this offence, even the laws of this kingdom have provided no other punishment than a pecuniary satisfaction to the injured family; which, in England, can be obtained only by one of the quaintest fictions in the world, by the father's bringing his action against the seducer for the loss of his daughter's service during her pregnancy and nurturing. (See Paley's Moral Philosophy, book iii. part iii. chap. 3.)

The moralist, however, who estimates the merit or demerit of actions, not by laws of human appointment, but by their general consequences as established by the laws of nature, must consider the seducer as a criminal of the deepest guilt. In every civilized country, and in many countries where civilization has made but small progress, the virtue of women is collected as it were into a single point, which they are to guard above all things, as that on which their happiness and reputation wholly depend. At first sight this may appear a capricious regulation; but a moment's reflection will convince us of the contrary. In the married state so much confidence is necessarily reposed in the fidelity of women to the beds of their husbands, and

Seduction.

See Amol ‖ Seebah.

evils so great result from the violation of that fidelity, that whatever contributes in any degree to its preservation, must be agreeable to Him who, in establishing the laws of nature, intended them to be subservient to the real happiness of all his creatures. But nothing contributes so much to preserve the fidelity of wives to their husbands, as the impressing upon the minds of women the highest veneration for the virtue of chastity. She who, when unmarried, has been accustomed to grant favours to different men, will not find it easy, if indeed possible, to resist afterwards the allurements of variety. It is therefore a wise institution, and agreeable to the will of Him who made us, to train up women so that they may look upon the loss of their chastity as the most disgraceful of all crimes; as that which sinks them in the order of society, and robs them of all their value. In this light virtuous women actually look upon the loss of chastity. The importance of that virtue has been so deeply impressed upon their minds, and is so closely associated with the principle of honour, that they cannot think but with abhorrence upon the very deed by which it is lost. He therefore who by fraud and falsehood persuades the unsuspecting girl to deviate in one instance from the honour of the sex, weakens in a great degree her moral principle; and if he reconcile her to a repetition of the crime, he destroys that principle entirely, as she has been taught to consider all other virtues as inferior to that of chastity. Hence it is that the hearts of prostitutes are generally steeled against the miseries of their fellow-creatures; that they lend their aid to the seducer in his practices upon other girls; that they lie, and swear, and steal without compunction; and that too many of them hesitate not to commit murder, if it can serve any selfish purpose of their own.

The loss of virtue, though the greatest that man or woman can sustain, is not the only injury which the seducer brings upon the girl whom he deceives. She cannot at once reconcile herself to prostitution, or even to the loss of character, and whilst a sense of shame remains in her mind, the misery which she suffers must be exquisite. She knows that she has forfeited what in the female character is most valued by both sexes; and she must be under the perpetual dread of a discovery. She cannot even confide in the honour of her seducer, who may reveal her secret in a fit of drunkenness, and thus rob her of her fame as well as of her virtue; and whilst she is in this state of anxious uncertainty, the agony of her mind must be insupportable. That it is so in fact, the many instances of child-murder by unmarried women of every rank leave us no room to doubt. The affection of a mother to her new-born child is one of the strongest and most unequivocal instincts in human nature; and nothing short of the extremity of distress can prompt any one so far to oppose nature as to embrue her hands in the blood of her imploring infant.

Even this deed of horror seldom prevents a detection of the mother's frailty, which is indeed commonly discovered, though no child has been the consequence of her intrigue. He who can seduce is base enough to betray; and assuredly no woman can part with her honour and yet retain any well-grounded hope that her amour shall be kept secret. The villain to whom she surrendered will glory in his victory, if it was with difficulty obtained; and if she surrendered at discretion, her own behaviour will reveal her secret. Her reputation is then irretrievably lost, and no future circumspection will be of the smallest avail to recover it. She will be shunned by the virtuous part of her own sex, and treated as a mere instrument of pleasure by the other. In such circumstances she cannot expect to be married with advantage. She may perhaps be able to captivate the heart of a heedless youth, and prevail upon him to unite his fate to hers, before the delirium of his passion shall give him time for reflection; she may be addressed by a man who is a stranger to her story, and married while he has no suspicion of her secret; or she may be solicited by one of a station inferior to her own, who, though acquainted with every thing that has befallen her, can barter the delicacy of wedded love for some pecuniary advantage. But from none of these marriages can she look for happiness. The delirium which prompted the first will soon vanish, and leave the husband to the bitterness of his own reflections, which can hardly fail to produce cruelty to the wife. Of the secret to which, in the second case, the lover was a stranger, the husband will soon make a discovery, or at least find room for harbouring strong suspicions; and suspicions of having been deceived in a point so delicate have hitherto been uniformly the parents of misery. In the third case, the man married her merely for her money, of which having got the possession, he has no further inducement to treat her with respect. Such are some of the consequences of seduction, even when the person seduced has the good fortune afterwards to get a husband. But this is a fortune which few in her circumstances can reasonably expect. By far the greater part of those who have been defrauded of their virtue by the arts of the seducer sink deeper and deeper into guilt, till they become at last common prostitutes. The public is then deprived of their services as wives and parents; and instead of contributing to the population of the state, and to the sum of domestic felicity, these outcasts of society become seducers in their turn, corrupting the morals of every young man whose appetites they can inflame, and of every young woman whom they can entice to their own practices.

All this complication of evil is produced at first by arts which, if employed to deprive a man of his property, would subject the offender to the execration of his fellow-subjects, and to an ignominious death. But while the forger of a bill is pursued with relentless rigour by the ministers of justice, and the swindler loaded with universal reproach, the man who by fraud and forgery has enticed an innocent girl to gratify his desires at the expense of her virtue, and thus introduced her into a path which must infallibly lead to her own ruin, as well as to repeated injuries to the public at large, is not despised by his own sex, and is too often caressed even by the virtuous part of the other. Yet the loss of property may be easily repaired; whilst the loss of honour is irreparable. It is vain to plead in alleviation of this guilt, that women should be on their guard against the arts of the seducer. Most unquestionably they should; but arts have been used which hardly any degree of caution would have been sufficient to counteract. It may as well be said that the trader should be on his guard against the arts of the forger, and accept of no bill without previously consulting him in whose name it is written. Cases, indeed, occur in trade, in which this caution would be impossible. But he must be little acquainted with the workings of the human heart, who does not know that situations likewise occur in life, in which it is equally impossible for a girl of tenderness and virtue to resist the arts of the man who has completely gained her affections.

SEE AMOL, a small island in the Eastern Seas, near the east coast of Borneo. Long. 118. 48. E. Lat. 5. 27. N.

SEE BANGOG, a small island in the Eastern Seas, near the east coast of Borneo. Long. 118. 24. E. Lat. 4. 18. N.

SEE BEEROO ISLE, an island that lies off the west coast of Sumatra, and is situated principally between the first and second degrees of south latitude, and the ninety-eighth and ninety-ninth of east longitude. It is seventy miles in length by ten in average breadth, and contains a volcano, which renders it conspicuous at a distance.

SEEASSEE ISLE, a small island in the Eastern Seas, one of the Sooloo archipelago. It is a woody island, well supplied with water, and yields many cowries and small baat, named Seeassee.

SEEBAH, a town and district in the Sikh territories, in the province of Lahore, between the thirty-first and thirty-second degrees of north latitude. The district is hilly, and covered with wood; and the town is fortified, being situated a hundred miles east by south from the city of Lahore. Long. 75. 34. E. Lat. 31. 39. N.

SEEBGUNGE, a town of Bengal, in the district of Dinagepoor, eighty-four miles north-north-east from Moorshedabad. Long. 89. 12. E. Lat. 25. 3. N.

SEEDGHUR, a celebrated fortress of Hindustan, in the province of Bejapore, taken, with scarcely any loss, from the Mahrattas in 1818.

SEEDLINGS, among gardeners, denote such roots of gilliflowers and others as come from seed sown; also the young and tender shoots of any plants that are newly sown.

SEEKS, or Sikhs, a religious sect settled at Patna, and so called from a word contained in one of the commandments of their founder, which signifies *learn thou*. In books giving an account of the oriental sects and oriental customs, we find mention made both of the Seeks and the Sikhs; and we are strongly inclined to think that the same tribe is meant to be denominated by both words. If so, however, different authors write very differently of their principles and manners. (See Mr Wilkins's account of them in the Asiatic Researches.)

SEENGHOO, a town of the Birman empire, situated on the banks of the Irrawaddy.

SEEOR, a town of Hindustan, in the Mahratta territories, and province of Malwah, twenty-two miles west by south from Bopal, situated on the small river Rootah Seein. It has a considerable manufactory of striped and chequered muslins.

SEEPARRAN, a small island in the Eastern Seas, near the east coast of Borneo. Long. 118. 23. E. Lat. 4. 8. N.

SEER, a principality of Arabia, in the province of Ommon, extending from Cape Mussendoon, along the shores of the Persian Gulf. This country not long since acknowledged the sovereign authority of the Imam; but the scheich has shaken off this dependence, and is often at war with his former master. His navy is one of the most considerable in the Persian Gulf; his subjects are much employed in navigation, and carry on an extensive trade.

SEERDHUNA, a town of Hindustan, in the province of Delhi, and district of Merat. This place was formerly the residence of Somroo Begum, and the capital of a small principality under her government, about twenty miles in length by twelve in breadth, which, with the town, were assigned to Somroo, who was originally a German, his real name being Walter Reinihard, who went to Bengal and entered the French service, and afterwards that of Gregory, an Armenian, who was high in favour with Cossim Ali, to whom he recommended Somroo. It was this adventurer who massacred the English prisoners at Patna in 1763. He died in 1776, leaving a favourite concubine, who resided at Delhi, under the protection of the British government, in 1807, and invested her property in the East India Company's funds at Calcutta. The district is fertile, producing all kinds of grain, sugar, and cotton. Long. of the town 77. 28. E. Lat. 29. 11. N.

SEERPOOR, a town in the province of Bengal, and district of Raujeshy, seventy-four miles north-east from Moorshedabad. Long. 89. 20. E. Lat. 24. 38. N.

SEES, a city of France, in the department of the Orne, and arrondissement of Alençon. It stands in a fruitful plain on the river Orne, near its source, is the seat of a bishop, and contains 900 houses, with 5860 inhabitants, who are employed in making black lace, hosiery, and cotton goods. Long. 6. 4. 44. E. Lat. 48. 36. 21. N.

SEETACOOND, a town of Bengal, in the district of Chittagong, remarkable for a warm spring, from which issues a flame, which is considered by the ignorant Hindus as an emanation from the deity, and consequently worthy of being worshipped. It is seventeen miles north from Islamabad. Long. 91. 36. E. Lat. 22. 37. N.

SEGALIEN. See Saghalien.

SEGMENT *of a* Circle, in *Geometry*, is that part of the circle which is contained between a chord and an arc of the same circle.

SEGMENTS, Line of, two particular lines on Gunter's sector. They lie between the lines of sines and superficies, and are numbered 5, 6, 7, 8, 9, 10. They represent the diameter of a circle, so divided into 100 parts, that a right line drawn through these parts, and perpendicular to the diameter, shall cut the circle into two segments, the greater of which shall have the same proportion to the whole circle as the parts cut off have to 100.

SEGO. See Bambarra.

SEGORBE, a city of Spain, upon the Palancia, in the province of Valencia, and in the neighbourhood of the Marmor Marsh, with 5000 inhabitants, whose trade consists of a few potteries, and the distillation of brandy.

SEGOVIA, one of the four provinces into which Old Castille, in Spain, is divided. It is generally an open and arid district, with scanty water, and little to merit description, except its capital, and the royal residences of Ildefonso and the Escurial, each of which is described under its appropriate article. The extent of the province is 290 square leagues, and its population amounts to 221,379 souls. The greater part of the province is destined to feed merino flocks, and the largest portion, particularly those with the finest wool, are shorn within it, as the weather is sufficiently warm to enable the sheep to bear that operation without feeling any inconvenience. Though it grows wine, oil, and corn, the harvests are by no means adequate to the consumption, and their wants must be supplied from other lands than their own. It is watered by the Ebro, the Cresma, the Xarama, and the Duraton; and it possesses mineral springs at Cinchon, Caballar, and Bartariejo. It belongs to the captain-generalship of Zamora.

Segovia, a city of Spain, and capital of the province of the same name, in Old Castille. It is situated on the right bank of the river Duero, not far from its source, and near to the ruins of the ancient Roman city of Numantia. Around it are most excellent pastures for sheep, and the wool of the best of the merinos takes its name from this city. The usual quantity of fine wool annually sent from this city is about 2,250,000 lbs., and the management of such extensive concerns necessarily creates considerable trade. There is in this city a manufactory of fine cloths, cassimeres, and other articles composed of the native wool, which is carried on by the government.

The remains of antiquity in this city are, however, the most interesting attractions to all travellers. The aqueduct, of very ancient construction, is yet in perfect preservation, and still conveys the water to the city. It is carried over one of the suburbs or arches, some of which are a hundred and four feet in height; the arches are in double rows, one above the other, and on the uppermost a channel is made, covered with large flag-stones, through which the water runs. It is a wonderful relic of antiquity, on account of the excellence of the masonry, which has withstood the ravages of time for so many centuries. The period of its erection is doubtful. The Spaniards, who delight in tracing every ancient monument to the highest antiquity, ascribe it to Hercules; it is, however, evidently of Roman construction, and none give it a later date than the reign of Trajan. It discovers as yet no marks of decay, and as the city to which it conveys water is on the top of a rock, if it were demolished the inhabitants would be greatly distressed for that necessary of life.

The ancient castle, or alcazar, is another of the curiosities of Segovia. It stands on a rude mass of rocks overlooking the surrounding country, whose base is washed by a rapid and limpid stream, whilst the houses of the city stretch themselves from it in both directions, and terminate in woody declivities. It is an astonishing pile of building, and contains some apartments of stupendous extent. The foundation and the lower part of the walls are obviously of Roman origin, whilst the upper part, and what may be called the keep, are as plainly the execution of the Moors, whose contrivances for shooting their arrows at the heads of assailants, without being themselves subject to annoyance, are in the most perfect preservation. Within this castle is a state-prison, which is well described by Le Sage in his Adventures of Gil Blas. A part of the building is used by the artillery department of government. The mint is below the castle, and furnished with all the machinery requisite for coining money, which is principally set in motion by water.

The cathedral of Segovia is one of the most complete specimens of the later Gothic style of architecture of any religious edifice in Spain. Excepting the antiquities of this celebrated city, the rest deserves little notice. The streets are crooked and narrow. Many of the houses are of wood, and most of them very dirty; and in spite of the great trade carried on in wool by some individuals, an air of poverty pervades the mass of the inhabitants.

SEGOVIA, a town of America, in Terra Firma, and in the province of Venezuela, situated on a river, near a very high mountain, where there are mines of gold. Long. 65. 30. W. Lat. 8. 20. N.

SEGOVIA, a town of Asia, in the island of Manilla, and one of the largest of the Philippines, situated at the north end of the island, 240 miles north of Manilla, and subject to Spain. Long. 120. 50. E. Lat. 18. 36. N.

SEGOVIA, *New*, a town of North America, in New Spain, and in the audiencia of Guatimala, situated on the river Yare, on the confines of the province of Honduras. Long. 84. 30. W. Lat. 13. 25. N.

SEGRE, an arrondissement of the department of the Maine and Loire, in France, extending over $408\frac{2}{3}$ square miles. It is divided into six cantons, and these into seventy-seven communes, and in 1836 contained 58,109 inhabitants. The capital is a small town of the same name, with some trade in linen goods. Its population in 1836 amounted to 2130.

SEGREANT is the herald's word for a griffin when drawn in a leaping position, and displaying his wings as if ready to fly.

SEGUE, in Italian music, is often found before *aria*, *alleluja*, *amen*, and some others, to show that those portions or parts are to be sung immediately after the last note of that part over which it is written; but if these words *si placet*, or *ad libitum*, are joined with it, it signifies that the portions may be sung or not at pleasure.

SEGUIDILLA, the Spanish name of a quick and animated melody in $\frac{3}{4}$ time, much used in Spain in singing and in dancing.

SEGURA, a city of Spain, the capital of a department of the same name, lying between La Mancha and Granada, in the province of Murcia. Near to it rises the river Segura, which traverses the whole province, and falls into the Mediterranean Sea about sixteen miles to the south-west of Alicant. The town is surrounded with walls, and is an episcopal see. It contains 820 houses, and 4000 inhabitants, who are mostly occupied in agriculture, producing wine, fruit, especially figs, and oil. Another town bears the same name in the province of Zaragoza, and department of Daroca. It stands on the river Xiloca, and contains 1800 inhabitants. There is also a Segura in the province of Guipuscoa, and department of St Sebastian, on the banks of the river Oria. It was once fortified, but its works have gone to decay.

SEGWIN, a small territory in Northern Hindustan, situated between Nepaul and Bootan, about the 28th degree of north latitude, and extending along the banks of the river Teesta, which bounds it to the west. In 1792, when the Chinese invaded Nepaul, the rajah of Segwin submitted to become a subject of China; and here accordingly the Chinese established a military post immediately adjoining the dominions of the East India Company in Bengal.

SEIGNIOR, or SIGNIOR, is, in its general signification, the same with lord, but is particularly used for the lord of the fee or of a manor, as seigneur among the feudists is he who grants a fee or benefit out of the land to another; and the reason is, because, having granted away the use and profit of the land, the property or dominion he still retains in himself.

SEIGNIORAGE is a royalty or prerogative of the king, by which he claims an allowance of gold and silver brought in the mass to be exchanged for coin. See COINAGE.

SEIGNIORY is borrowed from the French *seigneurie*, which means *dominatus*, *imperium*, *principatus*, and signifies with us a manor or lordship, *seigniory de sokemans*. *Seigniory in gross* seems to be the title of him who is not lord by means of any manor, but immediately in his own person; as *tenure in capite*, by which one holds of the king, as of his crown, is *seigniory in gross*.

SEINE, one of the departments of the north-eastern part of France, taking its name from the river which passes through it, and containing Paris, the capital of that mighty kingdom. As that city is the most important portion of the department, the account of it in this work comprehends what is most remarkable. It is on every side surrounded by the department of the Seine and Oise, and extends over 47,548 French hectares, equal to $167\frac{1}{6}$ square miles, or 106,983 English acres. It is generally a level district, but intersected with some hills of inconsiderable height. The river Seine receives within the department the navigable river Marne, and the smaller streams of the Ourcq and the Erould. The Canal of St Denis unites the Seine with the Oise; and the Canal of Ourcq, which terminates in a reservoir between La Vilette and La Chapelle, supplies Paris with water, and being navigable, serves to maintain an intercourse between that city and the north of France. The canal is supplied with water from the small streams of the Grisette, the Mai, the Therouanne, and the Beuvronne. The soil is for the most part by nature poor and sandy, but brought to a highly productive state by the vast quantities of manure furnished by the capital, and by the high state of the cultivation, which is mostly garden husbandry, whose products find advantageous markets in the metropolis. There are still some woods preserved, but mostly for the purpose of ornament, and to serve for the recreation of the inhabitants of Paris. The woods of Boulogne and of Vincennes occupy together about six thousand English acres. It is divided into three arrondissements, eight cantons, and eighty-one communes. The population, which includes Paris, amounted in 1821 to 822,171, in 1831 to 935,108, and in 1836 to 1,106,891, of which 909,126 were within the city.

SEINE, *Lower*, a department of the north-west of France, formed out of those northern parts of Upper Normandy which were in ancient times distinguished as the Roumais, Bezin-Normandy, Caux, and Bray. It is bounded on the north by the sea, on the east by the departments of the Somme and of the Oise, on the south by Eure and Calvados, and on the west by the Channel. It is $2144\frac{1}{4}$ square miles in extent, and comprehends five arrondissements, fifty cantons, and 757 communes. The population amounted in 1836 to 720,525 persons, who mostly adhere to the Roman Catholic church; but among them are 55,000 Protestants, having two consistorial and 113 other churches.

The surface is generally level, but intersected by some hills of moderate height, mostly composed of chalk. Towards the east the valleys are widest, and run from east to west. Along the whole coast are chalky cliffs from 150 to 700 feet in height, but interrupted in places by the bays and harbours. The soil is on the whole the most fertile in France, though there are portions of it very unproductive of corn, and generally covered with wood, which woods comprehend one seventh of the whole department. The agriculture is tolerably conducted, but the greater part of it is on the ancient system of a fallow succeeded by two crops of grain. About 340,000 acres are sown with wheat, and about 250,000 with oats, which is a large portion out of the 1,372,302 acres; yet it appears that the corn produced is scarcely equal to the consumption. The best lands are the meadows in the valleys through which the Seine and the other rivers run, and these afford nourishment for numerous herds of cows, which supply both meat and the products of the dairy. It is, however, in the interior of the department that the best breed of cows are to be seen, which are a mixture of the Flanders race, whereas on the coast they are commonly of a much smaller size.

The breed of the ancient Norman horses is now nearly extinct. Those now bred are of a mixed race, and more remarkable for their strength than for their beauty, and are well adapted for the plough, for which they are almost exclusively used. The sheep are numerous, and those of the fine woolled kind have of late years been rapidly on the increase. In the valleys of Arques and of Pouville the mutton is highly valued. In the more woody portions of the department are kept very great numbers of swine, in which the acorns are found of great benefit. Most kinds of fruit are abundant, with the exception of vines; but the deficiency of them is counterbalanced by the great quantity of apples, which are converted into cider, and form a good substitute for wine. The fishery on the sea-coast affords considerable occupation, and a great additional supply of food. The herring-fishery is extensively practised from Dieppe and Fecamp; and from other places on the shore enormous quantities of mackerel are taken, whilst the oyster-fishery employs many hands. The manufacturing industry is very active, especially in the arrondissement of Rouen. Woollen and cotton goods of every kind are made, and the best kinds of machinery are in full exercise. Large establishments exist which provide paper, glass, pottery, and china ware; and on the coast much linen is spun and woven. There are many ship and boat builders; and the cordage and equipments contribute their share to furnish occupation to labourers. There is much internal trade, especially with Paris, by the river Seine. The principal places within the department are Rouen, Havre de Grace, Dieppe, Fecamp, and Yvetot.

Seine *and Marne*, a department of the north of France. It has been formed out of parts of the ancient provinces of the Isle of France and of Champagne, called French Gatinois, and the Upper and Lower Brie. It is bounded on the north by the department of the Oise, on the east by the Aisne and the Marne and Aube, on the south by the Yonne and Loiret, and on the west by the Seine and Oise. It extends over 1981 square miles, is divided into five arrondissements, twenty-nine cantons, and 556 communes, and in 1836 contained 325,881 inhabitants. The capital of the department is the city of Melun, with a population of 6846 inhabitants in 1836. Besides the two rivers from which it is named, it is watered by the Great and Little Morin, the Bouzie, the Yonne, the Essonne, the Yres, the Therouanne, the Beuvronne, and the Otrin, all of whose waters reach the sea through the Seine. The surface is a plain, but intersected by some hills of very moderate height. The soil is fruitful, especially near the principal rivers; and though woods cover more than one tenth of the department, it is the chief granary from whence the capital draws its supply of corn, flour, garden-fruits, and fattened cattle. The rivers abound with fish, and the woods with game. The meadows are of great fertility, yielding abundance of hay and other fodder, and supporting numerous cows, whose dairies supply Paris with the greater part of its milk, butter, and veal, whilst the cheese of Brie has attained great celebrity. It yields some wine, but its quality is only moderate, and does not equal the consumption. There is much manufacturing industry applied to the making of glass, of paper of the best kind, of leather, of steel articles, of hosiery, of linen goods, and of various smaller articles. The chief towns are Coulommiers, Meaux, Fontainebleau, and Provins.

Seine *and Oise*, a department in the north of France. It is bounded on the north by the Eure and the Oise, on the east by the Seine-Marne, on the south by the Loiret, and on the west by the Eure and Loire. It extends over 1970 square miles, is divided into six arrondissements, thirty-six cantons, and 687 communes, and in 1836 contained 449,582 inhabitants, who elect four deputies to the legislative chamber. The chief river is the Seine, with which the Oise is united, and then it receives the waters of the Marne, the Essonne, the Juine, the Ept, and the Maudre, and of the various tributary streams which empty themselves into these rivers. It is generally a level district, with a few ranges of hills of moderate height. The soil is not naturally fertile, but has been rendered productive by careful cultivation, and the abundance of manure, arising from its vicinity to the metropolis. It surrounds the department of the Seine on every side, has easy water-communication with Paris, and, besides, contains within it the city of Versailles and some other populous places. There is much fruit raised, and some wine, not of the best quality. It breeds many sheep; and of late years the race of the merinos and other fine-woolled sheep has prodigiously increased. There are in many parts manufactures of linen, woollen, and cotton goods, and they are on the increase.

SEISIN, in *Law*, signifies possession. In this sense we say, *premier seisin*, for the first possession. Seisin is divided into that in deed or in fact, and that in law. A seisin in deed is where a possession is actually taken; but a seisin in law is where lands descend, and the party has not entered thereon; or it is where a person has a right to lands, and is by wrong disseised of them. A seisin in law is held to be sufficient to avow on, though to the bringing of an assize, actual seisin is required; and where seisin is alleged, the person pleading it must show of what estate he is seised.

Livery of Seisin, in *Law*, an essential ceremony in the conveyance of landed property, being no other than the pure feudal investiture, or delivery of corporal possession, of the land or tenement. This was held absolutely necessary to complete the donation, *Nam feudam sine investitura nullo modo constitui potuit;* and an estate was then only perfect when, as Fleta expresses it in our law, *fit juris et seisinæ conjunctio.*

Investitures, in their original rise, were probably intended to demonstrate in conquered countries the actual possession of the lord; and that he did not grant a bare litigious right, which the soldier was ill qualified to prosecute, but a peaceable and firm possession. And, at a time when writing was seldom practised, a mere oral gift, at a distance from the spot that was given, was unlikely to be either long or accurately retained in the memory of bystanders, who were very little interested in the grant. Afterwards they were retained as a public and notorious act, that the country might take notice of and testify the transfer of the estate, and that such as claimed title by other means might know against whom to bring their actions.

In all well-governed nations, some notoriety of this kind has ever been held requisite, in order to acquire and ascertain the property of lands. In the Roman law, *plenur*

Seisin.

dominium was not said to subsist unless where a man had both the right and the corporal possession; which possession could not be acquired without both an actual intention to possess, and an actual seisin or entry into the premises, or part of them in the name of the whole. And even in ecclesiastical promotions, where the freehold passes to the person promoted, corporal possession is required at this day to vest the property completely in the new proprietor, who, according to the distinction of the canonist, acquires the *jus ad rem*, or inchoate and imperfect right, by nomination and institution, but not the *jus in re*, or the complete and full right, unless by corporal possession. Therefore in dignities possession is given by instalment, and in rectories and vicarages by induction, without which no temporal rights accrue to the minister, though every ecclesiastical power is vested in him by institution. So also by our law, even in descents of lands, which are cast on the heir by act of the law itself, the heir has not *plenum dominium*, or full and complete ownership, till he has made an actual corporal entry into the lands; for if he dies before entry made, his heir shall not be entitled to take the possession, but the heir of the person who was last actually seised. It is not therefore a mere right to enter, but the actual entry, that makes a man complete owner, so as to transmit the inheritance to his own heirs: *Non jus, sed seisina, facit stipitem.*

Yet the corporal tradition of lands being sometimes inconvenient, a symbolical delivery of possession was in many cases anciently allowed, by transferring something near at hand, in the presence of credible witnesses, which by agreement should serve to represent the very thing designed to be conveyed; and an occupancy of this sign or symbol was permitted as equivalent to an occupancy of the land itself. Among the Jews, we find the evidence of a purchase thus defined in the book of Ruth: "Now this was the manner in former time in Israel, concerning redeeming and concerning changing, for to confirm all things; a man plucked off his shoe, and gave it to his neighbour, and this was a testimony in Israel." Among the ancient Goths and Swedes, contracts for the sale of lands were made in the presence of witnesses, who extended the cloak of the buyer, while the seller cast a clod of the land into it, in order to give possession; and a staff or wand was also delivered from the vender to the vendee, which passed through the hands of the witnesses. With our Saxon ancestors the delivery of a turf was a necessary solemnity in the conveyance of lands; and, to this day, the conveyance of our copyhold estates is usually made from the seller to the lord or his steward by delivery of a rod or verge, and then from the lord to the purchaser by redelivery of the same in the presence of a jury of tenants.

Conveyances in writing were the last and most refined improvement. The mere delivery of possession, either actual or symbolical, depending upon the ocular testimony and remembrance of the witnesses, was liable to be forgotten or misrepresented, and became frequently incapable of proof. Besides, the new occasions and necessities introduced by the advancement of commerce required means to be devised of charging and encumbering estates, and of making them liable to a multitude of conditions and minute designations, for the purposes of raising money, without an absolute sale of the land; and sometimes similar proceedings were found useful in order to make a decent and competent provision for the numerous branches of a family, and for other domestic views; none of which could be effected by a mere simple corporal transfer of the soil from one man to another, which was principally calculated for conveying an absolute and unlimited dominion. Written deeds were therefore introduced, in order to specify and perpetuate the peculiar purposes of the party who conveyed. Yet still, for a very long series of years, they were never made use of, but in company with the more ancient and notorious method of transfer by delivery of corporal possession.

Seistan.

SEISTAN, or Segestan, an extensive country or province, formerly called Nimrose, situated to the east of Persia, betwen Candahar and Khorassan. It is bounded on the north and north-west by Khorassan, on the east by Candahar, and on the south and south-west by Mekran and Kerman. This country, although now reduced to a deplorable condition, once rivalled in prosperity the most flourishing provinces of the empire. It was the country of Jamsheed and Rustum, the heroes of the Shah Nameh, and of Jacob Ben Leth, the conqueror of the caliph of Bagdad. The greater part of the country is flat, sandy, and uninhabited. This is partly occasioned by the wind, which blows during the hot months with such violence as to overwhelm with clouds of sand, houses, gardens, and fields. Captain Christie, who passed through the heart of Seistan in 1810, in his route from Kelat, in Beloochistan, to Herat, says, that from Nooshky to the banks of the Heermund, the country through which he travelled was little better than a desert, intersected by sand-hills. But he travelled at no time twenty-five miles without meeting water. He did not see a single town, or even a village, in the way; and the only inhabitants of this solitary wild that he saw were a few Belooche and Patan shepherds, who lived in tents pitched in the vicinity of the springs. The country through which he passed was covered with an astonishing number of ruined towns, villages, and forts, and at one of these, Kulcauput, was a noble palace, in a tolerable state of preservation; also the ruined remains of a city, which he describes as of great extent. He also met with the ruins of another large city; and a few miles beyond it, the remains of a third. Everywhere he thus saw the traces of ruin and desolation, the fatal consequences of commotion and war. The only remnants of fertility that he met with were near the banks of the noble river Heermund, the ancient Etymander, which flows through the centre of the country, from the mountains of Huzara, beyond Caubul, to the Lake of Zerreh, which is said to be thirty furlongs in length and six in breadth. This river flows through a valley varying in breadth from one to two miles, the desert on one side rising in perpendicular cliffs; the valley, watered by the river, is covered with verdure and brushwood. The capital of the country is Dooshak, where the prince of Seistan resides. It is about eight or nine miles from the Heermund or Helmund. The modern city is small and compact, but the ruins cover a vast extent of ground. It is populous, has a good bazaar, and the inhabitants, who are dressed in the Persian manner, had a more civilized appearance than the other natives of Seistan, who are either Patan or Belooche shepherds, that lead a wandering life, and pitch their tents amidst the ruins of ancient palaces. The country in the vicinity of the capital is open, well cultivated, and produces wheat and barley in sufficient quantities to be exported to Herat. The pasturage is also good and abundant. Colonel Kinneir supposes Dooshak to be no other than the Zaranga of Ptolemy, and that the old name has been lost in the constant revolutions to which the country has been exposed for more than a century, and to which its present desolate state may in a great measure be attributed. Between this city and Ferrah, Captain Christie, to whom we owe the knowledge that we possess of this region, found the country in general desert, except in the immediate neighbourhood of the towns and villages through which he passed. Seistan is at present divided into a number of small independent states, governed by chiefs, who live in fortified villages, situated principally on the banks of the Heermund. The country to the west of this river consists of an arid waste, intersected by one or two ranges of mountains, in the midst of which, about ten days' journey

Seize || Selden.

from Dooshak, lies the city of Kubbees, about fifteen days' march from Kerman and sixteen from Yezd. Couriers travel this desert from Kerman to Herat in eighteen days; but the risk of perishing is so great, that a courier demanded two hundred rupees from Mr Pottinger to carry a letter to Captain Christie. Seistan is now entirely independent of Persia, and is ruled by one of its own chiefs, who cannot raise a revenue of above 80,000 rupees, nor bring more than 3000 troops into the field.

SEIZE, in nautical language, is to make fast or bind, particularly to fasten two ropes together with rope-yarn. The seizing of a boat is a rope tied to a ring or little chain in the fore-ship of the boat, by which means it is fastened to the side of the ship.

SEIZURE, in commerce, an arrest of some merchandise, moveable, or other matter, either in consequence of some law, or some express order of the sovereign. Contraband goods, those fraudulently entered, or landed without entering at all, or at wrong places, are subject to seizure.

SEJANT, a term used in heraldry, when a lion or other beast is drawn in an escutcheon sitting like a cat with his fore-feet straight.

SEJANUS, Ælius, a native of Vulsinum, in Tuscany, who distinguished himself in the court of Tiberius, against whom he formed a conspiracy, and was by the senate condemned to death, and strangled.

SEJUR, a small river of Syria, which rises a little to the north of Antakia, and, after a course of about thirty miles, loses itself in the ground. It is also the name of a small town in Syria, fifteen miles south of Antakia.

SELAME, a cluster of small islands near the coast of Arabia, of which Selame is the chief, at the entrance of the Persian Gulf, near Cape Mussendoon.

SELANG, an island in the Eastern Seas, of inconsiderable size, flat and low. It lies off the southern coast of the island of Batchian, one of the Moluccas. The straits which it forms with this island are narrow, and not five feet in depth. The island forms two harbours with the mainland. Long. 124. 10. E. Lat. 0. 50. S.

SELBISTAN, a town of Persia, in the eastern part of the province of Fars, in a well-peopled and cultivated country, bordering on Kerman.

SELBY, a town of the wapentake of Barton Ash, in the west riding of the county of York, 178 miles from London. It is situated in a level country on the banks of the Ouse, and having a canal which unites that river with the Aire and Calder, has a considerable trade carried on by inland navigation. It has a fine bridge over the Ouse, constructed so as not to impede the vessels. There are some establishments for building large trading ships. The church is a conventual edifice, formerly belonging to the Benedictine monks. There is a good market, which is held on Wednesdays. The population in 1821 amounted to 4097, and in 1831 to 4600.

SELDEN, John, called by Grotius "the glory of England," was born at Salvington, in Sussex, in the year 1584. He was educated at the free school at Chichester, whence he was sent to Hart Hall, in the university of Oxford, where he staid four years. In 1612, he entered himself at Clifford's Inn, in order to study the law; and about two years afterwards removed to the Inner Temple, where he soon acquired great reputation by his learning. He had already published several of his works; and this year he wrote verses in Latin, in Greek, and in English. In 1614, he published his Titles of Honour; and in 1616 his Notes on Sir John Fortescue's book, *De Laudibus Legum Angliæ.* In 1618, he published his History of Tythes, which gave great offence to the clergy, and was animadverted upon by several writers; and for this book he was called before the High Commission Court, and obliged to make a public acknowledgment of his sorrow for having published it. In 1621, being sent for by the parliament, though he was not then a member of that house, and giving his opinion very strongly in favour of their privileges, in opposition to the court, he was committed to the custody of the sheriff of London, but was set at liberty after five weeks' confinement. In 1623, he was chosen burgess for Lancaster; but amidst all the divisions of the nation, he kept himself neutral, prosecuting his studies with such application, that though he was the next year chosen reader of Lyon's Inn, he refused to perform that office. In 1625, he was chosen burgess for Great Bedwin, in Wiltshire, to serve in the first parliament of Charles I., in which he declared himself warmly against the Duke of Buckingham; and on his Grace's being impeached by the House of Commons, he was appointed one of the managers of the articles against him. In 1627 and 1628, he opposed the court party with great vigour. The parliament being prorogued to the 20th of January 1629, Mr Selden retired to the Earl of Kent's house at Wrest, in Bedfordshire, where he finished his *Marmora Arundeliana.* The parliament being met, he, among others, again distinguished himself by his zeal against the court; when the king dissolving the parliament, ordered several of the members to be brought before the King's Bench bar, and committed to the Tower. Among these was Mr Selden, who insisting on the benefit of the laws, and refusing to make his submission, was removed to the King's Bench prison. Being here in danger of his life on account of the plague then raging in Southwark, he petitioned the lord high treasurer, at the end of Trinity term, to intercede with his majesty that he might be removed to the Gate-house, Westminster, which was granted. But in Michaelmas term following, the judges objecting to the lord treasurer's warrant, by which he had been removed to the Gate-house, an order was made for conveying him back to the King's Bench, whence he was released in the latter end of the same year; but fifteen years afterwards the parliament ordered him five thousand pounds for the losses he had sustained on this occasion. He was afterwards committed, with several other gentlemen, for dispersing a libel; but the author, who was abroad, being discovered, they were at length set at liberty. In 1634, a dispute having arisen between the English and Dutch concerning the herring-fishery on the British coast, he was prevailed upon by Archbishop Laud to draw up his *Mare Clausum,* in answer to Grotius's *Mare Liberum;* which greatly recommended him to the favour of the court. In 1640, he was chosen member for the university of Oxford; when he again opposed the court, though he might, by compliance, have raised himself to very considerable posts. In 1643, he was appointed one of the lay members to sit in the assembly of divines at Westminster, and was the same year appointed keeper of the records in the Tower. Whilst he attended his duty in the assembly, a warm debate arose respecting the distance of Jericho from Jerusalem. The party which contended for the shortest distance urged, as a proof of their opinion being well founded, that fishes were carried from the one city to the other, and sold in the market. Their adversaries were ready to yield to the force of this conclusive argument, when Selden, who despised both parties, as well as the frivolousness of their dispute, exclaimed, "Perhaps the fishes were salted." This unexpected remark left the victory doubtful, and renewed the debate; and our author, who was sick of such trifling, soon found employment more suited to his genius; for, in the year 1645, he was made one of the commissioners of the admiralty. The same year he was unanimously elected master of Trinity College, Cambridge, but declined accepting. He died in 1654, and was interred in the Temple-church, where a monument is erected to his memory. Dr Wilkes observes, that he was a man of uncommon gravity and greatness of soul, averse to flattery, liberal to scholars, charitable to the poor; and though he had great latitude in his principles with regard to ecclesiastical

siastical power, yet he had a sincere regard for the Church of England. He wrote many learned works besides those already mentioned, the principal of which are, 1. De Jure Naturali et Gentium, juxta Disciplinam Hebræorum; 2. De Nuptiis et Divorciis; 3. De Anno Civili veterum Hebræorum; 4. De Nummis; 5. De Diis Syris; 6. Uxor Hebraica; 7. Jani Anglorum Facies altera. All his works were printed together in 1726, in three vols. folio.

SELEFKEH, the ancient Calicadnus, in Asia Minor, in the province of Caramania, situated near the mouth of a river called Ghiuk Sooyoo. The modern town is merely an assemblage of mud and wooden huts; it is, however, the residence of an aga under the governor of Cyprus. It is on the site of the ancient Seleucia, the remains of which are still to be seen scattered over a large extent of ground on the western side of the river. Here are found the remains of a theatre, with porticos in front, and other large buildings. Farther on is a temple which had been converted into a Christian church, and several large Corinthian columns about four feet in diameter, a few of which are still standing. A little farther to the southward, near a marble quarry, which seems to have supplied materials for the town, is seen an extensive cemetery, containing sarcophagi of coarse workmanship; and also catacombs, which have been all opened and emptied. On all these remains are inscriptions denoting their origin and object. Near the catacombs is an enormous reservoir hewn out of the soft stone, one hundred and fifty feet by seventy-five, and thirty-five feet in depth. To the west of the town are seen the remains of a citadel. Long. 33. 35. E. Lat. 36. 20. N.

SELENGA, a large river of Siberia, in the southern part of the government of Irkoutsk, which rises beyond the frontier, in the country of the Mongols, where its stream is increased by the accession of the Kharatale and the Iga. It becomes navigable as it approaches the frontiers of the empire, and, flowing from south-east to north-west, it falls by three mouths into Lake Baikal. On its banks are several considerable Russian towns, namely, Verschnei, Oudinsk, Selenginsk, and Kiachta, the great point of commercial intercourse with China.

SELENGINSK, a town of Asiatic Russia, in the government of Irkoutsk, situated on the right bank of the Selenga, in a country consisting chiefly of naked and sandy mountains; and it is ten miles farther down the river before any lands are found fit for the purposes of agriculture. In 1566 a wooden fort or ostrog was built on this spot, which was afterwards converted into a regular fortress, and gave rise to the town, which now contains three churches and a hundred and fifty houses. It is supported, notwithstanding its dreary situation, by being the great thoroughfare of the China trade through Kiachta. Rhubarb is imported in large quantities from the adjacent country of Mongolia. Long. 107. 3. E. Lat. 51. 6. N.

SELENOGRAPHY, a branch of cosmography, which describes the moon, and all the parts and appearances thereof, as geography does those of the earth.

SELEUCIA, in *Ancient Geography*, surnamed *Babylonia*, because situated on its confines, at the confluence of the Euphrates and the Tigris. Ptolemy places it in Mesopotamia. It is called also *Seleucia ad Tigrim*, being washed on the south by the Euphrates, and on the east by the Tigris. It is generally believed to have been built or enlarged by Seleucus Nicanor, master of the east after Alexander by means of which Babylon came to be deserted. It is said to have been originally called *Coche*, though others, as Arrian, distinguish it, as a village, from *Seleucia;* and, according to Zosimus, the ancient name of Seleucia was *Zochasia.* It is now called Bagdad. Long. 44. 21. E. Lat. 33. 10. N. There were many other cities of the same name, all built by Seleucus Nicanor.

SELEUCIDÆ, in *Chronology*. The era of the Seleucidæ, or the Syro-Macedonian era, is a computation of time, commencing from the establishment of the Seleucidæ, a race of Greek kings, who reigned as successors of Alexander the Great in Syria, as the Ptolemies did in Egypt. This era we find expressed in the books of the Maccabees, and on a great number of Greek medals struck by the cities of Syria. The Rabbin call it the *era of contracts*, and the Arabs *therik dilkarnain*, or the era of the two horns. According to the best accounts, the first year of this era falls in the year 311 before Christ, being twelve years after Alexander's death.

SELF-DEFENCE implies not only the preservation of one's life, but also the protection of one's property, because without property life cannot be preserved in a civilized nation. The extent of property essential to life is indeed small and this consideration may enable us to decide a question which some moralists have made intricate. By what means, it has been asked, may a man protect his property? May he kill the person who attacks it, if he cannot otherwise repel the attack?

That a man, in a state of nature, may kill the person who makes an attack on his life, if he cannot otherwise repel the attack, is a truth which has never been controverted; and he may do the same in civil society, if his danger be so imminent that it cannot be averted by the interposition of the protection provided for individuals by the state. In all possible situations, except the three following, whatever is absolutely necessary to the preservation of life may be lawfully performed; for the law of self-preservation is the first and most sacred of those laws which are impressed on every mind by the Author of nature.

The three excepted situations are those of a soldier in the day of battle, of a criminal about to suffer by the laws of his country, and of a man called upon to renounce his religion. The soldier hazards his life in the most honourable of all causes, and cannot betray his trust, or play the coward, without incurring a high degree of moral turpitude. He knows that the very profession in which he is engaged necessarily subjects him to danger; and he voluntarily incurs that danger for the good of his country, which, with great propriety, annexes to his profession peculiar privileges and much glory. The criminal under sentence of death cannot, without adding to his guilt, resist the execution of that sentence; for the power of inflicting punishment is essential to society, and society is the ordinance of God. The man who is called upon to renounce his religion ought to submit to the most cruel death rather than comply with that request, since religion is his only security for future and permanent happiness. But in every other situation, that which is absolutely necessary to the preservation of life is undoubtedly lawful. Hence it is that a person sinking in water is never thought to be guilty of any crime, though he drag his neighbour after him by his endeavours to save himself; and hence, too, a man in danger of perishing by shipwreck may drive another from a plank which cannot carry both of them, for since one of two lives must be lost, no law, human or divine, calls upon either of them to prefer his neighbour's life to his own.

But though the rights of self-defence authorize us to repel every attack made upon our life, and in case of extremity to save ourselves at the expense of the life of our innocent neighbour, it is not so evident that, rather than give to an unjust demand a few shillings or pounds, we may lawfully deprive a fellow-creature of life, and the public of a citizen. A few pounds lost may be easily regained; but life when lost can never be recovered. If these pounds, indeed, be the whole of a man's property; if they include his clothes, his food, and the house where he shelters his head; there cannot be a doubt that, rather than part with them, he may lawfully kill the aggressor, for no man can exist without shelter, and food, and raiment. But it is seldom that an attempt is made, or is indeed practicable, to rob a man at once of all that he possesses. The question, then, of any importance is, may a man put a robber to death rather than part with a small portion of his property? Paley doubts whether he could innocently do so in a state of nature, "because it cannot be contended to be for the augmentation of human happiness, that one should lose his life or limb, rather than another a pennyworth of his property." He allows, that in civil society the life of the aggressor may always be taken away by the person aggrieved, or meant to be aggrieved, when the crime attempted is such as would subject its perpetrator to death by the laws of his country.

To us, however, he seems to lose sight of his own principles. No legislature can have a right to take away life in civil society, but in such cases as individuals have the same right in a state of nature. If therefore a man in the state of nature have not a right to protect his property by killing the aggressor, when it cannot be otherwise protected, it appears to us self-evident that no legislature can have a right to inflict the punishment of death upon such offences; but if the laws inflicting death upon the crime of robbery be morally evil, it is certain that an individual cannot be innocent when he prevents robbery by the death of the robber, merely because he knows that the laws of his country have decreed that punishment against those convicted of the crime. But we think that the protection of property by the death of the aggressor may be completely vindicated upon much more general principles. It is necessary in every state, that property be protected, or mankind could not subsist; but in a state of nature every man must be the defender of his own property, which in that state must necessarily be small; and if he be not allowed to defend it by every means in his power, he will not long be able to protect it at all. By giving him such liberty, a few individuals may, indeed, occasionally lose their lives and limbs for the preservation of a very small portion of private property; but we believe that the sum of human happiness will be more augmented by cutting off such worthless wretches than by exposing property to perpetual depredation; and therefore, if general utility be the criterion of moral good, we must be of opinion that a man may in every case lawfully kill a robber rather than comply with his unjust demand.

But if a man may without guilt preserve his property by the death of the aggressor, when it cannot be preserved by any other means, much more may a woman have recourse to the last extremity to protect her chastity from forcible violation. This, indeed, is admitted by Paley himself, and will be controverted by no man who reflects on the importance of the female character, and the probable consequences of the smallest deviation from the established laws of female honour.

Self-Love is that instinctive principle which impels every animal, rational and irrational, to preserve its life and promote its own happiness. It is very generally confounded with selfishness; but we think that the one propensity is distinct from the other. Every man loves himself, but every man is not selfish. The selfish man grasps at all immediate advantages, regardless of the consequences which his conduct may have upon his neighbour. Self-love only prompts him who is actuated by it to procure to himself the greatest possible sum of happiness during the whole of his existence. In this pursuit the rational self-lover will often forego a present enjoyment to obtain a greater and more permanent one in reversion; and he will as often submit to a present pain to avoid a greater one hereafter. Self-love, as distinguished from selfishness, always comprehends the whole of a man's existence, and in that extended sense of the phrase, we hesitate not to say that every man is a self-lover; for, with eternity in his view, it is surely not possible for the most disinterested of the human race not to prefer himself to all other men, if their future and everlasting interests could come into competition. This indeed they can never do; for though the introduction of evil into the world, and the different ranks which it makes necessary in society, put it in the power of a man to raise himself, in the present state, by the depression of his neighbour or by the practice of injustice, yet in the pursuit of a prize which is to be gained only by soberness, righteousness, and piety, there can be no rivalship among the different competitors. The success of one is no injury to another; and, therefore, in this sense of the phrase, self-love is not only lawful, but absolutely unavoidable. It has been a question in morals, whether it be not likewise the incentive to every action, however virtuous or apparently disinterested?

Those who maintain the affirmative side of this question say, that the prospect of immediate pleasure, or the dread of immediate pain, is the only apparent motive to action in the minds of infants, and indeed of all who look not before them, and infer the future from the past. They own, that when a boy has had some experience, and is capable of making comparisons, he will often decline an immediate enjoyment which he has formerly found productive of future evil more than equivalent to all its good; but in doing so they think, and justly, that he is still actuated by the principle of self-love, pursuing the greatest good of which he knows himself to be capable. After experiencing that truth, equity, and benevolence in all his dealings is the readiest, and indeed the only certain method of securing to himself the kindness and good offices of his fellow-creatures, and much more when he has learned that they will recommend him to the Supreme Being, upon whom depend his existence and all his enjoyments, they admit that he will practise truth, equity, and benevolence, but still, from the same principle, pursuing his own ultimate happiness as the object which he has always in view. The prospect of this great object will make him feel an exquisite pleasure in the performance of the actions which he conceives as necessary to its attainment, until at last, without attending in each instance to their consequences, he will, by the great associating principle which has been elsewhere explained, feel a refined enjoyment in the actions themselves, and perform them, as occasions offer, without deliberation or reflection. Such, they think, is the origin of benevolence itself, and indeed of every virtue.

Those who take the other side of the question can hardly deny that self-love thus modified may prompt to virtuous and apparently disinterested conduct; but they think it degrading the dignity of a man to suppose him actuated solely by motives which can be traced back to a desire of his own happiness. They observe, that the Author of our nature has not left the preservation of the individual, or the continuance of the species, to the deductions of our reason, computing the sum of happiness which the actions necessary to these ends produce to ourselves. On the contrary, he has taken care of both, by the surer impulse of instinct planted in us for these very purposes. And is it conceivable, say they, that he would leave the care of our fellow-creatures a matter of indifference, until each man should be able to discover or be taught that by loving his neighbour, and doing him all the good in his power, he would be most effectually promoting his own happiness? It is dishonouring virtue, they continue, to make it proceed in any instance from a prospect of happiness or a dread of misery; and they appeal from theory to fact, as exhibited in the conduct of savage tribes, who deliberate little on the consequences of their actions.

Their antagonists reply, that the conduct of savage tribes is to be considered as that of children in civilized nations, regulated entirely by the examples which they have before eligenstadt || elkirk.

them; that their actions cannot be the offspring of innate instincts, otherwise savage virtues would, under similar circumstances, be everywhere the same, which is contrary to fact; that virtue proceeds from an interested motive on either supposition; and that the motive which the instinctive scheme holds up is the more selfish of the two. The other theory supposes, that the governing motive is the hope of future happiness and the dread of future misery; the instinctive scheme supplies a present motive in the self-complacency arising in the heart from a consciousness of right conduct. The former is a rational motive; the latter has nothing more to do with reason than the enjoyment arising from eating or drinking, or from the intercourse between the sexes. See Metaphysics and Moral Philosophy.

SELIGENSTADT, a city of the grand duchy of Hesse-Darmstadt, in Germany, in the province of Starkenburg, and the capital of a bailiwick of the same name. It stands on the river Maine, is surrounded with walls, and contains an ancient monastery, 420 houses, and 2640 inhabitants.

SELINO, a town of the island of Candia, in the Levant. It is the capital of a circle of its own name, situated at the south-west point of that island, with good anchorage in the road, which is defended by a fort.

SELINGAN, a small island in the Sooloo Archipelago. Long. 118. 15. E. Lat. 6. 4. N.

SELINTY, a bold and romantic headland in Caramania, situated on the ruins of the ancient Trajanopolis. On the highest point are the ruins of a castle, which commands the ascent of the hills in every direction.

SELKIRK, Alexander, whose adventures gave rise to Defoe's well-known historical romance of Robinson Crusoe, was born at Largo, in Fifeshire, Scotland, about the year 1676. He was bred a seaman, and went from England in 1703, in the capacity of sailing-master of a small vessel called the Cinque-Ports galley, Charles Pickering captain. In September the same year he sailed from Cork, in company with another ship called the St George, commanded by the celebrated navigator William Dampier, intended to cruise against the Spaniards in the South Sea. On the coast of Brazil, Pickering died, and was succeeded in the command by his lieutenant Thomas Stradling. They proceeded on their voyage round Cape Horn to the island of Juan Fernandez, whence they were driven by the appearance of two French ships of thirty-six guns each, and left five of Stradling's men there on shore, who were taken off by the French. From this they sailed to the coast of America, where Dampier and Stradling quarrelled, and separated by agreement, on the 19th of May 1704. In September following, Stradling came again to the island of Juan Fernandez, where Selkirk and his captain had a difference, which, with the circumstance of the ship's being very leaky, and in bad condition, induced him to determine upon staying there alone; but when his companions were about to depart, his resolution was shaken, and he desired to be taken on board again. The captain, however, refused to admit him, and he was obliged to remain, having nothing but his clothes, bedding, a gun, and a small quantity of powder and ball; a hatchet, a knife, and a kettle; with his books, and mathematical and nautical instruments. He kept up his spirits tolerably till he saw the vessel put off, when, as he afterwards related, his heart yearned within him, and melted at parting at once with his comrades and all human society.

Thus left sole monarch of the island, with plenty of the necessaries of life, he found himself in a situation which was hardly supportable. He had fish, goats' flesh, turnips and other vegetables; yet he grew dejected, languid, and melancholy, to such a degree, as to be scarcely able to refrain from doing violence to himself. Eighteen months passed before he could, by reasoning, reading his Bible, and study, be thoroughly reconciled to his condition. At length he grew happy, employing himself in decorating his huts, chasing the goats, whom he equalled in speed, and scarcely ever failed in catching. He also tamed young kids, laming them to prevent their becoming wild; and he kept a guard of tame cats about him, to defend him when asleep from the rats, that were very troublesome. When his clothes were worn out, he made others of goat-skins, but could not succeed in making shoes, with the use of which, however, habit, in time, enabled him to dispense. His only liquor was water. He computed that during his abode in the island he had caught a thousand goats, of which he had let go five hundred, after marking them by slitting their ears. Commodore Anson's people, who were there about thirty years afterwards, found the first goat which they shot upon landing was thus marked, and, as it appeared to be very old, concluded that it had been under the power of Selkirk. But it appears by Captain Carteret's account of his voyage in the Swallow sloop, that other persons practised this mode of marking, as he found a goat with his ears thus slit on the neighbouring island of Mas-a-fuera, where Selkirk never was. He made companions of his tame goats and cats, often dancing and singing with them. Although he constantly performed his devotions at stated hours, and read aloud, yet, when he was taken off the island, his language, from disuse of conversation, had become scarcely intelligible. In this solitude he continued four years and four months, during which time only two incidents happened which he thought worth relating, the occurrences of every day being in his circumstances nearly similar. The one was, that, pursuing a goat eagerly, he caught it just on the edge of a precipice, which was covered with bushes, so that he did not perceive it; and he fell to the bottom, where he lay, according to Captain Rogers's account, twenty-four hours senseless; but, as he related to Sir Richard Steele, he computed, by the alteration of the moon, that he had lain three days. When he came to himself, he found the goat lying under him dead. It was with great difficulty that he could crawl to his habitation, whence he was unable to stir for ten days, and did not recover of his bruises for a long time. The other event was the arrival of a ship, which he at first supposed to be French. And such is the natural love of society in the human mind, that he was eager to abandon his solitary felicity, and surrender himself to them, although enemies; but upon their landing he found them to be Spaniards, of whom he had too great a dread to trust himself in their hands. They were by this time so near that it required all his agility to escape, which he effected by climbing into a thick tree, being shot at several times as he ran off. Fortunately the Spaniards did not discover him, though they stayed some time under the tree where he was hidden, and killed some goats just by. In this solitude Selkirk remained until the 2d of February 1709, when he saw two ships come into the bay, and knew them to be English. He immediately lighted a fire as a signal; and on their coming on shore, found they were the Duke, Captain Rogers, and the Duchess, Captain Courtney, being two privateers from Bristol. He gave them the best entertainment he could afford; and as they had been a long time at sea without fresh provisions, the goats which he caught were highly acceptable. His habitation, consisting of two huts, one to sleep in, and the other for dressing his food, was so obscurely situated, and so difficult of access, that only one of the ship's officers would accompany him to it. Dampier, who was pilot on board the Duke, and knew Selkirk very well, told Captain Rogers that, when on board the Cinque-Ports, he was the best seaman in the vessel, upon which Captain Rogers appointed him master's mate of the Duke. After a fortnight's stay at Juan Fernandez, the ships proceeded on their cruize against the Spaniards; plundered a town on the coast of Peru; took a Manilla ship off Califor-

Selkirk.

nia; and returned by way of the East Indies to England, where they arrived on the 1st of October 1711; Selkirk having been absent, on the day of his arrival in London, eight years one month and three days, more than half of which time he had spent alone on the island. The public curiosity being excited respecting him, he was induced to put his papers into the hands of Defoe, to arrange and form them into a regular narrative. These papers must have been drawn up after he left Juan Fernandez, as he had no means of recording his transactions there. Captain Cooke remarks, as an extraordinary circumstance, that he had contrived to keep an account of the days of the week and the month; but this might be done, as Defoe makes Robinson Crusoe do, by cutting notches in a post, or many other methods. From this account of Selkirk, Defoe adopted the notion of writing a more extensive work, the romance of Robinson Crusoe, and very dishonestly defrauded the original proprietor of his share of the profits. After his return to England he waited in London till he got his effects realized, and then proceeded, in the spring of 1712, to his native village Largo. For a few days he enjoyed the society of his relatives and friends; but, from long habit, he soon felt averse to society, and was most happy in being alone. In the upper part of the garden attached to his father's house, he formed a kind of cave or grotto, which commanded an extensive and delightful view of the bay of Largo, and the shores of the Forth. In musing here, or wandering through a secluded and solitary valley called Keil's Den, and fishing in the bay, he spent the greater part of his time. How long he remained here cannot be ascertained, but he eloped some time afterwards with a girl of the neighbourhood, named Sophia Bruce, and proceeded with her to London. He never returned to Largo, and but little is known of him during the latter part of his life. Sophia Bruce appears to have died between 1717 and 1720; for in the latter year he again married Frances Candis, who survived him. Selkirk died lieutenant on board his majesty's ship Weymouth, some time in the year 1723; and it is believed that he had no children by either of his wives.[1]

Selkirk, an ancient royal burgh, and chief town of the county of Selkirk, in Scotland. It is situated on an elevation overlooking the valley of the river Ettrick, and commands an extensive view. It consists chiefly of one street, which expands at the market-place into an open space; and in it is the ancient tolbooth. In addition to this main street, there are a few small streets that diverge from it. The town has not increased in size or in importance for centuries; but it has been much improved of late years, and now contains many good houses, with a town-hall, having an elegant spire 110 feet in height, and in which there are apartments for the burgh and sheriff courts. There are two places of worship, one belonging to the established church, and the other to the United Associate Synod. A new prison has been erected at the north side of the town; and it also possesses several excellent schools, in which the classics, French, Italian, and the more usual branches, are taught.

Selkirk was formerly famed for the manufacture of shoes, in which it had an extensive trade; but it has now no manufactures of any consequence, the restrictions on trade, and the jealousy of the burghers or freemen, preventing young men of small capital from pushing business, and forcing them to repair to places more open to enterprise. The property of the burgh extends to 1784 acres, and its yearly income amounts to nearly L.1100. In 1833, its debts amounted to L.16,088. It is governed by a provost, two bailies, a treasurer, and twenty-nine councillors; and it votes with the county in returning a member to parliament. The population of the burgh and parish in 1821 amounted to 2728, and in 1831 to 2833. The population of the burgh alone in the latter year was 1880.

During the wars between England and Scotland the citizens of Selkirk were famed for their courage. A party of them, amounting to between eighty and a hundred, under the command of the town-clerk, William Brydone, proceeded to the battle of Flodden, and fought with such gallantry that only a few returned. Brydone was afterwards knighted for his conduct; and the town received from James V. a grant of a thousand acres, as a recompense for the courage of the burghers, and for the town being totally burned by the English, in revenge for the bravery displayed by them at that battle. Brydone's sword is still in the possession of his lineal descendants; and a pennon, taken, it is believed, from the Percys, by a person of the name of Fletcher, is still kept by the successive deacons of the weavers, and displayed on all civic occasions by that corporation. A mile north from the town is Philiphaugh, where the celebrated Marquis of Montrose was defeated by the covenanters under General Leslie.

SELKIRKSHIRE, a county of Scotland, situated between 55° 21′ and 55° 42′ north latitude, and between 2° 48′ and 3° 20′ west longitude from Greenwich. It has Mid-Lothian, or the county of Edinburgh, on the north; Roxburghshire on the east and south-east; Dumfriesshire on the south; and Peeblesshire, or Tweeddale, on the west; the line which separates it from these counties being on all sides, but especially the south, exceedingly irregular. Its area has been computed very differently; but, according to the latest authorities, it appears that its extreme length is thirty miles, its extreme breadth twenty, and it is calculated to contain 264½ square miles, nearly equal to 169,280 English acres. It includes only two entire parishes, Yarrow and Ettrick; the parishes of Selkirk and Galashiels being partly in Roxburghshire. These may be said to form the county, although small parts of the parishes of Ashkirk, Innerleithen, Peebles, Roberton, and Stow, are also included in it.

This is almost entirely a pastoral district, and in many respects bears a resemblance to the higher parts of the contiguous county of Roxburgh. Like the latter county, the general declivity of the mountain range is from west-south-west to east-north-east, and all its streams discharge themselves into the Tweed. The rocks are of the transition series, and are chiefly graywacke, graywacke-slate, and clay-slate. On the borders of Peeblesshire extensive layers of porphyry, alternating with thin strata of slate and granite, are to be found. The hills are generally ridge-shaped, and rounded on the tops, with acclivities of from 10° to 30°. The secondary valleys are small, being caused by the Ettrick and Yarrow running nearly parallel, and at no very great distance from each other; but where the Yarrow and Tweed diverge, the valleys increase in magnitude, as they are then drained by larger streams. Several of the hills are above 2300 feet in height, such as Windlestraw Law, at the northern extremity of the county, on the confines of Mid-Lothian; Blackhouse Heights (2370); Minehmoor (2280), on the borders of Peeblesshire; and Ettrick-pen (2200), on the south-west boundary. The lower hills are for the most part green, and afford good pasturage for sheep; but heath prevails on many of the higher grounds, especially towards the south-west. The lowest land is 280 feet, and the sites of many of the houses are from 600 to 1000 feet and upwards, above the level of the sea.

The rivers are, the Tweed, which crosses the north side of the county in its course from Peeblesshire on the west to Roxburghshire on the east; the Gala, which for some distance forms the boundary with Roxburghshire on the north-east, and falls into the Tweed, from the north, a little below Galashiels; the Cador, a very beautiful stream, which also joins the Tweed from the north; the Ettrick and Yarrow, which have their sources on the confines of the county of Dumfries, and, flowing north-east almost parallel to each other, join their streams above Selkirk, and afterwards, under the name of Ettrick, passing to the west of that town, and for a short distance along the boundary with Roxburghshire, enter the Tweed, in which their name is lost, and which then becomes the boundary with that county; the Ale, which rises in the north-east, and soon after passes into Roxburghshire; and also the Borthwick, which washes the north-eastern boundary. Next to the Tweed, the most considerable waters are the Ettrick and the Yarrow, which receive, in the first instance, nearly all the other streams that traverse this district. Both have been celebrated in song, and have given their names to some plaintive melodies of great beauty and feeling. The scenery on the Yarrow is exceedingly romantic and delightful. Soon after its rise, it passes through two lakes, the Loch of the Lows, and St Mary's Loch; the latter, which is separated from the former only by a narrow neck of level ground, and is three miles long, having its banks partly covered with coppice-wood, is the finest piece of water in the south of Scotland. From thence the Yarrow flows for eight or nine miles, through sheep-walks, without wood or cultivation; but afterwards the sides of the lofty hills in its course are covered with wood to a considerable height, and its valley is embellished with a variety of bushes and wild flowers. Ettrick, the larger stream, has a wider and more cultivated valley; and a little before it receives the Yarrow, natural wood begins to appear on its banks. It afterwards flows for four miles through a rich tract, sheltered by plantations on the hills, till it loses its name in the Tweed. From this river the whole district has been sometimes called Ettrick Forest; but the name of Forest here, as elsewhere, has long since ceased to denote the existence of extensive woodlands, of which, whatever may have been the case formerly, scarcely any traces now remain. Besides the two lakes we have mentioned, a great many smaller ones are scattered over the east and south-east quarters, of which the more considerable are Loch Alemoor, the principal source of the Ale, and Loch Oakermoor, noted for the vast quantity of marl which it contains.

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[1] Life and Adventures of Alexander Selkirk, by John Howell, Edinburgh.

This county is deficient in coal, limestone, and sandstone, and it lies under the same disadvantages as Roxburghshire, from the great distance at which it lies from markets where coal and lime are to be had. It is fortunate, however, that in the lakes and mosses there is a great deal of marl, which serves as excellent manure for the arable land in their vicinity. The arable land lies on an elevation of from 280 to 800 feet, and does not much exceed one twentieth of the whole county. It is light, dry, and easily cultivated; and it produces wheat, oats, barley or bear, turnips, and potatoes. Wheat is regularly grown in the lower parts of the county, and even in the higher it has been raised at the height of 700 feet, yielding a good return; and it may be said that agriculture is as well understood and followed out in this as in any other of the Scotch counties. The rotation in crops is generally on the five-shift system of husbandry; although, near the towns, where land is high and manure can be easily had, the four-shift is too often followed. This has increased the disease of the turnip crop, called fingers-and-toes, and has proved very injurious to the red clover.

The average rent of land is, on the arable farms, from one pound four shillings to three pounds an acre; and on the pastoral farms from two shillings and sixpence to five shillings and sixpence an acre. The grazing of an ox or cow throughout the year is about five pounds. In Ettrick it is from two pounds to two pounds five shillings; and that of a sheep is from four shillings and sixpence to six shillings and sixpence. The wages paid to farm-servants and shepherds are nearly the same as in Roxburghshire. The following summary of the produce and value of the parishes of Selkirk, Galashiels, Yarrow, and Ettrick, as stated in the New Statistical Account of Scotland, will more fully explain the value of the county.

PARISH.	Square Miles in extent.	Acres.					Total yearly Value of Raw Produce raised.		
		Cultivated, or occasionally in Tillage.	Uncultivated.	Capable of being Cultivated with a Profit.	In undivided Common.	Under Wood.			
Selkirk.....	10	3000	2,300	0	0	1000	£10,681	18	0
Galashiels.	15	3000	6,000	0	0	500	10,869	10	6
Yarrow....	111	2740	67,800	260	0	610	28,606	0	0
Ettrick.....	68	217	43,086	163	0	270	12,745	0	0
	204	8957	119,186	423	0	2380	£62,902	8	6

The leases of the farms on the Buccleuch estates are for nine years; but this is almost no drawback, as the occupiers are rarely removed. On other estates the leases run generally for nineteen years.

The rest of the county is almost exclusively occupied by sheep, which are now, for the most part, of the Cheviot breed, though not often pure, and scarcely in any instance equal to those of Roxburghshire. The black-faced or forest breed are better adapted for the greater part of the pasturage than the Cheviots; but their wool is coarse, and not well adapted for manufacture. Yet it is generally allowed, that if proper care were taken to cross the ewes with Cheviot rams, and never allow them to recross, a stock of sheep suitable to the range of pasture, and with improved wool, would soon increase, and take the place of the present breed. The number of sheep usually in pasture amounts to 55,000, of which 3000 or 4000 are of the black-faced, 4000 Leicesters, and the remainder Cheviots. The cows are mostly of the short-horned, or of the Ayrshire breeds. Small farmers and feuars prefer the latter, as being more easily brought up, and affording more milk. Highland stots have been introduced, within these few years, to pasture among the sheep, as it has been found that from the complete draining of the district, the overflow of succulent grasses is such, that without a mixture of cattle with the sheep, the grass is totally lost. The greater number of cattle a farmer keeps on his pasture, according to its extent, from May to the middle of August, the more sheep he is able to feed during winter. The valued rent of the county is L.80,307. 15s. 6d. Scotch, and the real rent of the lands and houses in 1812 was L.41,162. 10s. sterling. The annual value of real property, as assessed in April 1815, was L.43,584. Two fifths of the whole property are held under entail. The principal proprietors are the Duke of Buccleuch, who possesses about one half of the extent, and about one third of the rental; the Earl of Traquair, Lords Elibank and Napier, Johnston of Alva, with fifteen other proprietors, whose lands stand valued in the cess-books from L.1000 to L.2000 Scotch.

Selkirk, the county town, and the town of Galashiels, contain nearly all that part of the population which is not employed in agriculture. A considerable portion of the wool of the county finds a ready market at Galashiels. An inkle-work and some tanneries are the only other branches carried on for sale out of the county; so that its exports consist chiefly of raw produce, of which its sheep and wool are by far the most considerable articles.

(See Douglas' Survey of Selkirkshire; the New Statistical Account of Scotland, No. 1; and the Quarterly Journal of Agriculture, No. 18.)

Selkirkshire returns a member to parliament. The population in 1811, 1821, and 1831, are shown in the following table.

Population of Selkirkshire.

YEARS.	HOUSES.			OCCUPATIONS.			PERSONS.		
	Inhabited.	Families.	Uninhabited.	Families chiefly employed in Agriculture.	Families chiefly employed in Trade, Manufactures, and Handicraft.	All other Families not comprised in the two preceding classes.	Males.	Females.	Total of Persons.
1811	1080	1258	41	500	363	395	2750	3139	5889
1821	1081	1372	36	421	409	542	3205	3432	6637
1831	1094	1391	62	474	450	467	3394	3439	6833

SELLA, a town of Spain, in what is called the kingdom of Valentia, in the province of Alcoy. It is situated on the banks of the river Alcoy, and near to its entrance into the Mediterranean Sea. It contains about 2000 inhabitants, who are chiefly employed in making cordage and fishing-nets from esparto, which grows abundantly in the neighbourhood.

SELMAST, a town of Persia, in the province of Azerbijan, containing about 2000 inhabitants, principally Nestorian Christians. It is famed for its lofty poplars and delightful gardens. It is seventy-five miles west-south-west of Tabreez.

SELTERS, or SELTZERS, a village of the principality of Nassau, in Germany, about ten miles from Coblentz. The name of the mineral spring here is celebrated in every part of Europe. Seltzer water is brought to this country in stone bottles, which are closely corked and sealed, and contain about three pints each; and when they are well secured, it keeps unchanged for a considerable time. Seltzer water, according to the analysis of Bergman, contains, in an English wine pint,

	Grains.
Carbonate of lime	3
Ditto of magnesia	5
Ditto of soda	4
Muriate of soda	17·5
	29·5

The same quantity of water also yields seventeen cubic inches of a gaseous substance, which is found to be almost entirely pure carbonic acid gas. This water has been long in high repute on account of its medicinal virtues, and we have no doubt that it may be used with considerable benefit in many of those complaints which arise from a deranged state of the stomach and bowels. The usual dose of this water is from half a pint to a pint; but in most cases it may be drunk freely. From its agreeable taste, and its exhilarating effects on the spirits, it is extensively employed at table as a common drink in Germany and Holland. In this country also both the real and the artificial Seltzer water is largely used for the same purpose. Seltzer water may be artificially imitated, by adding the ingredients discoverable by analysis, and in the same proportion.

SEMAO, an island in the Eastern Seas, about twenty-four miles in length from north to south, and from six to ten in breadth. A strait, called the Strait of Semao, separates it from the south-west end of the island of Timor. This strait, which has a good depth of water, affords secure shelter to ships during the strength of the westerly monsoons. Long. 123. 45. E. Lat. 10. 15. S.

SEMENDRA, a city in the north-west of Turkey in Europe, the capital of a province of the same name in the ancient Servia. It is built on the western branch of the river Morava, where it falls into the Danube. It is fortified and defended by an ancient castle, and contains the cathedral of a Greek bishop, several mosques, and about 8000 inhabitants, who subsist by trading and fishing on the rivers. Long. 21. 23. E. Lat. 44. 37. N.

SEMENTINÆ FERIÆ, in *Antiquity*, were feasts held annually among the Romans, to obtain of the gods a plentiful harvest. They were celebrated in the temple of Tellus, where solemn sacrifices were offered to Tellus and Ceres. These feasts were held about seed-time, usually in the month of January; for, as Macrobius observes, they were moveable feasts.

SEMI, a word borrowed from the Latin, signifying *half*, but only used in composition with other words.

SEMI-ARIANS, in *Ecclesiastical History*, a branch of the ancient Arians, consisting, according to Epiphanius, of such as, in appearance, condemned the errors of that heresiarch, but yet acquiesced in some of his principles, only palliating and hiding them under softer and more moderate terms. Though they separated from the Arian faction, they could never be brought to acknowledge that the Son was "homoousios," that is, consubstantial, or of the same substance with the Father; they would only allow him to be "homoiousios," that is, of a like substance with the Father, or similar to the Father in his essence, not by nature, but by a peculiar privilege.

The Semi-Arianism of the moderns consists in their maintaining that the Son was from all eternity begotten by the will of the Father, contrary to the doctrine of the orthodox, who seem to teach that eternal generation is necessary. Such, at least, are the respective opinions of Dr Clarke and Bishop Bull.

SEMICIRCLE in *Geometry*, is half a circle, or that figure which is comprehended between the diameter of the circle and half its circumference.

SEMICOLON, in *Grammar*, one of the points or stops used to distinguish the several members of a sentence from each other.

The mark or character of a semicolon is (;), and it has its name from being of somewhat less effect than a colon, or as demanding a shorter pause.

The proper use of the semicolon is to distinguish the conjunct members of a sentence. Now, by a conjunct member of a sentence is meant such a one as contains at least two simple members. Whenever, then, a sentence can be divided into several members of the same degree, which are again divisible into other simple members, the former are to be separated by a semicolon. For instance, "If fortune bear a great sway over him, who has nicely stated and concerted every circumstance of an affair; we must not commit every thing, without reserve, to fortune, lest she should have too great a hold of us."

SEMIDIAMETER, half the diameter, or a right line drawn from the centre of a circle to its circumference; being the same with what is otherwise called the *radius*.

SEMIPALATNOI, a fortress of Asiatic Russia, in the southern part of the government of Tomsk, erected for the purpose of protecting the trade carried on with the Calmucks and Bucharians. It was first built in the year 1718; but, owing to the inundations of the river, it was swept away, and had to be removed successively from one spot to another. The principal fortress forms a square composed of wooden ramparts, and surrounded by a ditch. There are two villages, the one above and the other below, both palisaded, like the fort, and containing above two hundred houses. The trade carried on by the Russians with the Kirghises consists of an exchange of toys and trifles for horses and cattle. It is also frequented by traders from Little Bucharia, who bring chiefly cotton goods of inferior quality. Long. 80. 10. E. Lat. 50. 20. N.

SEMIPELAGIANS, in *Ecclesiastical History*, a name given to such as retain some tincture of Pelagianism. See PELAGIANS.

The doctrines of this sect, as well as those of their predecessors the Pelagians, have their common source in Pelagius, a native of Britain, of whom we have already taken notice. He is said to have been but a simple monk, and not in orders. Having gone to Rome about the end of the fourth century, he lived there for some years with reputation, and was considered as both pious and virtuous. Rufinus, a priest of Aquileia, having come to Rome in the year 397, is affirmed by some to have been the person who suggested to Pelagius his peculiar doctrines.

In the year 400 Pelagius began to teach his opinions at Rome, both by speech and by writing. He was not the only person who taught these doctrines, of which we have elsewhere enumerated the heads. His friend and companion Celestius, an abler man than himself, likewise maintained them, and with much more address and subtilty. After having promulgated them in Rome, they went into Sicily, where they lived for some time; and thence, in the year 411, they passed over into Africa. Pelagius soon afterwards went into Palestine, while Celestius remained at Carthage, and was preparing himself to take the order of priesthood; but it being soon discovered that he taught a new doctrine,[1] he was accused by the deacon Paulinus in a synod held at Carthage in 412, at which Aurelius the bishop presided. Celestius, on being charged by Paulinus with denying original sin, made answer, "that in truth he doubted whether the sin of Adam was transmitted to his posterity." He did not, however, own that children had no need of baptism, although this was one of the Pelagian tenets. On the contrary, he wrote a little discourse, in which he acknowledged that children had need of redemption, and that they could not obtain it without baptism. The bishops at the council of Carthage condemned the doctrines of Celestius, and excommunicated him. From this sentence he appealed to the bishop of Rome; but he neglected to pursue his appeal, and went to Ephesus, where he endeavoured to get himself ordained priest. In the mean time, Pelagius having retired into Palestine, was kindly received by St Jerome's enemy, John of Jerusalem. With him he entered into an engagement to attack the reputation of that author. St Jerome defended himself from their assault, attacking the doctrines of Pelagius,[2] and in this undertaking he was soon assisted by St Augustin. About this time Orosius having gone from Spain into Africa, and thence into Palestine, published there the proceedings against Celestius at Carthage, and was prevailed upon by the bishop of Jerusalem to enter into a conference with Pelagius in his presence; but the bishop having shown too much partiality for Pelagius, Orosius would not acknowledge him as a judge, but demanded that the decision of that affair, which was among the Latins, might be referred to judges who understood the language. This happened in the year 415, at which time there were in Palestine two French prelates, who, being driven from their dioceses, fled into that country, and having been apprised of the opinions of Pelagius and Celestius, drew up an abridgment from their own books, of the errors imputed to them.[3] To this they joined the articles condemned in the synod of Carthage, and some others, which were sent from Sicily by Hilarius to St Augustin, and then presented the abridgment to the bishop of Cæsarea. The matter was referred to a council of fourteen bishops, at which, when the memoir was read, Pelagius explained himself upon some articles, and denied that he was the author of others. He also disowned the propositions condemned at Carthage, and some others ascribed to Celestius. He did not even hesitate to condemn them; upon which the bishops decided, that since Pelagius approved the doctrines of the church, and rejected and condemned what was contrary to its belief, they acknowledged him to be of the ecclesiastical and catholic communion.

Orosius, on his return to Africa, took with him the memoir against Pelagius, and presented it to a meeting of bishops held at Carthage in 416.[4] Having read over what had been done at a former meeting against Celestius, they declared that both he and Pelagius ought to be anathematized if they did not publicly renounce and condemn the errors imputed to them. The bishops of this meeting, and those of Numidia, assembled the same year at Milivetum, wrote upon the subject to Pope Innocent, who approved of the judgment of the African prelates, and declared Pelagius, Celestius, and their followers excommunicated.[5] Innocent gave an account of this judgment to the bishops of the East, and the matter seemed altogether at an end, when he died; but Celestius having been made priest at Ephesus, and having gone to Constantinople, whence he was driven by Atticus, bishop of that city, who also wrote against him to Asia and Africa, he came to Rome in the beginning of the pontificate of Zozimus, and undertook to pursue the appeal which he had formerly made from the judgment of the synod of Carthage. Having cited his accuser Paulinus, and offered to justify himself, he presented a confession of faith, in which he acknowleged that children ought to be baptized, in order to inherit the kingdom of heaven; but he denied that the sin of Adam was transmitted to his children. He appeared before the bishops and clergymen assembled by the pope, and declared that he condemned all the errors with which he had been charged. The pope delayed his judgment for two months, and in the mean time received a letter and a confession of faith from Pelagius, which were very artfully drawn up. When the time for judgment arrived, Zozimus held a synod, and said that he thought the declarations of Pelagius and Celestius sufficient for their justification. He was displeased at the two French bishops for not appearing against them, and wrote two letters on that head, one to the bishops of Africa, and another in particular to Aurelius, bishop of Carthage. The African bishops, to the number of 214, without regarding the judgment passed at Rome, assembled at Carthage, and, having confirmed their former decisions, condemned the doctrines of the Pelagians. They wrote to the bishop of Rome to acquaint him that he had been deceived by Celestius, and discovered to him the equivocations of his letter and the confession of faith of Pelagius, sending him a memoir of the errors of which he should require a distinct and precise revocation from the two heretics. The pope made answer, that although his authority was so great that none durst dissent from his judgment, still that he was willing to communicate the matter

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[1] Augustinus, lib. ii. *De Gratia.*

[2] St Jerome's Works, and the Apology of Orosius.

[3] St Augustin on Original Sin, and against the Pelagians.

[4] The Epistles of St Augustin.

[5] Marius Mercator's Commentary.

Semipelagians.

to them, and would let it remain in the same state, until a new deliberation could take place. This letter was presented to a council held at Carthage in 418, at which eight canons were drawn up against the Pelagian heresy. The bishop of Rome, in the mean time, was inclined to examine again the affair of Celestius, and to endeavour to draw from him distinct and precise answers according to the plan suggested by the African bishops in their memoir; but Celestius would not come forward, and accordingly withdrew from Rome. From his flight the pope concluded that he had formerly imposed upon him, and that he held the new doctrines; and, accordingly, changing his opinion with respect to him, he approved of the decrees of the African prelates, and renewed the condemnations of his predecessor, Pope Innocent, against him and Pelagius.[1] This judgment he published in a letter which was sent to all the bishops. About the same time an edict was published by the Emperor Honorius against Pelagius and Celestius, ordering that they should be banished from Rome, and that all their followers should be sent into exile.

In the following year Honorius published another edict, by which it was ordered, that the bishops who would not sign the pope's letter should be deprived of their churches. Accordingly, Julian the bishop of Eclana, who was afterwards head of the party, and seventeen other bishops, were cashiered; upon which they wrote a letter to Rufus, bishop of Thessalonica, and demanded a universal council from the emperor, which was refused. Celestius returned again to Rome, but was again expelled from the city; whilst his followers, being expelled from Italy, retired to different countries. Some of them came over into Britain, and others went into the East. Atticus banished them from Constantinople, and they were also banished from Ephesus. Theodotus, bishop of Antioch, condemned them in a synod held at Diospolis, and banished Pelagius and his followers out of Palestine, whither they had returned. Julian, the bishop, was condemned in a provincial synod of Cilicia, whither he had retired to Theodorus, bishop of Mopsuesta, who was obliged to anathematize him. What became of Pelagius is unknown, as history gives no further account of him; but Celestius having returned to Rome, and being driven from thence by Pope Celestin, went with Julian and some other bishops of their party to Constantinople, where they endeavoured to prevail upon the Emperor Theodosius to assemble a council, instead of which he ordered them to leave the city. After this they joined with the Nestorians,[2] and were condemned together with them in a general council held at Ephesus in 431; and there now remained but a small number of Pelagians dispersed in the West. Julian, after having endeavoured several times to get himself reinstated in his bishopric, was at last obliged to retire into Sicily, where he died.

To the Pelagians succeeded the Semipelagians, who rejected the doctrines of the former with respect to original sin and the power of free will to do any good.[3] They owned that man had need of the grace of God to persevere in welldoing; but they believed that the beginning of good will and faith did not necessarily depend upon grace; for that man, by the mere force of nature, might desire to do good, and that God seconded that good will by his assistance, which depended upon liberty, and was given to all men. Besides these, they maintained some other peculiar tenets. The origin of some of their opinions is founded in this, that some of the books which were written by St Augustin in his last years, with respect to the controversies which arose in the monastery of Adrumetum, relative to correction, grace, and predestination, having been carried into Gaul, happened to give offence to several persons, and particularly to the monks of Lerins, who considered his doctrines as hostile to that of free will. This led them to think and to maintain, that, in order to be saved, it was necessary to leave to man the power of knowing and desiring good by the force of nature, so that the beginning might come from man. Several considerable persons in Gaul, and even some bishops, but particularly the priests, were of this opinion. Cassian, deacon of Constantinople, and afterwards priest of Marseilles, authorized it in his conferences; and Faustus, bishop of Riez, supported it very strenuously. From its very first appearance, St Augustin stood up to oppose this doctrine, and was supported by Prosper and Hilarius. Pope Celestin complained to the bishops of Gaul, that they suffered their priests to speak ill of the doctrines of St Augustin; Popes Gelasius and Hormisdas condemned the books of Faustus; and, last of all, the council of Orange, held in 529, condemned particularly the principal tenets of the Semipelagians, and put an end at that time to the controversy, about a hundred years after the death of St Augustin.

Semipelagians.

The Semipelagians were very numerous; and their doctrines, though variously explained, were received in many of the monastic schools in Gaul, whence they spread themselves far and wide throughout Europe. With respect to the Greeks and other Christians of the East, we may remark, that they had adopted the Semipelagian tenets, even before they were promulgated in Gaul by Cassian and Faustus.

After the period, however, at which the Semipelagian doctrines were condemned in the council of Orange, we find but little notice taken of this sect by historians. Although its tenets were maintained by a few in the succeeding centuries, the sect could boast of no eminent leaders, and sunk into obscurity. In the beginning, indeed, of the Reformation, some of the Pelagian tenets were again brought into circulation. Every one is acquainted with the hostility of Luther to the doctrine of free will, who went so far into the opposite extreme as to entitle one of his works against the celebrated Erasmus on this subject, *De Servo Arbitrio*. But notwithstanding that Luther was their leader, this doctrine of his was not adopted by some of the most eminent of the reformers. His learned friend, the mild and worthy Melancthon, although he at first, either from not having sufficiently considered the subject, or because this doctrine was so unpalatable to the great body of the reformers on account of the authority of Luther, joined with Luther in his hostility to the doctrine of free will so far as to say that free will could have no effect under the influence of grace, shortly afterwards changed his opinion so as to run into the opposite extreme. For although Luther at his outset had affirmed, that the prescience of God annihilated free will in all his creatures, he was so softened down into moderation at the time of the drawing up of the famous Confession of Augsburg, as to allow Melancthon, who composed it, to insert these words, "that it was necessary to allow free will to all who possessed the use of reason, not however in such things as regarded God, which they could not commence, or at least which they could not complete, without his assistance and grace, but in the affairs or works of the present life solely, and in order to perform their duty towards society."[4] In this passage two truths are clearly admitted: First, that there is free will in man; and, secondly, that of itself it has no efficacy in such works as are purely Christian or religious. But although this be evident, and although it would seem as if he attributed the efficacy of religious works solely to the grace of God, yet the restricting words "at least," show that he was of opinion that free will, by its own natural force and efficacy, though it could not complete, could at least commence, Christian or religious works, without the assistance of grace.

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[1] See the Letters of St Augustin.

[2] Prosper in his Chronicle.

[3] Hilary's Letters to Augustin.

[4] See the 18th article, and Melancthon's Apology.

To such of our readers as are acquainted with ecclesiastical history, it is unnecessary to remark, that this was one of the leading tenets of the Semipelagians. But Melancthon did not stop here. It is true, that, in order to keep well with the reformers, he was obliged, in those public instruments which he drew up, to insinuate rather than avow his partiality for the doctrine of free will, the exercise of which, we see, he confined, in the Confession of Augsburg, to such actions merely as regarded civil life and our duties to society. In the Saxon Confession of Faith, however, he proceeds a step farther, and says, "that the will is free; that God neither wishes for, nor approves, nor co-operates in the production of sin; but that the free will of man and of the devils is the true cause of their sin and of their fall." Many, no doubt, will be of opinion, that Melancthon merits praise for having thus corrected Luther, and for having more clearly expressed his own opinion, than he had done in the Confession of Augsburg. He even proceeds farther, and extends the exercise of free will to religious or Christian works. For after having explained in the Saxon Confession of Faith the nature of free will, and the manner in which it makes a choice, and having also shown that it is not of itself sufficient in those works, or actions, which regard a future life, he affirms twice "that the will, even after having received the influence of the Holy Spirit, does not remain idle;" that is to say, it is not merely passive under the influence of grace, but can reject it, or co-operate with it, at pleasure. Necessity, it is true, obliged him to express his opinion rather obscurely. But what he insinuates only in these last-quoted words, is clearly and fully expressed in one of his letters to Calvin. "I had," says he, "a friend who, in reasoning upon predestination, believed equally the two following things; namely, that every thing happens among men as it is ordained by Providence, but that there is, nevertheless, a contingency in actions or in events. He confessed, however, that he was unable to reconcile these two things. For my part," continues Melancthon, "who am of opinion that God neither wishes for nor is the cause of sin, I acknowledge this contingency in the feebleness of our judgment, in order that the ignorant may confess that David fell of himself, and voluntarily, into sin; that he had it in his power to preserve the grace of the Holy Spirit which he had within him; and that in this combat or trial it is necessary to acknowledge some exercise or action of the will."[1] This opinion he confirms and illustrates by a passage from St Basil, where he says, "Have but the will or the inclination, and God is with you." By these words Melancthon seems to insinuate, that the will is not only active in the works of religion, but even begins them without grace. This, however, was not the meaning of St Basil, as is evident from several other parts of his writings; but that it was the opinion of Melancthon, appears fully from this passage, as well as from that which we have cited from the Confession of Augsburg, in which he insinuates that the error is not in saying that the will can of itself commence, but in thinking that it can, without grace, finish or complete religious or Christian works. Thus it appears, that he considered the will as capable of rejecting the influence of grace, since he declares, that David could preserve the Holy Spirit when he lost it, as well as he could lose it when he kept it within him. But although this was his decided opinion, he durst not avow it fully in the Saxon Confession of Faith, but was obliged to content himself with insinuating it gently in these words: "The will, even after receiving the grace of the Holy Spirit, is not idle or without action." All this precaution, however, was insufficient to save Melancthon from censure. Francowitz, better known by the name of Illyricus, being jealous of him, and his enemy, by his influence with his party procured the condemnation of these words of the Saxon Confession, and of the passage from St Basil, at two synods held by the reformers. At the same time that one party of the Lutherans were unwilling to adopt Melancthon's opinion, "that the will is not passive when under the influence of grace," we are at a loss to think how they could deny it, since they almost unanimously confess, that a person under the influence of grace may reject and lose it. This opinion is avowed in the Confession of Augsburg and in Melancthon's Apology. It was even, long after that, decided upon anew, inculcated strongly in their book of Concord, and brought frequently against them by their opponents as a proof of inconsistency and contradiction.

These are not the only instances in which the Lutherans were charged with Semipelagian principles. One of the ablest and the most learned of their opponents, we cannot help thinking, had in more than one instance made good the charge against them. To prove this we need only refer to the remarks that have been made on the eight celebrated propositions in the third book of Concord, relative to the co-operation of the will with grace. According to the first seven of these propositions, an attentive listening to the preaching of the word of God produces grace; and according to the fifth, any man, even a libertine or an infidel, is free, or has it in his power, to listen attentively to the preaching of the word of God. He has it then in his power to give to himself that which to him is productive of grace, and may thus be the sole author of his own conversion or regeneration. In the eighth proposition it is affirmed, that we are not permitted to doubt that the grace of the Holy Spirit, even though it may not be felt, does accompany an attentive hearing of the word of God; and, to do away every doubt about the species of attention which they mean, we must observe, that they speak of attention inasmuch as it precedes the grace of the Holy Spirit, and of that attention which, in consequence of its dependence on free will, we have it in our power to bestow upon the word or not, just as we please. It is the exercise of this free attention which they say operates grace. But here it would seem that they were in extremes; for, as they said, upon the one hand, that when the Holy Spirit begins to move us we act not at all, so they maintained, on the other, that this operation of the Holy Spirit, which converts us without any co-operation on our part, is necessarily attendant upon an act of our wills, in which the Holy Spirit has no share, and in which our liberty acts purely by its natural force or power. Such of our readers as are anxious to examine the progress of the Pelagian and Semipelagian principles after the dawn of the Reformation, we must refer to the works of the principal reformers and to those of their adversaries, as well as to the different writers upon ecclesiastical history.

SEMIRAMIS, queen of Assyria, reigned about five generations before Nitocris, and constructed some wonderful works to restrain the waters of the Euphrates within its banks. Diodorus gives a more detailed account of her, which is copied principally from Ctesias. Omitting the fabulous statements respecting her youth, we there find that she had a son, Ninyas, from Ninus; and that after her husband's death she thought herself capable of governing the empire. She founded the city of Babylon, which she surrounded by walls of immense strength, and adorned by very wonderful buildings. On the top of the temple of Belus she placed three statues of massive gold, and from the middle of the temple rose a tower higher than the highest pyramid of Egypt. Some have thought that this was the tower of Babel. She made warlike expeditions against the Medes, Persians, Libyans, and Æthiopians. She is said to have executed many wonderful works in different parts of her kingdom; changing mountains into plains, and constructing canals and palaces. Hearing of the riches and power of India, she determined to make war on that kingdom, and prepared an immense army; but she was in a great measure unsuccessful, and returned with the loss of nearly her whole army. When she reached Babylon, her son laid snares for her; and as it had been predicted by the oracle of Jupiter Ammon that she would disappear from the world when this took place, the prediction was fulfilled. Semiramis was no more seen, having died in the sixty-second year of her age, and the forty-second of her reign.

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[1] See Calvin's Letters.

SEMITONE. See MUSIC.

SEMLIN, a city of the Austrian dominions, on the frontier towards Turkey. It stands in that district which forms a part of the military colonies of Austria, distinguished by the name of the Sclavonian boundary. It is situated on a point of land where the river Drave falls into the Danube; and it is strongly fortified, and tolerably well built. The Catholics have one church and four chapels; the Greeks have two churches, over which a propapa presides. There are a convent of Franciscans, a German normal school, a hospital, a Jews' synagogue, and 1250 dwelling-houses, with about 8700 inhabitants. At this place is the lazaretto, where all persons arriving from Turkey must exhibit bills of health, and perform quarantine. In a meadow between this place and Belgrade a daily market is held, where two rows of palisades separate the dealers, and where sentinels are continually on the watch, to see that no hazardous communication takes place; and all goods bought from the Turks must be exposed to the air and fumigated. It is a place of considerable traffic with Turkey. The communication by steam-vessels between Vienna and Constantinople has given a stimulus to its commerce, and is likely to occasion a much greater increase. There are now more than 120 mercantile houses established here, some of which are Greek, others Turkish, and a part Austrian. There are 380 persons employed in manufactures, and more than 100 hotels or taverns. The colonists regimented here form the Peterwarden branch of the army. Long. 20. 19. 39. E. Lat. 44. 51. 22. N.

SEMUR, an arrondissement of the department of Côte d'Or, in France, which extends over 598 square miles. It is divided into six cantons, and these into 145 communes, with a population, in 1836, of 70,505 inhabitants. The capital is the city of the same name, standing on a rock washed on three sides by the river Armançon. It contains a fine collegiate church, built in 1065, a public library with 12,000 volumes, and 920 houses, with 4035 inhabitants, who make some woollen goods, and trade largely in wine, cattle, corn, and hemp. Long. 3. 30. E. Lat. 47. 18. N.

SEMYLE, a fortress of Hindustan, in the province of Assam, situated on the banks of the Brahmapootra river, which it commands. It was taken by the Mahommedans in the year 1662.

SENAN-FOU, a city of China, of the first rank, in the province of Koeitchoo, situated on a fine river, in an extensive plain, surrounded on all sides by mountains, among which dwell a barbarous race, who have little intercourse with the Chinese. Long. 107. E. Lat. 27. 56. N.

SENATE, in general, is an assembly or council of senators, that is, of the principal inhabitants of a state, who have a share in the government.

The senate of ancient Rome is of all others the most celebrated. It exercised no contentious jurisdiction, but appointed judges, either from among the senators or knights, to determine processes. It also appointed governors of provinces, and disposed of the revenues of the commonwealth. Yet the whole sovereign power did not reside in the senate, since it could not elect magistrates, make laws, or decide of war and peace; for, in all these cases, the senate was obliged to consult the people.

The senate, when first instituted by Romulus, consisted of a hundred members; to whom he afterwards added the same number when the Sabines had migrated to Rome. Tarquin the ancient made the senate consist of three hundred, and this number remained fixed for a long time; but afterwards it fluctuated greatly, and was increased, first to seven hundred, and afterwards to nine hundred, by Julius Cæsar, who filled the senate with men of every rank and order. Under Augustus the senators amounted to a thousand; but this number was reduced, and fixed at six hundred. The place of senator was always bestowed upon merit. The monarchs had the privilege of choosing the members; and after the expulsion of the Tarquins, it was one of the rights of the consuls, until the election of the censors, who from their office seemed most capable of making choice of men whose character was irreproachable, whose morals were pure, and whose relations were honourable. Only particular families were admitted into the senate; and when the plebeians were permitted to share the honours of the state, it was then required that they should be born of free citizens. It was also required that the candidates should be knights before their admission into the senate. They were to be above the age of twenty-five, and to have previously passed through the inferior offices of quæstor, tribune of the people, edile, prætor, and consul.

The senate always met on the first of January for the inauguration of the new consuls; and in all months, universally, there were three days, the kalends, nones, and ides, on which it regularly met. But it always met on extraordinary occasions, when called together by consul, tribune, or dictator.

To render their decrees valid and authentic, a certain number of members was requisite, and such as were absent without some proper cause were always fined. In the reign of Augustus, four hundred senators were requisite to make a senate. Nothing was transacted before sunrise or after sunset. In their office the senators were the guardians of religion; they disposed of the provinces as they pleased; they prorogued the assemblies of the people; they appointed thanksgivings, nominated their ambassadors, and distributed the public money; and, in short, they had the management of every thing political or civil in the republic, except the creating of magistrates, the enacting of laws, and the declaration of war or peace, which were confined to the assemblies of the people.

SENATOR, in general, denotes a member of some senate.

The dignity of a Roman senator could not be supported without the possession of eighty thousand sesterces, or about L.7000 English money; and therefore such as squandered away their money, and reduced their fortune below this sum, were generally struck out of the list of senators. This regulation was not made in the first ages of the republic, when the Romans boasted of their poverty. The senators were not permitted to be of any trade or profession. They were distinguished from the rest of the people by their dress. They wore the laticlave, half-boots of a black colour, with a crescent or silver buckle in the form of a C; but this last honour was confined only to the descendants of those hundred senators who had been elected by Romulus, as the letter C seems to imply.

Among us, senator is a member of parliament. In the laws of Edward the Confessor, we are told that the Britons called those senators whom the Saxons called afterwards aldermen and borough-masters, though not on account of their age, but their wisdom; for some of them were young men, but very well skilled in the laws. Kenulph king of the Mercians granted a charter, which ran thus: *Consilio et consensu episcoporum et senatorum gentis suæ largitus fuit dicto monasterio*, &c. In Scotland the lords of session are called senators of the college of justice.

SENATUS CONSULTUM, a part of the Roman law. When any public matter was introduced into the senate, which was always called *referre ad senatum*, any senator whose opinion was asked was permitted to speak upon it as long as he pleased; and on that account it was often usual for the senators to protract their speeches until it was too late to determine. When the question was put, they passed to the side of that speaker whose opinion they approved, and a majority of votes was easily collected, without the trouble of counting the numbers. When the majority was known, the matter was determined, and a *senatus consultum* was immediately written by the clerks of the house, at the feet of the chief magistrates, and it was signed by all the principal members of the house. When there was not a sufficient number of members to make a senate, the decision was called *senatus auctoritas;* but it was of no force if it did not afterwards pass into a *senatus consultum.*

The *senatus consulta* were at first left in the custody of the kings, and afterwards of the consuls, who could suppress or preserve them; but about the year of Rome 304 they were always deposited in the temple of Ceres, and afterwards in the treasury by the ediles of the people.

SENDWAH, a town of Hindustan, in the Mahratta territories, and province of Khandesh, eighty-two miles from Boorhanpoor. Long. 75. 8. E. Lat. 21. 48. N.

SENECA, LUCIUS ANNÆUS, a Stoical philosopher, was born at Cordoba, in Spain, about the beginning of the Christian era, of an equestrian family, which had probably been transplanted thither in a colony from Rome. He was the second son of Marcus Annæus Seneca, commonly called the Rhetorician, whose remains are printed under the title of *Suasoriæ et Controversiæ, cum Declamationum Excerptis;* and his youngest brother Annæus Mela, for there were three of them, had the honour of being father to the poet Lucan. He was removed to Rome, together with his father and the rest of his family, while he was yet in his infancy. There he was educated in the most liberal manner, and under the best masters. He learned eloquence from his father; but his genius rather leading him to philosophy, he put himself under the stoics Attalus, Sotion, and Papirius Fabianus, men famous in their way, and of whom he has made honourable mention in his writings. It is probable, too, that he travelled when he was young, since we find him, in several parts of his works, particularly in his *Quæstiones Naturales*, making very exact and curious observations upon Egypt and the Nile. But this, though entirely agreeable to his own humour, did not at all correspond with that plan of life which his father had drawn out for him; and therefore he forced him to the bar, and put him upon soliciting for public employments, so that he afterwards became quæstor, prætor, and, as Lipsius will have it, even consul.

In the first year of the reign of Claudius, when Julia the daughter of Germanicus was accused of adultery by Messalina, and banished, Seneca was also banished, being charged as one of the adulterers. Corsica was the seat of his exile, where he lived eight years, "happy in the midst of those things which usually make other people miserable" (*inter eas res beatus quæ solent miseros facere*); and he wrote his books of consolation, addressed to his mother Helvia, and to his friend Polybius, and perhaps some of those tragedies which go under his name. Agrippina being married to Claudius upon the death of Messalina, she prevailed with the emperor to recall Seneca from banishment, and afterwards procured his appointment as tutor to her son Nero, whom she designed for the empire. Africanus Burrhus, a prætorian præfect, was joined with him in this important charge; and these two preceptors, who were intrusted with equal authority, had each his respective department. By the bounty and generosity of his royal pupil, Seneca acquired that prodigious wealth which rendered him in a manner equal to kings. His houses and walks were the most magnificent in Rome. His villas were innumerable; and he had immense sums of money placed out at interest in almost every part of the world. The historian Dio reports him to have had L.250,000 sterling at interest in Britain alone, and reckons his calling it in all at once as one of the causes of a war with that nation.

All this wealth, however, together with the luxury and effeminacy of the court, does not appear to have had any ill effect upon the temper and disposition of Seneca. He continued abstemious, exact in his manners, and, above all, free from the vices so commonly prevalent in such places, flattery and ambition. "I had rather," said he to Nero, "offend you by speaking the truth, than please you by lying and flattery" (*maluerim veris offendere, quam placere adulando*). How well he acquitted himself in quality of preceptor to his prince, may be known from the first five years of Nero's reign, which have always been considered as a perfect pattern of good government; and if that emperor had but been as observant of his master through the whole course of it as he was at the beginning, he would have been the delight, and not, as he afterwards proved, the curse and detestation, of mankind. But when Poppæa and Tigellinus had got the command of his humour, and hurried him into the most extravagant and abominable vices, he soon grew weary of his master, whose life must indeed have been a constant rebuke to him. Seneca, perceiving that his favour declined at court, and that he had many accusers about the prince, who were perpetually whispering in his ear the great riches of Seneca, his magnificent houses and fine gardens, and what a favourite, through the means of these, he was grown with the people, made an offer of them all to Nero. Nero refused to accept them. This, however, did not hinder Seneca from changing his way of life; for, as Tacitus relates, he "kept no more levees, declined the usual civilities which had been paid to him, and, under pretence of indisposition, or some engagement or other, avoided as much as possible appearing in public."

In the mean time Nero, who, as it is supposed, had despatched Burrhus by poison, could not be easy till he had also rid himself of Seneca; for Burrhus was the manager of his military concerns, and Seneca conducted his civil affairs. Accordingly, he attempted, by means of Cleonicus, a freedman of Seneca, to take him off by poison; but as this did not succeed, he ordered him to be put to death, upon an information that he was privy to Piso's conspiracy against his person. Not that he had any real proof of Seneca's being concerned in this plot, but only that he was glad to lay hold of any pretence for destroying him. He left Seneca, however, at liberty to choose his manner of dying; and the latter caused his veins to be opened immediately. His wife Paulina, who was very young in comparison of himself, had yet the resolution and affection to bear him company, and therefore ordered her veins to be at the same time opened; but as Nero was not willing to make his cruelty more odious and insupportable than there seemed occasion for, he gave orders to have her death prevented. Her wounds were therefore bound up, and the blood stopped, just in time enough to save her; though, as Tacitus says, she looked so miserably pale and wan all her life afterwards, that it was easy to read the loss of her blood and spirits in her countenance. In the mean time, Seneca, finding his death slow and lingering, desired Statius Annæus, his physician, to give him a dose of poison, which had been prepared some time before in case it should be wanted; but this not having had its usual effect, he was carried to a hot bath, where he was at length

Senegal.

stifled with the steam. He died, as Lipsius conjectures, in the sixty-third or sixty-fourth year of his age, and in about the tenth or eleventh of Nero's reign. Tacitus, on mentioning his death, observes, that, as he entered the bath, he took of the water, and with it sprinkled some of his nearest domestics, saying, " that he offered these libations to Jupiter the Deliverer." These words are an evident proof that Seneca was not a Christian, as some have imagined him to have been; and that the thirteen epistles from Seneca to St Paul, and from St Paul to Seneca, are supposititious pieces. The writings of Seneca, excepting his books of Physical Questions, are chiefly of a moral kind. They consist of a hundred and twenty-four epistles, and distinct treatises on Anger, Consolation, Providence, Tranquillity of Mind, Constancy, Clemency, The Shortness of Life, Happiness, Retirement, and Benefits. A number of tragedies are extant under the name of Seneca, and written in a vicious style; but it is uncertain whether the whole or any part of them were his. The first good edition of his acknowledged works was published by Justus Lipsius, which was succeeded by the *Variorum*, 1672, three vols. 8vo, and others. Of the tragedies, the best are that of Scriverius, 1621, the *Variorum*, 1651, and Schrœder's, 1728, 4to.

SENEGAL, a great river of Western Africa, which, like the Gambia and Rio Grande, has its source in a group of mountains situated a short distance to the north-west of Temboo, in Foota Jallon. Mollien places the source of the Ba Fing, the middle branch of the Senegal, in latitude 10° 10′ north, longitude 11° 18′ west; and that of the Falemé, the western branch, in latitude 10° 20′ north, and longitude 11° west. This traveller thus describes the spot whence the former mighty stream issues. " Ascending the stream, I perceived two basins, one above the other, from which the water gushed forth; and still higher a third, which was only humid, as well as the channel that led to the basin immediately below it. The negroes consider the upper basin as the principal source of the river. These three springs were situated about the middle of the side of the mountain. In the rainy season, two ponds, at equal distances above the upper source, supply it with water by two deep channels. The Senegal, called Baleo (Black River) in the Poula language, and Bafing in Mandingo, which has the same signification, or Foura, which means simply the river, runs at first from north to south, then passes at a little distance to the south of Teembo, and afterwards pursues a western direction," which, we may add, it maintains till its embouchure in the Atlantic Ocean. We are indebted chiefly to the enterprises of the French for our knowledge of the Senegal, of which river they were long the sole masters as high as the cataract of Feloo, and at the mouth of which they fixed the capital of the factories they possessed from Arguin to Sierra Leone. Amongst the copious descriptions of this great river, we avail ourselves of that of M. Golberry. The course of the Senegal, from its mouth to the rock of Feloo, the boundary of French navigation, is nearly 280 leagues, although the distance in a direct line is not more than 160 leagues. This cataract, which is situated sixty miles above Galam, is the principal one on the river; forty miles above it is that of Govinea. The windings of the Senegal are remarkably tortuous and circuitous. As far as the rock of Feloo, the country through which it flows is a level, having so small an inclination that a very slight interruption is sufficient to divert the course of the stream, so that it frequently seems on the point of returning to its source. It is only navigable during the rainy season; but Adanson informs us that he found the river, at its greatest ebb, from twenty to thirty feet deep at Podor, sixty leagues up, where, however, the influence of the tide reaches. The greatest rise of the tide at the mouth of the river is two feet and a half. Here there is a bar, which prevents the entrance of all vessels drawing ten feet of water, although immediately within it there is sufficient depth for ships of any size. The entrance of the bar has shifted from time to time, owing to the influence of opposing currents. Sand-banks and rocks embarrass the navigation; enormous trees and portions of the bank are continually borne down by the current; frequent hurricanes and storms are encountered, followed by dead calms; and the burning atmosphere, when not violently agitated, becomes extremely oppressive, so that the voyage into the interior has always proved highly detrimental to Europeans. Were it not for these perils, it would be particularly interesting to the naturalist, as the extremely picturesque banks present a rich variety of the noblest productions of the vegetable kingdom, whilst the extensive forests abound with all kinds of wild animals. Amongst others, elephants are seen in large troops. In the shallow parts of the river are a vast number of hippopotami, and caymans of prodigious size. The whole length of the river is estimated at 800 miles, its embouchure taking place in latitude 16° 5′ north. About eight leagues below Galam, at the village of Tafalisga, the Senegal receives the Falemé, which may be navigated during the rainy season by vessels of sixty tons. The easterly and inferior arm of the Senegal, called the Kokora, is formed of a number of streams which rise between 5° and 7° of west longitude, and 12° and 13° of north latitude. The Ba Fing and the Kokora unite a short distance above Feloo, and the combined streams then take the name of the Senegal.

Senegambia.

Isle of SENEGAL, sometimes called *Saint Louis*, is a small island in the mouth of the river Senegal, and, according to Maskelyne's tables, is situated in long. 16. 31. W. and lat. 15. 53. N.

SENEGAMBIA, a large country of Africa, on the Atlantic Ocean, lying between the rivers Senegal and Gambia, from the mouth of the Nunez to Portendik, with several adjoining districts, and extending from 8° to 18° 20′ of north latitude, and from about 5° to 17° 30′ 30″ of west longitude. It is bounded on the west by the Atlantic Ocean, on the south by Guinea, on the east by Nigritia or Soudan, and on the north by the great desert of Sahara. This fine territory lies upon the western and northern declivities of the mountains of Kong, which here stretch from east to west in some degree parallel with the Gulf of Guinea, and is separated by the great valley of the Quorra or Niger from that part of the northern table or terrace land in which the elevated portion of Africa sinks into Soudan. The interior of this extensive tract of high land, called High Soudan, whose southern limit towards the Gulf of Guinea more especially bears the name of the Kong Mountains, is wholly unknown to us; but its general height is not more than two thousand feet above the level of the sea. It appears to be fine pasture-land, to have an excellent climate, and to support a vast number of African tribes. Surrounding it on the west and north, are those table-lands called the Wildernesses of Jallonkadu, which are only inhabited by wild beasts and reptiles, and through which Mungo Park travelled five days without seeing the face of man. But beyond these to the north and west extends a fertile country, rich in streams, which descend to the coast in a westerly or north-westerly direction. Immediately north from Sierra Leone the fruitful part of the coast is narrow, but enlarges as we proceed in the same direction, especially where the mountains on the middle of the Gambia fall back to the east; and on the Senegal it expands into broad plains, which reach to the foot of the highlands already mentioned. The principal capes upon the coast are called Verga, Roxo, St Mary, and Verd. The low parts of this tract of country are reckoned amongst the hottest on the globe, the average temperature throughout the year being 63° Fahrenheit; but the heat is of course moderated on the mountainous districts and high table-lands. From November till the end of March is the dry and healthy season, during which the nights are cool, and the east and north-east winds prevail. Between the dry and the wet season a period intervenes when those terrific visitations, the tornadoes, prevail, and which are in general accompanied by violent thunder-storms. During the rainy season the heat is suffocating and the air loaded with humidity. Bad fevers are then common, and multitudes of insects and crawling vermin swarm in the air and on the ground, the torment and terror of man. Towards the end of the rainy season the harmatta begins to blow from the Sahara, which, although troublesome in itself, dries up the soaked ground, and purifies the air from its pernicious miasmata.

The mountains of Kong are more rich in water than any other part of Africa. Great numbers of rivers of various sizes descend its declivities, and after traversing large tracts of country, find their embouchure in the Atlantic Ocean. The most important are, the Rio Grande, the Gambia, and the Senegal, each of which is described under its own head; the Rio Nunez, which originates in the high table-lands in the interior, and, without having a very long course, is abundant in water; the Katherine and the Domingo, or the Upper and Lower Geba, originating in the table-land of Mandingo, and forming during its course a large lake, whence a considerable river flows to the sea, where it has deposited an extensive delta. From this point to the embouchure of the Gambia, numerous rivers or arms of the sea intersect the flat coast like net-work, so that between 10° and 14° of north latitude it appears as if partitioned into numberless islands. In front of this maritime tract extends a long bank of sand, out of which the islands called the Bissagos have been formed.

The inhabitants consist of Moors and Negroes, which races present a remarkable contrast in respect to their physiognomy, hair, colour, manners and customs, and the like. To the last-named people belong the Jallofs, situated between the Senegal and the Gambia. They are a fine specimen of the negro. Their colour is of a deep glossy black, of which they are very proud, and also of their ancient origin. The Mandingoes, who are partly Mahommedans, are situated on the Gambia; but, on account of their trade, they have colonies scattered over the interior of Africa. The Soosoos lie between the sources of the Gambia and the Senegal. The Feloops are scattered along the banks of the Lower Gambia, in Casamansa, and St Domingo. The Serawoollies occupy the kingdoms of Galam and Senegal. The Serreres, or Seraires, are distributed in little republics on the borders of the kingdom of Kayor; and the Pappels are situated on the south side of the St Domingo, and on the Bissagos islands. The Foulahs, on the Senegal, the same race which in Soudan is called the Fellatahs, are not true negroes; they have silken hair, and a reddish or olive complexion. Amongst those tribes which have more recently become known to us, we have to mention the Timmanees, whose principal place is Rokon, on the river Rokelle, some miles distant from the colony of Sierra Leone. From their youth they accustom themselves so much to drinking palm wine, that they get into a relaxed and effeminate state at a very early age. The Koorankas are mixed with the Mandingoes. They go constantly armed, usually with a firelock and dagger. Lastly, the Soolimas are a gay, thoughtless, stirring race, whose principal town is called Falaba, not far from the sources of the rivers Rokelle and Kabba. The principal languages spoken are the Jallof, Mandingo, Serawool, Soosoo, Arabic, Portuguese, and many varying dialects formed out of these.

In the trade of Senegambia, the English, French, Dutch, Danes, and North Americans participate. The exports consist of slaves, which, however, are of less value than those of Guinea; skins of tigers, and other animals; wax, hides, ivory, gums, cotton, and the like. England obtains ivory and gold from the countries situated between Cape Blanco and Cape Negro, and gives in return such of her own manufactures as are required. The trade in gold amounts to 30,000 ounces yearly.

Of the numerous kingdoms and countries into which the vast territory of Senegambia is partitioned, there will be found described in this work, each under its own head, BAMBOOK, BISSAGOS, BONDOO, and KAJAAGA. There still remain unnoticed a considerable number, of which we shall here present a brief account.

1. The land of the Foulahs consists of a number of provinces or kingdoms, interspersed throughout the tract comprehended between the mountainous border of the country of Sierra Leone on the west and that of Timbuctoo on the east, as also a large tract on both sides of the Senegal, and several districts on the Gambia; these provinces being insulated from each other in a very remarkable manner. The principal of the Foulah states is that within Sierra Leone, and of which Temboo is the capital. The next in order appears to be that bordering on the south of the Senegal river, and on the Jallofs. Others of less note lie between the rivers Gambia and Falemé; Foola-doo and Brooko are situated along the upper part of the Senegal; Wassela, beyond the upper part of the Niger; and Massina, lower down on the same river, adjoining Timbuctoo on the west. Amongst other districts belonging to the Foulahs may be mentioned Morfil or Ivory Island, Bilbos, and other islands of the river Senegal. On the former is a French factory, at a place called St Podhor, which is fortified. A trade in gum is here carried on. Not far from the sources of the Senegal, and three hundred and seventy miles inland, are situated, on the mountains of Kong, the towns of Temboo, which has eight thousand inhabitants, and Ladi, which has five thousand inhabitants. In both are Maraboot schools; and some trade is carried on in iron, silk, and leather. The other towns it is unnecessary to enumerate, nor can the whole number of inhabitants in the land of the Foulahs be ascertained. 2. Ludamar, situated on the borders of the Sahara. It is ruled over by a Moorish king, who resides at Benowm. On the borders of the neighbouring kingdom of Kaarta lies Tsharra, where the unfortunate Houghton met his fate. 3. The land of the Jallofs or Yolofs, comprising four territories or governments, and situated near the sea-coast, in the region between the rivers Senegal and Gambia. This country is rich in provisions, cattle, and poultry, and flourishes under a more regular administration than that of the adjoining states. The people manufacture cotton goods. The chief ruler bears the title of emperor of the Jallofs, and resides at Hikarkor, the principal town. The states separated from the Jallof empire, such as those of Baol and Cayor, are governed by a prince, who bears the title of Damel. 4. Sin, or Barb-Sin, for the most part situated on the north of the Gambia, has a hundred and forty square leagues of territory, and contains sixty thousand inhabitants. The regent, who is called Boor, has his principal seat at Joal, a seaport, formed by the mouth of the river of that name. There is a trade carried on in cattle, poultry, rice, slaves, wax, hides, and ivory. 5. Boorsali, or Salum, situated on a river of the same name, which discharges itself into the Atlantic in latitude 13° 44′ north. It comprehends a surface of 1500 square miles, and contains 300,000 inhabitants. The principal place, and the residence of the king, is called Calyoon. Upon the Gambia are situated Kahan or Cahon, and Cower or Kayee, where cotton-weaving is carried on. 6. Bar or Barrah, situated at the mouth of the Gambia, has an area of 700 square miles, and contains 200,000 inhabitants, who are Mahommedans. There are here public schools, so that it must have risen above the barbarism of most of the surrounding states. The country is tributary to Salum, and is governed by regents of circumscribed authority. The principal town is called Ba-

rinding; the others are Albreda, on the river Gambia, which has 7000 inhabitants, and Jellifree, on the same river, a Portuguese settlement, where there is also an English factory. Salt is the principal article of trade. 7. Badiboo, situated to the east of the former, on the right bank of the Gambia, is about 600 square miles in extent. The capital is a small place of the same name. The population of the country may amount to 150,000. 8. Yani, also situated on the Gambia. The chief towns are Pisania, where there is an English factory, and Jonkadouda, where are several other European factories. There is a trade carried on in gold, ivory, and other products of the country. 9. Wally, or Bembook, is situated to the east of the former, and is rich in wood, corn, rice, garden-stuffs, cotton, indigo, cattle, and fish. Malchme is the chief town, where resides the king, who exercises a limited sovereignty. 10. Wooli, a Mandigo kingdom, extends along the northern bank of Gambia, between Salum and Bondoo. The country is generally covered with extensive woods; the soil is everywhere fertile, producing cotton, tobacco, and esculent vegetables; and there are a number of towns situated in the valleys, which are the tracts chiefly cultivated. Medina, the capital, is a walled town, the residence of the king and state officers. It does not appear that this is a place of any considerable trade. 11. Gedumah, situated on the northern bank of the Senegal, and inhabited by nomadic Moors, who here find pasture for their cattle. It appears to be destitute of either town or village. 12. Combo, Foini, Caen, Jemaroa, Tommani, and Kolar, are the names of small kingdoms or territories, generally productive in rice, wax, goats, poultry, and the like, and in the principal towns of which are European factories. 13. The land of the Soosoos, which is situated between the sources and head waters of the Senegal and Gambia. This country is inhabited by an active race of men, who appear to live under a monarchy. From the conflicting statements of travellers and geographers, it seems doubtful if these people do not form a part of the Foulahs. 14. The land of the Feloops, situated upon the banks of the Casamanza, and on the upper course of the Vintain, is about twenty-five leagues in length by fifteen in breadth. The country is very fertile, and the inhabitants rear cattle, which they defend with much courage against lions and other wild animals, with which their forests abound. Rice, goats, poultry, bees' wax, and honey, are abundant, and partly exported. The population may amount to fifty thousand, who inhabit about sixty villages. 15. Kaboo is a territory situated on the upper part of the rivers St Domingo and Geba. It is subject to a king, who trades with the Portuguese in slaves, gold, and ivory. His residence, which is in the chief town, lies on the lake from which the river Geba flows. The Portuguese have here a settlement. Kaboo is very fertile in rice, millet, maize, indigo, and cotton. It is inhabited by a mixture of nations, chiefly Pagan Mandingoes, whose language prevails. 16. The important kingdom of Foota Torra, which extends considerably both to the north and south of the middle Senegal, but whose interior has not yet been explored by Europeans. There are a number of other kingdoms or territories in Senegambia, but they do not require particular notice. The most distinguished are the kingdom of Jallonkadoo, in which the river Senegal takes its rise; and the kingdom of Soolimana, which extends along the rocky Rokelle, and the Camaranca and Mungo.

Besides those places we have mentioned as possessing European factories, the English, French, and Portuguese have also settlements. The English have factories on the rich gum coast at Portendik, to the north of the Senegal; the island of James, situated a few miles from the mouth of the Gambia, with the fort of the same name; the island of Boolam, with a secure and spacious harbour, and formerly one of the Sierra Leone Company's stations, for promoting civilization amongst the Indians, for assisting in putting down the slave-trade, and for cultivating West Indian products; and the island of St Maria, on the Gambia, with twelve thousand inhabitants.

The French possess the island of St Louis or Senegal, at the mouth of the river of the same name, with 16,130 inhabitants, and the Fort St Louis, whence ships proceed on their voyage up the Senegal; but navigation is very much embarrassed by a dangerous bank across the mouth of the river. The trade between this place and the mother country was at one time very considerable, amounting to L.750,000 annually; and the English disposed of an equal amount of goods on the Gambia. At the French settlement a considerable quantity of cotton is still grown, and gum collected. The names of the other places are, the island of Goree, which is separated from the mainland by the canal of Dakar, 1500 toises in breadth. It is a great basaltic rock, with a town upon it, which bears the same name, and a fort, which bears that of St Michael. The French have also in the neighbourhood of Cape Verd a place called Riofresco. On the left bank of the Senegal is the settlement of Bakel, a hundred and five miles from St Louis, to which there is a steam-boat sent annually with goods. There are, besides, St Charles, formerly called Fort St Joseph; and the islands of Babaghee, Safal, and Geber.

The Portuguese possess St Cachao or Cacheu, situated on the north-east of the island of Bassao, at the mouth of the river St Domingo, in the kingdom of Koombo. It is fortified, has a Catholic church and a monastery, is the seat of a Portuguese governor, trades with the Cape Verd and Azore Islands, and contains 8000 inhabitants. The Portuguese also possess the island of Bissago, and the posts of Farim, Zeguichor, and Geba, which belong to the government of Cape Verd. (R. R. R.)

SENESCHAL (*Seneschallus*), derived from the German *sein*, "a house or place," and *scale*, "an officer," is a steward, and signifies one who has the dispensing of justice in some particular cases: as the high seneschal or steward of England; *seneschal de la hôtel de roi*, "steward of the king's household, seneschal or steward of courts." (*Co. Lit.* 61; Croke's *Jurisd.* 102; Kitch. 83.)

SENGBEST, a town of Persia, in the province of Khorassan, twenty-five miles south-east of Meshed.

SENGEN, a city of China, of the first rank, in Quangsee, situated in a small and mountainous district. Long. 107. 34. E. Lat 23. 24. N.

SENGOA, a village of Persia, in the province of Azerbijan, forty-eight miles south-east of Tabreez.

SENJEN, one of the largest islands of the kingdom of Norway, after Hindoen. It is separated from the continent by a narrow strait, and is about fifty miles in length and thirty-nine in breadth. It is surrounded by cliffs of more than 600 feet in height, which are covered with birch and pine trees; and, considering the climate, there are some tolerably good sections of pasture-land, upon which black cattle are reared. It comprehends three parishes, viz. Bergfiord cum Medfiord, with 370 inhabitants; Torask, with 350; and Tronoe, with 1560. There are two trading ports on the shore, Klowen and Gabostad, where small vessels repair.

SENLIS, an arrondissement of the department of the Oise, in France, which extends over 516 square miles. It contains seven cantons and 132 communes, with, in 1836, 78,790 inhabitants. The capital is the city of the same name, situated on the river Nonnette, an ancient place, with walls built at some remote period. The cathedral is also antique, and has the loftiest tower in France. It contains nine churches, and 950 houses, with 5016 inhabitants.

SENNA, a town of Persia, the capital of the eastern part of Kurdistan, known under the name of the province of Ardelan. It is situated in the bosom of a luxuriant valley, richly cultivated, and interspersed with orchards affording abundance of fruits of various kinds, namely, the peach, the apricot, the pear, apple, and cherry, besides producing tobacco and quantities of grain. It is a flourishing town, containing 8000 inhabitants, of which number 2000 are Jews, Armenians, and Nestorians, who trade to Mosul, Bagdad, and Ispahan. The town is surrounded by mountains, which are inhabited by wandering tribes of Kurds and Iliats. It is eighty miles south-east of Mosul. Lat. 35. 12. N.

SENNAAR, a country of Nubia, in Africa, forming that peninsula of land which lies between the two main branches of the Nile, immediately prior to their junction. From the confluence of the Bahr el Abiad, and the Bahr el Azrek, in north latitude 15° 34′ 40″, and east longitude 32° 11′ 25″, to the town of Sennaar, on the Bahr el Azrek, may be about a hundred and twenty miles; but the sway of the pasha of Egypt extends two hundred miles farther southward between the two rivers, so that the length of the country, which appears to have no other distinctive name but Sennaar, may be estimated at above three hundred miles. On account of its wedge-like shape, its breadth is various, from a point to a hundred and fifty or two hundred miles. Eastward from the Bahr el Azrek or eastern branch of the Nile, there is an immense tract of country nearly enclosed by the above-named river, and the Atbara or Tacazze, the great tributary of the Nile. In many maps and geographical works this is laid down as a part of Sennaar, and it certainly at one time bore that name. But it is now distinguished by the appellation of Atbari, and corresponds to the Meröe of the ancients, to which article the reader is referred. The territory included between the Abiad and the Azrek, and to which we limit the name of Sennaar, is usually called El Gezira, or the Island, because, in the season of the rains, the numerous streams which flow into these rivers from the mountains in the south encompass several districts with their spreading waters. But, viewed as a whole, the country has no pretensions to the name of island; for there is no large insulating stream cutting it off from the mainland. With more propriety, it is sometimes called Dar Fungi, or the land of Fungi, that is, the Conqueror, a negro tribe, which in 1504 descended from the interior of Ethiopia, and founded the kingdom of Sennaar. A race of hereditary monarchs, called Muck or Melek, continued to rule the country from that period till 1821, when the pasha of Egypt despatched an expedition into these regions, by which they were subdued. The former sovereign retired, on a pension (which was never paid), to the government of a small and obscure colony, over which he was not permitted to exercise any authority.

Sennaar is, for the most part, an elevated plain, which, except during the rainy season, is not only dry, but well ventilated by the breezes from the south and the east. These winds are generally cool, because they come either from the mountains of Abyssinia, or from the huge ridges that compose the Gebel el Gamara. The climate is healthy, except during the Khareef, the period which succeeds the rains; yet even then Sennaar is the most healthy of the Soudan possessions of the pasha. In summer the heat is represented as by no means oppressive, where there is any protection from the direct rays of the sun. The soil is capable of cultivation after the rains, when the doura is sown, the principal product of the country. This being reaped, the land is allowed to remain undisturbed till after the next rains, when the process is renewed. Camels, cattle, and sheep, are abundant in some parts, the plains frequently producing excellent pasture, and the superintendence of flocks and herds forming one of the chief occupations of the inhabitants. The woods abound in various kinds of birds, including ostriches, whose feathers constitute an article of trade. Elephants, lions, tigers, camelopards, monkeys, and other denizens of the forest, are found in Sennaar, and frequently carry off the cattle and sheep. There is likewise a rare animal called maraseen very abundant here. It is described as being in appearance "more like the hyena than the wolf," measuring six feet in length from head to tail, and standing above three feet in height. Guinea-fowl are very plentiful in the woods and on the banks of the rivers.

Sennaar, the capital of the country, formerly a large, well-built, and populous city, is now little more than a heap of ruins. In the days of Poncet it contained 100,000 inhabitants; but they are now reduced to 9000. It is situated on the western bank of the Bahr el Azrek, in a bare plain, and presents the appearance of a long, low, straggling ruin. There are indeed in some of its quarters several hundred habitable but almost deserted houses; and at every step the traveller treads upon portions of burned bricks, amongst which are often found fragments of porcelain, and even of marble. The most conspicuous buildings of fine baked brick which remain are the mosque, and a palace adjoining to it. The former is in a state of good preservation. Its windows, the work of India, are covered with bronze gratings skilfully manufactured, and the doors are handsomely and curiously carved. The palace is large, but in ruins, except a single pile of building in the centre, which is six stories in height, and has five rows of windows. The houses themselves are rarely of more than one story in height, and generally built of mud or straw. There is a bazaar, a wretched establishment, ill supplied with goods. Sennaar is situated in north latitude 13° 36′ 51″, and east longitude 33° 30′ 30″.

A great number of villages are scattered over the country, and especially along the banks of the rivers. One of these, called Misselemieh, situated some fifty miles below Sennaar, on the same river, is famous for its market, and is the resort of many merchants from Souakin, who bring cotton, spices, and perfumes to exchange for gold. One great staple of commerce in Sennaar is slaves, who are either taken in war, or stolen from Abyssinia, or sold from Darfur and other places where the inhabitants are born slaves. A considerable portion of the population of this country is free, but vast numbers are slaves. The natives are of two sorts, the free cultivators and the Mowelleds. The latter are a peculiar race; they are the descendants of slaves who for many generations have lived at large, and pay the masters to whom they belong, as locomotive property, a part of their monthly gains. Some of the great sheicks possess six or eight hundred of these Mowelleds, who may be sold like other slaves. The province below the town of Sennaar, and as far down as Berhee, is governed by a bey. The country above this town is divided into two commands, those who hold them having to pay an annual contribution to the pasha of Egypt, of so many ounces of gold, which, of course, is rigorously exacted from the inhabitants. The capital of one of these districts is called Goleh; it is said to be as large as Sennaar, and famous for its workers in iron. Reysenas is the name of another place of some consequence. (R. R. R.)

SENNERTUS, Daniel, an eminent physician, was born in 1572, at Breslau. In 1593 he was sent to Wittemberg, where he made great progress in philosophy and in physic. He visited the universities of Leipsig, Iena, Frankfort on the Oder, and Berlin; but he soon returned to Wittemberg, where he was promoted to the degree of doctor of physic, and soon afterwards to a professorship in the same faculty. He was the first who introduced the study of chemistry in to that university; and he gained a great reputation by his works and practice. He died of the plague at Wittemberg in 1637. By contradicting the ancients, he made himself enemies. He thought the seed of all living creatures animated, and that the soul of this seed produced organization.

He was accused of impiety for asserting that the souls of beasts are not material, for this was affirmed to be the same thing with asserting that they are immortal; but he rejected this consequence, as he well might do.

SENONES, in *Ancient Geography*, a people of Gallia Celtica, situated on the Sequana, to the south of the Parisii, near the confluence of the Jeauna or Yonne with the above-mentioned river. Their most considerable exploit was their invasion of Italy, and the taking and burning of Rome, as related under that article. This was done by a colony of them long before transported into Italy, and settled on the Adriatic. Their capital, Agendicum, in Gaul, was in the lower age called Senones, now Sens. In Italy the Senones extended themselves as far as the river Æsis, but were afterwards driven beyond the Rubicon, which became the boundary of Gallia Cisalpina.

SENRAB, a town of Hindustan, in the province of Allahabad, and district of Callinger, on the east side of the river Cane, twenty-four miles north from the town of Callinger. Long. 80. 25. E. Lat. 25. 18. N.

SENS, an arrondissement in the department of the Yonne, in France, which extends over 422 square miles, and comprehends six cantons, divided into ninety communes, with a population in 1836 of 61,036 inhabitants. The capital is the city of the same name, situated in a district rich in vines, on the river Yonne, where it is joined by the river Vannes. It has a cathedral of great antiquity and beauty, and pleasing walks on the banks of the river; and it contains 9095 inhabitants, who make cotton goods, hats, hosiery, and silks. Long. 3. 12. 16. E. Lat. 48. 11. 55. N.

SENSATION, in *Philosophy*, is the perception of external objects by means of the senses. See Metaphysics.

SENSE is a faculty of the soul, by which it perceives external objects by means of the impressions they make upon certain organs of the body. See Metaphysics.

Common Sense is a term that has been variously used both by ancient and by modern writers. With some it has been synonymous with public sense; with others it has denoted prudence; in certain instances it has been confounded with some of the powers of taste; and, accordingly, those who commit egregious blunders with regard to decorum, saying and doing what is offensive to their company, and inconsistent with their own character, have been charged with a defect in common sense. Some men are distinguished by an uncommon acuteness in discovering the characters of others; and this talent has been sometimes called common sense, similar to which is that use of the term which makes it to signify that experience and knowledge of life which is acquired by living in society. To this meaning Quintilian refers, when speaking of the advantages of a public education. "Sensum ipsum qui communis dicitur, ubi discet, cum se a congressu, qui non hominibus solum, sed mutis quoque animalibus naturalis est, segregarit? (Lib. i. cap. 2.)

But the term common sense has in modern times been employed to signify that power of the mind which perceives truth, or commands belief, not by progressive argumentation, but by an instantaneous, instinctive, and irresistible impulse, derived neither from education nor from habit, but from nature, acting independently of our will, whenever its object is presented according to an established law, and therefore called *sense;* and acting in a similar manner upon all, or at least upon a great majority of mankind, and therefore called *common sense.* See Metaphysics.

Moral Sense is a determination of the mind to be pleased with the contemplation of the affections, actions, or characters, of rational agents, which we call good or virtuous.

This moral sense of beauty in actions and affections may at first view appear strange. Some of our moralists themselves are offended at it in Lord Shaftesbury, as being accustomed to deduce every approbation or aversion from rational views of interest. It is certain that his lordship has carried the influence of the moral sense very far, and some of his followers have carried it farther. The advocates for the selfish system seem to drive their opinions to the opposite extreme; and we have elsewhere endeavoured to show that the truth lies between the contending parties. See Moral Philosophy.

SENSES, Pleasures and Pains of. The natural agreeableness, disagreeableness, and indifference of our sensations and perceptions, present to the mind an important and extensive field of inquiry; and on this subject we shall here make a few observations. All our senses have been certainly bestowed upon us for wise and beneficent purposes; and accordingly we find, that all of them, when properly cultivated, or exercised and improved, are capable of affording us pleasure. The senses of smell and of taste seem rather intended for the preservation of our animal existence, and in this point of view are properly an object of the natural history of man; whilst the other three seem to be more peculiarly intended for our mental improvement, and accordingly form the object of intellectual and of moral philosophy. And agreeably to this we know that we derive a great deal of useful knowledge, in an easy and simple manner, concerning the objects that surround us, in the early part of life, from all the senses, particularly from sight and touch, and this too without labour or study. But this is not the only purpose for which the senses were designed.

It being thus certain that the senses were bestowed upon us partly to preserve our animal existence, and partly for our mental improvement, it seems reasonable, even *a priori,* to expect that nature would attach some pleasure to such use and exercise of them as are calculated to promote these ends, and pain to the contrary; particularly in those instances in which she has left the management of them subject to our own control. And accordingly we cannot but observe what delight we derive from our senses, especially in the morning of life, by which it would seem that nature intended thus winningly to invite us to the proper exercise and improvement of them, and as it were unconsciously acquire much useful knowledge. It is this species of pleasure that supports and excites boys in the constant and often immoderate exercise of their organs of voluntary motion, the powers of which are thus increased and invigorated.

The exercise and improvement of the senses being subservient to our intellectual improvement, nature has also kindly attached much refined and rational pleasure to the mental exertions; so that we are thus seduced, as it were, to the cultivation of the various extraordinary powers and faculties of the mind.

It is evident that nature has given such organs and faculties to man, as are calculated not only to make him live, but also to render life agreeable. Here too we obtain a slight glimpse at least of some of the final causes of the pleasures of sense. But if it be asked how it happens that there are such wide diversities between our sensations, some being by nature very agreeable to all men, and some as disagreeable, whilst there are others so indifferent as to give neither pleasure nor pain, we must confess that we can give no satisfactory answer, to show how so many very different sensations are produced by various kinds of impressions made on certain organs of the body, and how all these different impressions excite such sensations as suggest not only corresponding perceptions and external qualities, but at the same time affect the mind with pleasure, pain, trouble, anxiety, or disgust. To be successful in these inquiries, we must presuppose some knowledge of the nature of the connection subsisting between the mind and the body, which there is reason to think is placed beyond the limits prescribed by nature to human research.

The pleasure or pain which constantly attends certain sensations is not uniform in degree, but varies considerably, not only in different individuals, but even in the same persons at different times. It is not thus with the sensations themselves. These are always constant and uniform. The same kind of impression, when the organs are sound, uniformly and invariably produces similar sensations; and these are as invariably followed by the perception of their own peculiar exciting causes. For any particular impression is never known to excite in the same person a new sensation, or the perceptions of an external object different from that which it previously suggested, excepting in cases of disease. And when it does rarely occur, as in those who cannot distinguish a particular colour, smell, or taste, from certain others, we uniformly attribute it to disease or malconformation. Were we not thus to have uniformly similar sensations and perceptions of external objects from similar impressions, the senses would not be at all subservient to our intellectual improvement, since, by giving different lessons concerning the same or similar objects at different times, they would render it impossible for us to be certain of any thing, or to benefit by experience.

The effects of custom, which are at all times so considerable and evident with respect both to the mind and the body, as in the case of particular organs or faculties much improved by attention and exercise, have little or no influence at all in interrupting or modifying this uniformity in our sensations and perceptions. For no sound or properly organized person will, either naturally or by custom, ever mistake hardness for softness, or red for green, or sweet for bitter. But the influence of custom in modifying the pains and pleasures of sense is well known and considerable. For a person who can most accurately distinguish sweetness from sourness, will, at the same time, either by particular conformation, or more frequently in consequence of use and habit, prefer wormwood or tobacco to honey.

But although we may despair of ever being able to discover the physical cause of the pleasures and pains of the senses, we may, however, advance a little by observing and registering particular facts. It is accordingly of use to remark, that every species of sensation, if its nature be otherwise unchanged, is agreeable or disagreeable in proportion to its strength or intenseness. For there is no sensation, however agreeable, that will not become disagreeable, and even intolerable, if it be immoderately intense. And, on the contrary, those which by their strength and nature are very troublesome, if rendered more mild and moderate, become not only tolerable, but agreeable. Thus, with respect to the senses, it would seem that pain and pleasure are only different degrees of the same feeling; and when we consider the great varieties of which the sensation, not only of different organs, but even of any one of them, is susceptible, and that each degree of these may be accompanied with pleasure or pain, more or less, we must conclude that the pains and pleasures of sense are capable of numberless modifications both in degree and in kind.

We frequently observe, that sensations which were at first agreeable, if often repeated, lose their relish, though the nature and strength of the impressions be the same; whilst others, from being at first very disagreeable, as the taste of tobacco and opium, become very pleasing, though the nature and strength of the impressions have suffered no change. For the explanation of such facts as these we must have recourse to the effects of custom. Thus, in both these opposite cases, the sensations, from being often repeated, lose part of the strength and of the novelty of their first impressions; and, with respect to the former instance, being unable to command the attention, they become in the course of time almost wholly, or altogether neglected, whilst in the latter case, from being very offensive, they become highly agreeable. But if it be asked why habit and custom produce these effects, and in what manner, we are unable to explain it farther, than by saying, since the fact is unquestionable, that such is the nature of the human constitution. Of the effects themselves, no man can entertain a doubt; and their causes, though at present unknown, may by time and inquiry be further developed and simplified. "The labyrinth," says Dr Reid, "may be too intricate, and the thread too fine, to be traced through all its windings; but if we stop where we can trace it no farther, and secure the ground we have gained, there is no harm done; a quicker eye may in time trace it farther."

These principles are capable of affording us still farther explanations. Why are new sensations always more agreeable, and variety so pleasing? Because they fix the attention more, and are not as yet blunted by frequent repetition or by habit. It is because some sensations lose their wonted effect by custom and by repetition, that we require stronger ones, or at least stronger impressions on the organs and nerves, to increase or continue our pleasures. It is also in consequence of their becoming less poignant through habit that we may neglect so many pleasures, which we hardly know to be such, till they have flown for ever; and it is because in the morning of life every thing has more novelty, and because habit has not destroyed their relish, that the pleasures of youth are much more intense than those of age. The degree of pleasure is similar to that which a blind man would feel on being made to see, or to that which a man would enjoy on suddenly acquiring a new sensitive faculty, although by long use and habit these pleasures are at present for the most part or wholly blotted away.

Although most sensations, when strong and lively enough to make themselves accurately and easily distinguished, generally please most, each in its own kind and manner; still, as there are different kinds of pleasure, different sensations may please the mind in various ways; and accordingly, it is not from the lustre of the midday sun, nor from the beautiful and lively appearance of all nature at noon, solely, that the eyes can derive pleasure, any more than grand musical sounds are the only things that please the ear. For we often contemplate with a very different and a very considerable degree of pleasure the sublime and awful scenes of nature, the twilight darkness of the shady grove, and even the gloomy horror of night itself. We listen with delight to the tempest shaking the forest, as well as to the gentle murmurs of the passing stream. There is even a time when nothing gives so much pleasure as darkness, silence, and the absence of all sensation.

Amidst the great variety of good and evil with which we are everywhere surrounded, it is a matter of the highest importance to be able to discern aright. This we should be incapable of doing were we not endowed with agreeable as well as painful sensations. These serve to direct our choice. Whatever contributes in any degree to our preservation, and to the improvement of our organs and faculties, is accompanied with pleasure; and, on the contrary, when we are threatened with danger, a painful sensation gives us the alarm. It is to the establishment of this law that we are indebted for the duration of our lives, the improved and vigorous state of our faculties, and the enjoyment of that small portion of happiness allotted to us by nature. "God," says a French writer, "having endowed man with various faculties, bodily as well as intellectual, in order to promote his happiness, also vouchsafes to conduct him to this noble end, not only by the deductions of reason, but also by the force of instinct and sensation, which are more powerful and efficacious principles. Thus nature, by a sensation of pain, instantaneously apprises us of what might prove hurtful to us; and, on the contrary, by an agreeable sensation, gently leads us to whatever may tend to the preservation of our existence, and to the perfect state of our faculties, these being the two points on which our happiness depends. Our faculties can neither be of use, nor display themselves, farther than as we exercise them. Motion or action is therefore so necessary to us, that without it we must inevitably sink into a deplorable state of insensibility and languor. On the other hand, as we are weak and limited creatures, all excessive and violent action would impair and destroy our organs; we must therefore use only moderate motion or exercise, since by these means the use or perfection of our faculties is reconciled with our chief interest, which is self-preservation. Now it is to this happy medium, we mean to a moderate exercise of our faculties, that the Author of our nature has so wisely annexed pleasure.

The pleasures of sense are thus confined within narrow limits; for they cannot be much increased without pain, or often repeated without losing their relish, at least in a great measure; nor can they be long continued, partly for the same reason, and because they exhaust the mind, or rather the nervous system. Hence we see that our animal appetites are confined within a narrow range, as is evident from the effects of excess in eating and drinking. All our sensitive powers are impaired; whilst, on the contrary, our intellectual powers are strengthened and improved by use and exercise. And in proportion as we indulge our sensitive powers, our desires of indulgence increase, whilst the pleasures which are the objects of these desires become regularly less poignant. These, indeed, are wise regulations of nature; for it would seem as if she intended to whisper gently to us in this way, by means of practical experience, that we are not born solely for the enjoyment of pleasure, at least not for that of the pleasures of the senses; for all of them, as we have already remarked, if much indulged, lead to listlessness and disgust, and sometimes to considerable pain. And indeed, just as pleasure passes thus readily into trouble and pain, so does the sudden cessation of pain, at least when this has been considerable, produce often extraordinary pleasure; so that we may here apply the beautiful allegory of Socrates, "that although pleasure and pain are contrary in their nature, and have their faces turned different ways, yet that Jupiter has tied them so together, that he who lays hold of the one draws the other along with it."

We have just said, that the sudden cessation of pain, at least when this has been considerable, produces often extraordinary pleasure. But this opinion seems to be denied by the author of an inquiry concerning taste. "Among the pleasures of sense," says Mr Knight, "more particularly among those belonging to touch, there is a certain class, which, though arising from negative causes, are nevertheless real and positive pleasures; as when we gradually sink from any violent or excessive degree of action or irritation into a state of tranquillity and repose. I say gradually, for if the transition be sudden and abrupt, it will not be pleasant; the pleasure arising from the inverted action of the nerves, and not from the utter cessation of action. From this inverted action arises the gratification which we receive from a cool breeze when the body has been excessively heated; or from the rocking of a cradle, or the gentle motion of a boat, or easy carriage, after having been fatigued with violent exercise. Such, too, is that which twilight, or the gloomy shade of a thicket, affords to the eye after it has been dazzled by the blaze of the mid-day sun; and such, likewise, is that which the ear receives from the gradual diminution of loudness of tone in music." That pleasure follows a gradual cessation of any violent action or irritation, we mean not to deny; but we are at a loss to comprehend how it follows that the transition from strong pain, if it be sudden and abrupt, will not be pleasant.

But although the pleasures of sense be thus limited, these limits are very different with respect to the different senses. Some of them are soon exhausted, and do not any longer distinguish well the objects that correspond to them; nor are they pleased with those objects which were at first very agreeable, and which they distinguish with sufficient accuracy; whilst others continue to perform their functions longer, and to enjoy a more continued pleasure. Thus the senses of smell and of taste are almost immediately satiated, the sense of hearing more slowly; but the sight is in this respect the last of all to be fatigued or satiated; whilst the pleasures that arise from the exercise of our mental faculties are by far the most durable of all. "Exercise of the mind is as necessary as that of the body to preserve our existence. The senses of other animals, being more quick than ours, are sufficient to direct them to follow what is agreeable to their nature, or to shun whatever is contrary thereto. But we are endowed with reason in order to supply the deficiency of our senses; and pleasure presents herself as an incitement to exercise, in order to keep the mind from a state of hurtful inactivity. Pleasure is not only the parent of sports and amusements, but also of arts and sciences; and as the whole universe is, as it were, forced by our industry to pay tribute to our wants and desires, we cannot but acknowledge our obligation to that law of nature which has annexed a degree of pleasure to whatever exercises without fatiguing the mind. The pleasure accompanying it is sometimes so great that it transports the very soul, so that she seems as it were disengaged from the body. We know what is recorded in history concerning Archimedes,[1] and several other geometricians, both ancient and modern. If we doubt the truth of such facts, we must at least acknowledge their probability, since we meet every day with a number of similar examples. When we see a chess-player so deeply immersed in thought as to be in a manner lost to his outward senses, should we not imagine him to be wholly engrossed with the care of his own private affairs, or of the public weal? But the object of all this profound meditation is the pleasure of exercising the mind by the movement of a piece of ivory. From this exercise of the mind also arises the pleasure we sometimes take in refined and delicate sentiments, which, after the manner of Virgil's shepherdess (*Et fugit ad salices, sed se cupit ante videri*), are sometimes artfully concealed, but so as to afford us the pleasure of discovering them."[2]

From some of the foregoing remarks we likewise see that nature points out to us the superiority and excellence of our mental faculties, thus suggesting to us that we ought to cultivate them most, as being our better and nobler part, to the cultivation of which that of our sensitive faculties should be merely subservient. But although our pleasures are thus by nature rendered in a great degree independent of ourselves, still we have it in our power to make them all more durable, by varying and mixing them with one another, or by interposing between those that are very agreeable others that are less pleasing, so as that no individual pleasure shall be in excess.

Besides the circumstances already noticed, there are others of a very different kind, which have also considerable influence on the pleasures of the senses; such as different conditions of the whole body, particularly of the nerves, or of certain organs or functions, to which functions some organs of sense, and perhaps even the sensation of these, are in a great measure subservient. This is one of the causes why many pleasures, which we cultivate with all our might, cannot be immortal. If a person be thirsty, spring-water is nectar to him; if hungry, any kind of food is agreeable, even the smell of food is grateful. To a man in a heat, or in a fever, cold is pleasing; and to one in a cold fit nothing is so agreeable as heat. To these same persons, at other times, so far are these things from being agreeable, that they are often disgusting. The most decided glutton cannot always relish a sumptuous feast.

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[1] When Syracuse was taken by the Romans under Marcellus, Archimedes was in his study, so intent upon some geometrical problems, that he neither heard the clamour of the Romans, nor perceived that the city was taken. In this transport of study and contemplation, a soldier came on him with his drawn sword; Archimedes, on seeing him, besought him to hold his hand till he had finished the problem he was about. But the soldier, deaf to his entreaty, ran him through the body, although Marcellus, upon entering the city, had given orders that Archimedes should be spared.

[2] *Théorie des Sentiments Agréables.*

Besides the sensations excited by external objects, there are others also which cause pain and pleasure. If the action of the muscles be strong, easy, and cheerful, and not continued so as to fatigue us, it causes pleasure. On the contrary, when this action is attended with a sense of listlessness, lassitude, difficulty, and debility, it more or less causes pain. In fine, various states and affections of the mind, such as the exercise of memory, imagination, and judgment, nearly for similar reasons, are sometimes painful, at other times agreeable. "Animi affectus, qui modici grate excitant, vehementes, aut graves et diuturni, hujus pariter ac corporis vires frangunt; hominem interdum statim extinguunt, sæpius longa valetudine macerant. Somni etiam, quo ad exhaustas vires reficiendas egemus, excessus, vel defectus, et animo et corpori nocet." "Desidia, sive animi sive corporis, utriusque vires languescunt: nimia exercitatione haud minus læduntur. Statuit enim provida rerum parens, ut singularum partium, et universi corporis animique vires usu roborentur et acuantur; et huic iterum certos fines posuit: ita ut neque quem voluit natura usus impune omittatur, neque ultra modum intendatur." (*Conspectus Medicinæ.*)

"Of such sensations and feelings as are agreeable or disagreeable, we may remark," says Dr Reid, "that they differ much, not only in degree, but in kind and in dignity. Some belong to the animal part of our nature, and are common to us with the brutes; others belong to the rational and moral part. The first are more properly called sensations, the last feelings. The French word *sentiment* is common to both."

"The Author of nature, in the distribution of agreeable and painful feelings, hath wisely and benevolently consulted the good of the human species; and hath even shown us, by the same means, what tenor of conduct we ought to hold. For, first, the painful sensations of the animal kind are admonitions to avoid what would hurt us; and the agreeable sensations of this kind invite us to those actions that are necessary to the preservation of the individual, or of the kind. Secondly, by the same means nature invites us to moderate bodily exercise, and admonishes us to avoid idleness and inactivity on the one hand, and excessive labour and fatigue upon the other. Thirdly, the moderate exercise of all our rational powers gives us pleasure. Fourthly, every species of beauty is beheld with pleasure, and every species of deformity with disgust; and we shall find all that we denominate beautiful to be something estimable or useful in itself, or a sign of something that is estimable or useful. Fifthly, the benevolent affections are all accompanied with an agreeable feeling, the malevolent with the contrary. And, sixthly, the highest, the noblest, and most durable pleasure is that of doing well and acting the part that becomes us; and the most bitter and painful sentiment is the anguish and remorse of a guilty conscience." These observations with regard to the economy of nature in the distribution of our painful and agreeable sensations and feelings are so well illustrated by the elegant and judicious author of *Théorie des Sentiments Agréables*, that we deem it unnecessary to make any further remarks on this subject. A little reflection may satisfy us that the number and variety of our sensations and feelings are prodigious. For, to omit all those which accompany our appetites, passions, and affections, our moral sentiments and sentiments of taste, even our external senses, furnish a variety of sensations differing in kind, and almost in every kind an endless variety of degrees. Every variety we discern with regard to taste, smell, sound, colour, heat, and cold, and in the tangible qualities of bodies, is indicated by a sensation corresponding to it.

The most general and the most important division of our sensations and feelings is into the agreeable, the disagreeable, and the indifferent. Every thing we call pleasure, happiness, or enjoyment, on the one hand, and, on the other, every thing we call misery, pain, or uneasiness, is sensation or feeling. For no man can for the present be more happy, or more miserable, than he feels himself to be. He cannot be deceived with regard to the enjoyment or suffering of the present moment.

But, besides the sensations that are agreeable or disagreeable, there is still a greater number that are indifferent. To these we give so little attention that they have no name, and are immediately forgotten, as if they had never been; it even requires attention to the operations of our minds to be convinced of their existence. For this end we may observe, that to a good ear every human voice is distinguishable from all others. Some voices are pleasant, and some disagreeable; but the far greater part cannot be said to be the one or the other. The same thing may be said of other sounds, and no less of tastes, smells, and colours; and if we consider that our senses are in continual exercise while we are awake, that some sensation attends every object they present to us, and that familiar objects seldom raise any emotion pleasant or painful, we shall see reason, besides the agreeable and disagreeable, to admit a third class of sensations, that may be called indifferent. But these sensations that are indifferent are far from being useless. They serve as signs to distinguish things that differ; and the information we have concerning things external comes by these means. Thus, if a man had not a musical ear so as to receive pleasure from the harmony or melody of sounds, he would still find the sense of hearing of great utility. Though sounds gave him neither pleasure nor pain of themselves, they would give him much useful information; and the same may be said of the sensations which we have by all the other senses.

SENSIBLE NOTE, in *Music* (derived from the French term *note sensible*), means simply the note which ascends by a semitone to the tonic or key-note of any scale, major or minor. For example, in scale of C, B to C; or in scale of A, G♯ to A, and so on. (See MUSIC.) This note is one of the marked characteristics of modern European tonality.

SENSIBILITY is a nice and delicate perception of pleasure or pain, beauty or deformity. It is very nearly allied to taste, and, as far as it is natural, seems to depend upon the organization of the nervous system. It is capable, however, of cultivation, and is experienced in a much higher degree in civilized than in savage nations, and among persons liberally educated than among boors and illiterate mechanics. The man who has cultivated any of the fine arts has a much quicker and more exquisite perception of beauty and deformity in the execution of that art, than another of equal or even greater natural powers, who has but casually inspected its productions. He who has been long accustomed to that decorum of manners which characterizes the polite part of the world, perceives almost instantaneously the smallest deviation from it, and feels himself almost as much hurt by behaviour harmless in itself as by the grossest rudeness; and the man who has long proceeded steadily in the paths of virtue, and often painted to himself the deformity of vice, and the miseries of which it is productive, is more quickly alarmed at any deviation from rectitude than another who, though his life has been stained by no crime, has yet thought less upon the principles of virtue and consequences of vice.

Every thing which can be called sensibility, and is not born with man, may be resolved into association, and is to be regulated accordingly; for sensibilities may be acquired which are inimical to happiness and to the practice of virtue. The man is not to be envied who has so accustomed himself to the forms of polite address as to be hurt by the unaffected language and manners of the honest peasant with whom he may have occasion to transact business; nor is he likely to acquire much useful knowledge, who has so sedulously studied the beauties of composition, as to be unable to read without disgust a book of science or of history, of which the style comes not up to his standard of perfection. That sensibility which we either have from nature, or necessarily acquire, of the miseries of others, is of the greatest use when properly regulated, as it powerfully impels us to relieve their distress; but if it by any means become so exquisite as to make us shun the sight of misery, it counteracts the end for which it was implanted in our nature, and only deprives us of happiness, while it contributes nothing to the good of others. Indeed there is reason to believe that all such extreme sensibilities are selfish affectations, employed as apologies for withholding from the miserable that relief which it is in our power to give; for there is not a fact better established in the science of human nature, than that passive perceptions grow gradually weaker by repetition, while active habits daily acquire additional strength.

It is of great importance to a literary man to cultivate his taste, because it is the source of much elegant and refined pleasure; but there is a degree of fastidiousness which renders that pleasure impossible to be obtained, and is the certain indication of expiring letters. It is necessary to submit to the artificial rules of politeness, for they tend to promote the peace and harmony of society, and are sometimes a useful substitute for moral virtue; but he who with respect to them has so much sensibility as to be disgusted with all whose manners are not equally polished with his own, is a very troublesome member of society. It is every man's duty to cultivate his moral sensibilities so as to make them subservient to the purposes for which they were given to him; but if he either feel, or pretend to feel, the miseries of others to so exquisite a degree as to be unable to afford them the relief which they have a right to expect, his sensibilities are of no good tendency.

That the man of true sensibility has more pains and more pleasures than the callous wretch, is universally admitted, as well as that his enjoyments and sufferings are more exquisite in their kinds; and as no man lives for himself alone, no man will acknowledge his want of sensibility, or express a wish that his heart were callous. It is, however, a matter of some moment to distinguish real sensibilities from ridiculous affectations, those which tend to increase the sum of human happiness from such as have a contrary tendency; and to cultivate them all in such a manner as to make them answer the ends for which they were implanted in us by the beneficent Author of nature. This can be done only by watching over them as over other associations (see METAPHYSICS); for excessive sensibility, as it is not the gift of nature, is the bane of human happiness. "Too much tenderness," as Rousseau well observes, "proves the bitterest curse instead of the most fruitful blessing; vexation and disappointment are its certain consequences. The temperature of the air, the change of the seasons, the brilliancy of the sun, or thickness of the fogs, are so many moving springs to the unhappy possessor, and he becomes the wanton sport of their arbitration."

SENSITIVE PLANT. The sensitive plants are well known to possess a kind of motion, by which the leaves and stalks are contracted, and fall down on being slightly touched, or shaken with some degree of violence.

The contraction of the leaves and branches of the sensitive plant when touched is a very singular phenomena, and different hypotheses have been formed by botanists in order to explain it; but we are disposed to believe that these have generally been deduced rather from analogical reasoning than from a collection of facts and observations. We shall therefore give an account of all the important facts which we have been able to collect upon this curious subject; and then draw such conclusions as obviously result from them, without, however, attempting to support any old, or to establish a new, hypothesis.

First, it is difficult to touch the leaf of a healthy sensitive plant so delicately that it will not immediately collapse, the foliola or little leaves moving at their base till they come into contact, and then applying themselves close together. If the leaf be touched with a little more force, the opposite leaf will exhibit the same appearance. If a little more force be applied, the partial footstalks bend down towards the common footstalk from which they issue, making with it a more acute angle than before. If the touch be more violent still, all the leaves situated on the same side with the one that has been touched will instantly collapse, and the partial footstalk will approach the common footstalk to which it is attached, in the same manner as the partial footstalk of the leaf approaches the stem or branch from which it issues; so that the whole plant, from having its branches extended, will immediately appear like a weeping birch.

Secondly, these motions of the plant are performed by means of three distinct and sensible articulations; the first that of the foliola or lobes to the partial footstalk, the second that of the partial footstalk to the common one, and the third that of the common footstalk to the trunk; the primary motion of all which is, the closing of the leaf upon the partial footstalk, which is performed in a similar manner, and by a similar articulation. This, however, is much less visible than the others. These motions are wholly independent of one another, as may be proved by experiment. It appears, that if the partial footstalks are moved, and collapse toward the petioli, or these toward the trunk, the little leaves, whose motion is usually primary to these, should be affected also; yet experiment proves that it is possible to touch the footstalks in such a manner as to affect them only, and make them apply themselves to the trunk, while the leaves feel nothing of the touch. But this cannot be, unless the footstalks are so disposed as that they can fall to the trunk, without suffering their leaves to touch any part of the plant in their passage, because, if they do, they are immediately affected.

Thirdly, winds and heavy rains make the leaves of the sensitive plant contract and close; but no such effect is produced from slight showers.

Fourthly, at night, or when exposed to much cold in the day, the leaves meet and close in the same manner as when touched, folding their upper surfaces together, and in part over each other, like scales or tiles, so as to expose as little as possible of the upper surface to the air. The opposite sides of the leaves, or foliola, do not come close together in the night, for when touched they apply themselves closer together. Dr Darwin kept a sensitive plant in a dark place for some hours after daybreak; the leaves and footstalks were collapsed as in its most profound sleep, and on exposing it to the light, above twenty minutes passed before it was expanded.

Fifthly, in the month of August, a sensitive plant was carried in a pot out of its usual place into a dark cave; the motion that it received in the carriage shut up its leaves, and they did not open till twenty-four hours afterwards: at this time they became moderately open, but were afterwards subject to no changes at night or morning, but remained three days and nights with their leaves in the same moderately open state. At the end of this time they were ensitive Plant.

brought out again into the air, and there recovered their natural periodical motions, shutting every night, and opening every morning, as naturally and as strongly as if the plant had not been in this forced state; and while in the cave, it was observed to be very little less affected with the touch than when abroad in the open air.

Sixthly, the great heats of summer, when there is open sunshine at noon, affect the plant in some degree like cold, causing it to shut up its leaves a little, but never in any very great degree. The plant, however, is least of all affected about nine o'clock in the morning, and that is consequently the most proper time to make experiments on it. A branch of the sensitive plant cut off, and laid by, retains still its property of shutting up and opening in the morning for some days; and it holds it longer if kept with one end in water, than if left to dry more suddenly.

Seventhly, the leaves only of the sensitive plant shut up in the night, not the branches; and if it be touched at this time, the branches are affected in the same manner as in the day, shutting up, or approaching to the stalk or trunk, in the same way, and often with more force. It is of no consequence what the substance is with which the plant is touched, it answers alike to all; but there may be observed a little spot, distinguishable by its paler colour, in the articulations of its leaves, where the greatest and nicest sensibility is evidently placed.

Eighthly, Duhamel having observed, about the 15th of September, in moderate weather, the natural motion of a branch of a sensitive plant, remarked, that at nine in the morning it formed with the stem an angle of 100 degrees; at noon, 112 degrees; at three afternoon, it returned to 100, and after touching the branch, the angle was reduced to 90. Three quarters of an hour afterwards, it had mounted to 112; and at eight at night, it descended again, without being touched, to 90. The day after, in finer weather, the same branch, at eight in the morning, made an angle of 135 degrees with the stem; after being touched, the angle was diminished to 80; an hour after, it rose again to 135; being touched a second time, it descended again to 80; an hour and a half afterwards, it had risen to 145; and on being touched a third time, descended to 135, and remained in that position till five o'clock in the afternoon, when being touched a fourth time, it fell to 110.

Ninthly, the parts of the plants which have collapsed, afterwards unfold themselves, and return to their former expanded state. The time required for that purpose varies, according to the vigour of the plant, the season of the year, the hour of the day, the state of the atmosphere. Sometimes half an hour is requisite, sometimes only ten minutes. The order in which the parts recover themselves varies in like manner; sometimes it is the common footstalks, sometimes the rib to which the leaves are attached, and sometimes the leaves themselves are expanded, before the other parts have made any attempt to be reinstated in their former position.

Tenthly, if, without shaking the other smaller leaves, we cut off the half of a leaf or lobe belonging to the last pair, at the extremity or summit of a wing, the leaf cut, and its antagonist, that is to say, the first pair, begin to approach each other; then the second, and so on successively, till all the lesser leaves or lobes of that wing have collapsed in like manner. Frequently, after twelve or fifteen seconds, the lobes of the other wings, which were not immediately affected by the stroke, shut; whilst the stalk and its wing, beginning at the bottom, and proceeding in order to the top, gradually recover themselves. If, instead of one of the lesser extreme leaves, we cut off one belonging to the pair that is next the footstalk, its antagonist shuts, as do the other pairs successively, from the bottom to the top. If all the leaves of one side of a wing be cut off, the opposite leaves are not affected, but remain expanded. With some address, it is possible even to cut off a branch without hurting the leaves or making them fall. The common footstalk of the winged leaves being cut as far as three fourths of its diameter, all the parts which hang down collapse, but quickly recover without appearing to have suffered any considerable violence by the shock. An incision being made into one of the principal branches to the depth of one half the diameter, the branches situated between the section and the root will fall down; those above the incision remain as before, and the lesser leaves continue open; but this direction is soon destroyed, by cutting off one of the lobes at the extremity, as was observed above. Lastly, a whole wing being cut off with precaution near its insertion into the common footstalk, the other wings are not affected by it, and its own lobes do not shut. No motion ensues from piercing the branch with a needle or other sharp instrument.

Sensitive Plant.

Eleventhly, if the end of one of the leaves be burned with the flame of a candle, or by a burning-glass, or by touching it with hot iron, it closes up in a moment, and the opposite leaf does the same, and after that, the whole series of leaves on each side of the partial or little footstalk; then the footstalk itself; then the branch or common footstalk; all do the same, if the burning has been in a sufficient degree. This proves that there is a very nice communication between all the parts of the plant, by means of which the burning, which only is applied to the extremity of one leaf, diffuses its influence through every part of the shrub. If a drop of aquafortis be carefully laid upon a leaf of the sensitive plant, so as not to shake it in the least, the leaf does not begin to move till the acrid liquor corrodes the substance of it; but at that time, not only the particular leaf, but all the leaves placed on the same footstalk, close themselves up. The vapour of burning sulphur has also this effect on many leaves at once, according as they are more or less exposed to it; but a bottle of very acrid and sulphureous spirit of vitriol, placed under the branches unstopped, produces no such effect. Wetting the leaves with spirit of wine has been observed also to have no effect, nor the rubbing of oil of almonds over them; though this last application destroys many plants.

From the preceding experiments the following conclusions may be fairly drawn. First, the contraction of the parts of the sensitive plant is occasioned by an external force, and the contraction is in proportion to the force. Secondly, all bodies which can exert any force affect the sensitive plant; some by the touch or by agitation, as the wind or rain; some by chemical influence, as heat and cold. Thirdly, touching or agitating the plant produces a greater effect than an incision or cutting off a part, or by applying heat or cold.

Attempts have been made to explain these curious phenomena. Dr Darwin, in the notes to his Botanic Garden, lays it down as a principle, that "the sleep of animals consists in a suspension of voluntary motion; and as vegetables are subject to sleep as well as animals, there is reason to conclude," says he, "that the various action of closing their petals and foliage may be justly ascribed to a voluntary power; for without the faculty of volition sleep would not have been necessary to them." Whether this definition of sleep when applied to animals be just, we shall not inquire. But it is evident the supposed analogy between the sleep of animals and the sleep of plants has led Dr Darwin to admit this astonishing conclusion, that plants have volition. As volition presupposes a mind or soul, it were to be wished that he had given us some information concerning the nature of a vegetable soul, which can think and will. We suspect, however, that this vegetable soul will turn out to be a mere mechanical or chemical one; for it is affected by external forces uniformly in the same way, its volition is merely passive, and never makes any successful resistance against those causes by which it is influenced. All this is a mere abuse of words. The sleep of plants is a metaphorical expression, and has not the least resemblance to the sleep of animals. Plants are said to sleep when the flowers or leaves are contracted or folded together; but we never heard that there is any similar contraction in the body of an animal during sleep.

The fibres of vegetables have been compared with the muscles of animals, and the motions of the sensitive plant have been supposed to be the same with muscular motion. Between the fibres of vegetables and the muscles of animals, however, there is not the least similarity. If muscles be cut through, so as to be separated from the joints to which they are attached, their powers are completely destroyed; but this is not the case with vegetable fibres. The following ingenious experiment, which was communicated to us by a respectable member of the university of Edinburgh, is decisive on this subject. He selected a growing poppy at that period of its growth, before unfolding, when the head and neck are bent down almost double. He cut the stalk where it was curved half through on the under side, and half through at a small distance on the upper side, and half through in the middle point between the two sections, so that the ends of the fibres were separated from the stalk. Notwithstanding these several cuttings on the neck, the poppy raised its head, and assumed a more erect position. There is, therefore, a complete distinction between muscular motion and the motions of a plant; for no motion can take place in the limb of an animal when the muscles of that limb are cut.

In fine, we look upon all attempts to explain the motions of plants as absurd, and all reasoning from supposed analogy between animals and vegetables as the source of wild conjecture, and not of sound philosophy. We view the contraction and expansion of the sensitive plant in the same light as we do gravitation, chemical attraction, electricity, and magnetism, as a singular fact, the circumstances of which we may be fully acquainted with, but must despair of understanding its cause.

SENTENCE, in *Law*, a judgment passed in court by the judge in some process, either civil or criminal. See JUDGMENT.

SENTENCE, in *Grammar*, denotes a period, or a set of words comprehending perfect sense, or a sentiment of the mind. The business of pointing is to distinguish the several parts and members of sentences, so as to render the sense as clear, distinct, and full, as possible.

In every sentence there are two parts necessarily required; a noun for the subject, and a definite verb. Whatever is found more than these two, affects one of them, either immediately or by the intervention of some other, by which the first is affected.

Again, every sentence is either simple or compound. A simple sentence is that which consists of one single subject, and one finite verb. A compound sentence contains several subjects and finite verbs, either expressly or implicitly.

A simple sentence needs no point or distinction, but only a period to close it, as "A good man loves virtue for itself." In such a sentence, the several adjuncts affect either the subject or the verb in a different manner. Thus the word *good* expresses the quality of the subject, *virtue* the object of the action, and *for itself* the end thereof. Now none of these adjuncts can be separated from the rest of the sentence; for if one be, why should not all the rest? and if all be, the sentence will be minced into almost as many parts as there are words. But if several adjuncts be attributed in the same manner either to the subject or the verb, the sentence becomes compound, and is to be divided into parts.

In every compound sentence, as many subjects or as many finite verbs as there are, either expressed or implied, so many distinctions may there be. Thus, "My hopes, fears, joys, pains, all centre in you;" and thus, "*Catilina abiit, excessit, evasit, erupit.*" The reason of thus pointing is obvious; for as many subjects or finite verbs as there are in a sentence, so many members does it really contain. Whenever, therefore, there occurs more nouns than verbs, or contrariwise, they are to be conceived as equal; since, as every subject requires its verbs, so every verb requires its subject, with which it may agree, excepting, perhaps, in some figurative expressions.

SENTINEL, or SENTRY, in military affairs, is a private soldier placed in some post, to watch the approach of the enemy, to prevent surprises, or to stop such as would pass without orders or discovering who they are. They are placed before the arms of all guards, and at the tents and doors of general officers, colonels of regiments, &c.

SENTINEL Perdu, a soldier posted near an enemy, or in some dangerous position, where he is in hazard of being lost.

SENTINEL, *Great and Little*, are two islands in the Eastern Seas. The first is about ten miles in circumference, and is about twenty miles from the Greater Andaman. Long. 92. 40. E. Lat. 11. 36. N. The second is about eight miles from the Little Andaman. Long. 92. 23. E. Lat. 10. 59. N.

SEOUNY, a town of Hindustan, in the province of Gundwana, sixty-eight miles north by east from the city of Nagpoor. Long. 80. 3. E. Lat. 22. 4. N.

SEOUNY, a town of Hindustan, in the Mahratta territories, and province of Khandesh, seventy-three miles north by west from Ellichpoor. Long. 77. 1. E. Lat. 22. 21. N.

SEPARATISTS. This name has for some years been generally applied to a particular sect in these countries. It originated with a few Christians in Dublin, about the year 1803, who had their attention strongly directed to the principles of Christian fellowship. Convinced that the authority of the apostolic word was divine and unchangeable, not to be annulled or weakened by the lapse of time, by the customs of nations, or by the laws of earthly legislators, they set out in the attempt to return fully to the course marked out for Christians in the New Testament. There they perceived that all the first Christians in any place were connected together in the closest brotherhood, and that this connection, grounded on the apostolic gospel which they believed, was altogether regulated by the apostolic precepts, the commands of the divinely-commissioned ambassadors of Christ; and they also perceived that the same divine rule which regulated their fellowship in the gospel with each other, forbade them to maintain any religious fellowship with others. From the practice consequent on this, they received the name of *Separatists*, a designation since applied to them, by an act of parliament passed in the year 1833, for their relief in the matter of oaths. To give even a concise account of the tenets and practices by which they are distinguished from most other religionists in these countries, would require more space than could be allotted to this article; but among them the following principal may be noted. They hold that the only true God is made known to men exclusively in the gospel of his son Jesus Christ; that those alone who believe the divine testimony there revealed know the true God, whose distinguishing glory is displayed in the fullest harmony of perfect righteousness and perfect mercy, as the Saviour of sinful creatures, and the justifier of the ungodly, through the redemption that is in Christ Jesus, through the propitiation for sin which he made by his obedience unto death, and the divine acceptance of which is proved by his resurrection from the dead. They hold that forgiveness of all sin, acceptance in the sight of God, and eternal life, come to the guiltiest of sinners, as such, and are assured in the divine word to every one, without distinction, who believes the testimony concerning Jesus of Nazareth. They understand by the faith with which justification and eternal life are connected, nothing else but the belief of the things declared to all alike in the gospel; and by repentance, nothing but the change of mind which takes place on a sinner's believing the gospel. Both these they hold to be solely the work of God in his people; the Spirit of God working by his revealed word, in them to will and to do; and they acknowledge God to be the sole author and agent of every thing that is good, and that every thing which comes from the sinner himself, either before his conversion to God, or after it, is essentially evil. As a church they assemble on the first day of the week, as the memorial day of Christ's resurrection, to show forth his death, the only ground of their hope, by taking bread and wine, as the symbols of his body broken and his blood shed for the remission of sins; to join in the exercises of prayer and praise; to contribute to the necessities of the poor; to express their fraternal affection by saluting each other with an holy kiss; and to attend, as occasion requires, to the discipline appointed by the apostles for removing any evil which may appear among them. For a full account of their doctrines on baptism, the clerical character, and other subjects, see Essays and Correspondence of the late John Walker, London, 1838, two vols. 8vo.

SEPOURY, or Sipry, a town and fortress of Hindustan, province of Agra, and district of Gohud, taken by the British in 1781. It is eighteen miles south-west of Narwa.

SEPOYS, or Seapoys, natives of Hindustan serving in a military capacity under the European powers, and disciplined after the European manner.

SEPTEMBER, the ninth month of the year, consisting of thirty days. It took its name as being the seventh month from March, with which the Romans began their year.

SEPTENTRIO, in *Astronomy*, a constellation, usually called *ursa minor*.

In cosmography, the term *septentrio* denotes the same with north; and hence septentrional is applied to any thing belonging to the north.

SEPTICS are those substances which promote putrefaction, chiefly the calcareous earths, magnesia, and testaceous powders.

SEPTIZON, or Septizonium, in Roman antiquity, a celebrated mausoleum, built by Septimius Severus, in the tenth region of the city of Rome. It was so called from *septem* and *zona*, because it consisted of seven stories, each of which was surrounded by a row of columns.

SEPTUAGESIMA, in the calendar, denotes the third Sunday before Lent, or before Quadragesima Sunday. It is supposed by some to take its name from its being about seventy days before Easter.

SEPTUAGINT, the name given to a Greek version of the books of the Old Testament, from its being supposed to be the work of seventy-two Jews, who are usually called the seventy interpreters, because seventy is a round number.

The history of this version has been expressly written by Aristæas, an officer of the guards to Ptolemy Philadelphus. Ptolemy having erected a noble library at Alexandria, which he took care to fill with the most curious and valuable books from all parts of the world, was informed that the Jews had one containing the laws of Moses, and the history of that people; and being desirous of enriching his library with a Greek translation of it, he applied to the high priest of the Jews, and, to engage him to comply with his request, set at liberty all the Jews whom his father Ptolemy Soter had reduced to slavery. After such a step, he easily obtained what he desired. Eleazar the Jewish high priest sent back his ambassadors with an exact copy of the Mosaical law, written in letters of gold, and six elders of each tribe, in all seventy-two, who were received with marks of respect by the king, and then conducted into the isle of Pharos, where they were lodged in a house prepared for their reception, and supplied with every thing necessary. They set about the translation without loss of time, which they finished in seventy-two days; and the whole being read in presence of the king, he admired the profound wisdom of the laws of Moses, and sent back the deputies laden with presents, for themselves, the high priest, and the temple.

Aristobulus, who was tutor to Ptolemy Physcon, Philo, who lived in our Saviour's time, and was contemporary with the apostles, and Josephus, speak of this translation as made by seventy-two interpreters, in the reign of Ptolemy Philadelphus. All the Christian writers during the first fifteen centuries of the Christian era have admitted this account of the Septuagint as an undoubted fact. But since the Reformation, critics have boldly called it in question, because it was attended with circumstances which they think inconsistent, or at least improbable. Dupin has asked, why were seventy-two interpreters employed, since twelve would have been sufficient? Such an objection is trifling. We may as well ask, why did King James I. employ fifty-four translators in rendering the Bible into English, since Dupin thinks twelve would have been sufficient?

Prideaux objects, that the Septuagint is not written in the Jewish, but in the Alexandrian dialect; and could not therefore be the work of natives of Palestine. But these dialects were at that time probably the same, for both Jews and Alexandrians had received the Greek language from the Macedonians about fifty years before. Prideaux further contends, that all the books of the Old Testament could not be translated at the same time; for they exhibit great difference of style. To this it is sufficient to reply, that they were the work of seventy-two men, each of whom had separate portions assigned him.

The dean also urges, that Aristæas, Aristobulus, Philo, and Josephus, all directly tell us, that the law was translated, without mentioning any of the other sacred books. But nothing was more common among writers of the Jewish nation, than to give this name to the Scriptures as a whole. In the New Testament, law is used as synonymous with what we call the Old Testament. Besides, it is expressly said by Aristobulus, in a fragment quoted by Eusebius, that the whole Sacred Scripture was rightly translated through the means of Demetrius Phalereus, and by the command of Philadelphus. Josephus, indeed, says the learned dean, asserts, in the preface to his Antiquities, that the Jewish interpreters did not translate for Ptolemy the whole Scriptures, but the law only. Here the evidence is contradictory, and we have to determine whether Aristobulus or Josephus be most worthy of credit. We do not mean, however, to accuse either of forgery, but only to inquire which had the best opportunities of knowing the truth. Aristobulus was an Alexandrian Jew, tutor to an Egyptian king, and lived within a hundred years after the translation was made, and certainly had access to see it in the royal library. Josephus was a native of Palestine, and lived not until three hundred years or more after the translation was made, and many years after it was burned along with the whole library of Alexandria in the wars of Julius Cæsar. Supposing the veracity of these two writers equal, as we have no proof of the contrary, which of them ought we to consider as the best evidence? Aristobulus certainly. Prideaux, indeed, seems doubtful whether there was ever such a man; and Dr Hody supposes that the Commentaries on the five books of Moses, which bear the name of Aristobulus, were a forgery of the second century. To prove the existence of any human being, who lived two thousand years before us, and did not perform such works as no mere man ever performed, is a task which we are not disposed to undertake; and we believe that it would not be less difficult to prove that Philo and Josephus existed, than that such a person as Aristobulus did not exist. If the writings which have passed under his name were a forgery of the second century, it is surprising that they should have imposed upon Clemens Alexandrinus, who lived in the same century, and was a man of abilities, learning, and well acquainted with the writings of the ancients. Eusebius, too, quotes the Commentaries of Aristobulus. But, continues the learned dean, "Clemens Alexandrinus is the first author that mentions them. Now, had any such commentaries existed in the time of Philo and Josephus, they would surely have mentioned them." But is the circumstance of its not being quoted by every succeeding author a sufficient reason to disprove the authenticity of any book? Neither Philo nor Josephus undertook to give a list of preceding authors, and it was by no means the uniform practice of these times always to name the authors from whom they derived their information.

Prideaux further contends, that the sum which Ptolemy is said to have given to the interpreters is too great to be credible. If his computation were just, it certainly would be so. He makes it L.2,000,000 sterling; but other writers[1] reduce it to L.85,421, and some to L.56,947, neither of which is a sum so very extraordinary in so great and magnificent a prince as Philadelphus, who spent, according to Athenæus, not less than ten thousand talents on the furniture of one tent, which is six times more than what was spent in the whole of the embassy and translation, which amounted only to 1552 talents.

Prideaux says, "that what convicts the whole story of Aristæas of falsity is, that he makes Demetrius Phalereus to be the chief actor in it, and a great favourite of the king; whereas Philadelphus, as soon as his father was dead, cast him into prison, where he soon after died." But it may be replied, that Philadelphus reigned two years jointly with his father Lagus, and it is not said by Hermippus that Demetrius was out of favour with Philadelphus during his father's life. Now, if the Septuagint was translated in the beginning of the reign of Philadelphus, as Eusebius and Jerome think, the difficulty will be removed. Demetrius might have been librarian during the reign of Philadelphus, and yet imprisoned on the death of Lagus. Indeed, as the cause of Philadelphus's displeasure was the advice which Demetrius gave to his father, to prefer the sons of Arsinoë to the son of Bernice, he could scarcely show it till his father's death. The Septuagint translation might therefore be begun while Philadelphus reigned jointly with his father, but not be finished till after his father's death.

Besides the objections which have been considered, there is only one that deserves notice. The ancient Christians not only differ from one another concerning the time in which Aristobulus lived, but even contradict themselves in different parts of their works. Sometimes they tell us he dedicated his book to Ptolemy Philometer; at other times they say it was addressed to Philadelphus and his father. Sometimes they make him the same person who is mentioned in second Maccabees, and sometimes one of the seventy-two interpreters a hundred and fifty-two years before. It is difficult to explain how authors fall into such inconsistencies, but it is probably occasioned by their quoting from memory. This was certainly the practice of almost all the early Christian writers, and sometimes of the apostles themselves. Mistakes were therefore inevitable. Josephus has varied in the circumstances of the same event, in his Antiquities and Wars of the Jews, probably from the same cause; but we do not hence conclude, that every circumstance of such a relation is entirely false. In the account of the Marquis of Argyll's death in the reign of Charles II. we have a very remarkable contradiction. Lord Clarendon relates that he was condemned to be hanged, which was performed the same day. On the contrary, Burnet, Wodrow, Heath, and Echard, concur in stating that he was beheaded; and that he was condemned upon the Saturday, and executed upon the Monday.[2] But was any reader of English history ever sceptical enough to raise from hence a question, whether the Marquis of Argyll was executed or not? Yet this ought to be left in uncertainty, according to the way of reasoning in which the facts respecting the translation of the Septuagint are attempted to be disproved.

Such are the objections which Prideaux has raised against the common account of the Septuagint translation, and such are the answers which may be given to them. We have chosen to support that opinion which is sanctioned by historical evidence, in preference to the conjectures of modern critics, however ingenious; being persuaded that there are many things recorded in history, which, though perfectly true, yet, from our imperfect knowledge of the concomitant circumstances, may, at a distant period, seem liable to objections. To those who require positive evidence, it may be stated thus. Aristæas, Aristobulus, Philo, and Josephus, assure us that the law was translated. Taking the law in the more restricted sense, we have at least sufficient authority to assert that the Pentateuch was rendered into Greek under Ptolemy Philadelphus. Aristobulus affirms, that the whole Scriptures were translated by the seventy-two. Josephus confines their labours to the books of Moses. He therefore who cannot determine to which of the two the greater respect is due, may suspend his opinion. It is certain, however, that many of the other books were translated before the age of our Saviour; for they are quoted both by him and by his apostles; and, perhaps, by a minute examination of ancient authors, in the same way that Dr Lardner has examined the Christian fathers to prove the antiquity of the New Testament, the precise period in which the whole books of the Septuagint were composed might, with considerable accuracy, be ascertained.

For four hundred years this translation was in high estimation with the Jews. It was read in their synagogues in preference to the Hebrew, not only in those places where Greek was the common language, but in many synagogues of Jerusalem and Judæa. But when they saw that it was equally valued by the Christians, they became jealous of it; and at length, in the second century, Aquila, an apostate Christian, attempted to substitute another Greek translation in its place. In this work he was careful to give the ancient prophecies concerning the Messiah a different turn from the Septuagint, that they might not be applicable to Christ. In the same design he was followed by Symmachus and Theodotion, who also, as St Jerome informs us, wrote out of hatred to Christianity.

In the mean time, the Septuagint, from the ignorance, boldness, and carelessness of transcribers, became full of errors. To correct these, Origen published a new edition in the beginning of the third century, in which he placed the translations of Aquila, Symmachus, and Theodotion. This edition was called *Tetrapla*, the translations being arranged opposite to one another in four columns. He also added one column, containing the Hebrew text in Hebrew letters, and another exhibiting it in Greek. In a second he published two additional Greek versions, one of which was found at Nicopolis, and the other at Jericho. This was called the *Hexapla*. By comparing so many translations, Origen endeavoured to form a correct copy of the Scriptures. Where they all agreed, he considered them as right. The passages which he found in the Septuagint, but not in the Hebrew text, he marked with an obelisk; what he found in the Hebrew, but not in the Septuagint, he marked with an asterisk. St Jerome says, that the additions which Origen made to the Septuagint, and marked with an asterisk, were taken from Theodotion. From this valuable work of Origen the version of the Septuagint was transcribed in a separate volume, with the asterisks and obelisks for the use of the churches; and from this circumstance the great work itself was neglected and lost.

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[1] Blair's Lectures on the Canon.

[2] *Biographia Britannica.*

About the year 300, two new editions of the Septuagint were published; the one by Hesychius, an Egyptian bishop, and the other by Lucian, a presbyter of Antioch. But as these authors did not mark with any note of distinction the alterations which they had made, their edition does not possess the advantages of Origen's.

The best edition of the Septuagint is that of Dr Grabe, which was published in the beginning of the last century. He had access to two manuscripts nearly of equal antiquity, the one found in the Vatican library at Rome, the other in the royal library at St James's, which was presented to Charles I. by Cyril, patriarch of Alexandria, and hence is commonly called the Alexandrian Manuscript. Anxious to discover which of these was according to the edition of Origen, Dr Grabe collected the fragments of the Hexapla, and found that they agreed with the Alexandrian Manuscript, but not with the Vatican where it differed with the other. Hence he concluded that the Alexandrian Manuscript was taken from the edition of Origen. By comparing the quotations from Scripture in the works of Athanasius and St Cyril, who were patriarchs of Alexandria at the time St Jerome says Hesychius's edition of the Septuagint was used there, with the Vatican manuscript, he found they agreed so well that he justly inferred that the manuscript was taken from the edition of Hesychius.

This version was in use to the time of our blessed Saviour, and is that out of which most of the citations in the New Testament from the Old are taken. It was also the ordinary and canonical translation made use of by the Christian church in the earliest ages; and it still subsists in the churches both of the east and the west.

(Those who desire a more particular account of the Septuagint translation may consult Hody *De Bibliorum Textibus*, Prideaux's Connections, Owen's Inquiry into the Septuagint Version, Blair's Lectures on the Canon, and Michaelis's Introduction to the New Testament, last edition.)

Septuagint *Chronology*, the chronology which is formed from the dates and periods of time mentioned in the Septuagint translation of the Old Testament. It reckons 1500 years more from the creation to Abraham than does the Hebrew Bible. Dr Kennicot, in the dissertation prefixed to his Hebrew Bible, has shown it to be very probable that the chronology of the Hebrew Scriptures, since the period just mentioned, was corrupted by the Jews between the years 175 and 200, and that the chronology of the Septuagint is more agreeable to the truth. It is a fact, that during the second and third centuries the Hebrew Scriptures were almost entirely in the hands of the Jews, while the Septuagint was confined to the Christians. The Jews had therefore a very favourable opportunity for this corruption. The following is the reason which is given by oriental writers. It being a very ancient tradition that the Messiah was to come in the sixth chiliad, because he was to come in the last days, the contrivance was to shorten the age of the world from about 5500 to 3760, and thence to prove that Jesus could not be the Messiah. Dr Kennicot adds, that some Hebrew copies having the larger chronology were extant till the time of Eusebius, and some till the year 700.

SEPULCHRE, a tomb or place destined for the interment of the dead. This term is chiefly used in speaking of the burying-places of the ancients, those of the moderns being usually called tombs.

Sepulchres were held sacred and inviolable, and the care taken of them has always been held a religious duty, grounded on the fear of God, and the belief of the soul's immortality. Those who have searched or violated them have been thought odious by all nations, and were always severely punished.

The Egyptians called sepulchres "eternal houses," in contradistinction to their ordinary houses or palaces, which they called "inns," on account of the short stay in the one in comparison with their long abode in the other.

Regular Canons of St Sepulchre, a religious order, formerly instituted at Jerusalem in honour of the holy sepulchre, or the tomb of Jesus Christ.

Many of these canons were brought from the Holy Land into Europe, particularly into France, by Louis the Younger; into Poland, by Jaxa, a Polish gentleman; into Flanders, by the counts of that country; and many also came into England. This order was, however, suppressed by Pope Innocent VIII., who gave its revenues and effects to that of our Lady of Bethlem; and this also becoming extinct, they were bestowed on the knights of St John of Jerusalem. But the suppression did not take effect in Poland, where they still subsist, as also in several provinces of Germany. These canons follow the rule of St Augustin.

Knights of the Holy Sepulchre, a military order, established in Palestine about the year 1114.

The knights of this order in Flanders, in 1558, chose Philip II. king of Spain for their master, and afterwards his son; but the grand-master of the order of Malta prevailed on him to resign; and when afterwards the Duke de Nevers assumed the same quality in France, the same grand-master, by his interest and credit, procured a like renunciation by him, and a confirmation of the union of this order to that of Malta.

SEQUANI, a people anciently forming a part of Gallia Celtica, but annexed to Belgica by Augustus, separated from the Helvetii by Mount Jura, with the Rhine on the east, bordering on the Ædui and Segustiani to the south, and Lingones to the west; now Franche Comté.

SEQUESTRATION, in *Common Law*, is setting aside the thing in controversy from the possession of both the parties that contend for it. In this sense it is either voluntary, as when done by the consent of the parties; or necessary, as where it is done by the judge, of his own authority, whether the parties are inclined or the reverse.

Sequestration is also used for the act of gathering the fruits of a benefice void, to the use of the next incumbent.

Sometimes a benefice is kept under sequestration for many years, when it is of so small value that no clergyman fit to serve the cure will be at the charge of taking it by institution; in which case the sequestration is committed either to the curate alone, or to the curate and churchwardens jointly. Sometimes the profits of a living in controversy, either by the consent of the parties, or by the judge's authority, are sequestered, and placed for safety in a third hand, till the suit is determined, a minister being appointed by the judge to serve the cure, and allowed a certain salary out of the profits. Sometimes the profits of a living are sequestered for neglect of duty, for dilapidations, or for satisfying the debts of the incumbent.

SEQUIN, a gold coin, struck at Venice, and in several parts of the grand signior's dominions. In Turkey it is called *dahob*, or piece of gold, and, according to Volney, is in value about 6s. 3d. sterling. It varies, however, considerably in its value in different countries. At Venice it is equal to about 9s. 2d. sterling.

SERA, a town of the south of India, in the province of Mysore, and capital of a district of the same name. The climate is subject to drought, and there seldom falls as much rain as is required to raise a full crop. Rice is the most beneficial product, and in favourable years the greater part of the watered land is sown with it; but in dry seasons coarser grains are sown. The trade carried on is to the nizam's country, the Mahrattas, and Bednore, Seringapatam, and Bangalore, and the article of exportation is the dried kernel of the cocoa-nut. This place, which was first conquered by the Bejapoor Mohammedan government in 1644, was afterwards the seat of an independent principality, which was at its greatest prosperity under Delawar Khan, immediately before it was conquered by Hyder, at which time the natives assert it to have contained 50,000 houses. It afterwards suffered many calamities from Tippoo and the Mahrattas, and now contains scarcely 300 houses; but it is fast reviving. In the district of Sera, all the villages were strongly fortified; and frequent famines took place, when the inhabitants were in the practice of plundering each other to support life. The defence of the villages against plunderers was conducted, not by fire-arms, but by throwing stones, in which the inhabitants are very dexterous. The town is eighty four miles north from Seringapatam. Long. 76. 55. E. Lat. 13. 37. N.

SERAGLIO, formed from the Persian word *seraw*, or Turkish word *serai*, which signifies a house, is commonly used to express the house or palace of a prince. In this sense it is frequently used at Constantinople, where the houses of foreign ambassadors are called seraglios. But it is commonly used by way of eminence for the palace of the grand signior at Constantinople, where he keeps his court, where his concubines are lodged, and where the youth are trained up for the chief posts of the empire.

SERAI, a building on the high road, or in large cities, in India, erected for the accommodation of travellers.

SERAMPEI, a country or district in the interior of the island of Sumatra. It has on the north and north-west Korinchi; on the east, south-east, and south, Pakalang, Jambee, and Sungei-tenang; and on the west and south-west, a river and chain of high mountains. It comprehends fifteen fortified and independent villages.

SERAMPOOR, a town in the province of Bengal, and district of Birbhoom, 107 miles west from Moorshedabad. Long. 80. 24. E. Lat. 24. 6. N.

SERAMPORE, a town of Bengal, belonging to the Danes, situated on the west side of the Hooghly river, about twelve miles above Calcutta. Serampore has a pleasing appearance viewed from the river, the houses being tolerably well built, of brick, and whitened; they have flat roofs, with balconies and Venetian windows, though few of them are more than two stories in height. There is a handsome church, and a battery of twelve pieces of cannon, chiefly for saluting, for the town is without fortifications. The trade which the Calcutta merchants carried on during the war, under cover of the Calcutta flag, was very profitable to the Danes who were settled here. The trade which it now carries on with Europe and China is but trifling. It is chiefly supported by missionaries; and insolvent debtors from Calcutta found here an asylum, from whence they could set their creditors at defiance. The missionaries have here established a printing-press, and printed the Scriptures in various dialects. During the short war with the Danes it was taken possession of by the British; but it was soon afterwards restored. Long. 88. 26. E. Lat. 22. 45. N.

SERANGANI Isles, a group of small islands in the Eastern Seas, about five leagues south of Magindanao, and between the fifth and sixth degrees of north latitude. The largest island is called Hummock Isle, about thirty miles in circumference. The next in size is about twenty-five miles in circumference; and there is another of somewhat inferior dimensions. This island, which is the most westerly, is very high and of a conical form, and its northern coast is very bold. It is fertile and well cultivated, and produces most of the tropical fruits, also rice, sugar-canes, pine-apples, mangoes, sour oranges, limes, jacks, plantains, cocoa-nuts, sago, sweet potatoes, tobacco, &c. The ships that pass, trade with the inhabitants for poultry, goats, and other refreshments; and one principal article of trade is bees' wax. There is a great demand among the natives for white or printed cottons, such as loose gowns or jackets, coloured handkerchiefs, knives, razors, and bar-iron. The inhabitants are, like almost all the islanders in the Eastern Seas, addicted to piracy; and they have canoes, and also larger boats, armed with small brass cannon, with which they carry on this trade of plunder. The Dutch claimed the sovereignty over these islands, which, however, they seldom exercised.

SERAPH, or Seraphim, spirits of the highest rank in the hierarchy of angels, who are so called from their being supposed to be the most inflamed with divine love, by their nearer and more immediate attendance at the throne of God, and to communicate their fervour to the remoter and inferior orders. Seraphim is the Hebrew plural of seraph.

SERAPION, a physician of Alexandria. He and Philinus of the isle of Cos were both scholars of Herophilus, and were founders of the empirical sect, which happened about 287 before Christ.

SERAPIS, in *Mythology*, an Egyptian deity, who was worshipped under various names and attributes, as the tutelary god of Egypt in general, and as the patron of several of their principal cities. Tacitus informs us, that he was worshipped as a kind of universal deity, that represented Æsculapius, Osiris, Jupiter, and Pluto. He was sometimes taken for Jupiter Ammon, the Sun, and Neptune; and the honours that were rendered to him at Alexandria were more solemn and extraordinary than those of any other place.

Plutarch and Clemens of Alexandria, as well as Tacitus,[1] inform us, that whilst the first Ptolemy was employed in fortifying Alexandria with walls, and adorning it with temples and stately buildings, there appeared to him in his sleep a young man of extraordinary beauty, of a stature more than human, admonishing him to despatch into Pontus some of his most trusty friends, to bring from thence his statue; assuring him that the city and kingdom which possessed it should prove happy, glorious, and powerful. The young man having thus spoken, disappeared, mounting up into heaven in a blaze of fire.

Ptolemy discovered his vision to the priests; but finding them ignorant of Pontus, he had recourse to an Athenian, who informed him that near Sinope, a city of Pontus, there was a temple much resorted to by the natives, which was consecrated to Pluto, where he had a statue, near which stood that of a woman. Ptolemy neglecting the injunctions of the apparition, it again appeared to him in a menacing attitude; and the king immediately despatched ambassadors to the Serapian monarch, loaded with presents. The king of Sinope consented, but his subjects opposed the removal of the statue. The god, however, of his own accord, as we are informed, conveyed himself to the ambassadors' ship, and in three days landed in Alexandria. The statue of Serapis was erected in one of the suburbs of the city, where a magnificent temple was afterwards reared.

The statue of Serapis, according to Macrobius, was of a human form, with a basket or bushel on his head, signifying plenty; his right hand leaned on the head of a serpent, whose body was wound round a figure with three heads, of a dog, a lion, and a wolf; and in his left hand he held a measure of a cubit in length, as if it were to take the height of the waters of the Nile. The figure of Serapis is found on many ancient medals.

The famous temple of Serapis at Alexandria was destroyed by order of Theodosius; and the celebrated statue of this deity was broken in pieces, and its limbs carried first in triumph by the Christians through the city, and then thrown into a fierce fire kindled for that purpose in the amphitheatre. As the Egyptians ascribed the overflowing of the Nile, to which was owing the fertility of their country, to the benign influence of their god Serapis, they concluded, that now he was destroyed, the river would no longer overflow, and that a general famine would ensue; but when they observed, on the contrary, that the Nile swelled to a

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[1] Tacitus, *Hist.* lib. iv. cap. 3; Plutarch, *De Iside et Osiride*; Clemens Alexandrinus *in Protrep.*

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greater height than had been known in the memory of man, and thereby produced plenty of all kinds of provisions, many of the pagans, renouncing the worship of idols, adored the God of the Christians.

SEREEK, a town of Persia, in the province of Mekran, about four miles from the coast, near the entrance of the Persian Gulf. It contains a large mud fort and 600 huts, and is 105 miles north of Jask.

SERENADE (*Serenata*), a concert of instrumental or of vocal music, or of both, given under the windows of a house, generally after nightfall; and common in Italy and Spain as a mark of amatory respect. The *Notturno* is of the same kind.

SERENUS SAMMONICUS, a celebrated physician in the reigns of the Emperors Severus and Caracalla, about the year 200. He wrote several treatises on history and the works of nature; but there is only one of them extant, which is a very indifferent poem on the Remedies of Diseases. He was murdered at a festival by the order of Caracalla. He had a library that contained sixty-two thousand volumes, which Quintus Serenus Sammonicus, his son, gave to Gordian the younger, to whom he was preceptor.

SERES, a people of the Farther Asia, bounded on the west by Scythia without Imaus, on the north and east by Terra Incognita, and on the south by India beyond the Ganges. According to these limits, their country answers nearly to Cathay or Northern China. Mela places them between the Indi and Scythæ, and perhaps beyond the Indi, if we distinguish them from the Sinæ. The ancients commend them for their cotton manufactures, different from the produce of the bombyces or silk-worms, called *seres* by the Greeks; and hence *serica* means silk.

SERES, or *Sirus*, a city of European Turkey, in the province of Rumelia, and the circle of the Bay of Contessa. It stands on a fine plain watered by the rivers Egrifu and Stromza; but it is considered as unhealthy. It is surrounded with walls, which are in a neglected state. It contains ten mosques, several Greek and Armenian churches, and about thirty thousand inhabitants. It is the chief market for cotton wool, which is extensively cultivated on the fertile plains around it. It has also a considerable trade in rice, tobacco, and fruits of all kinds.

SERGE, a woollen quilted stuff, manufactured on a loom with four treddles, after the manner of rateens, and other stuffs that have the whale. The goodness of serges is known by the quilting, as that of cloths by the spinning. Of serges there are various kinds, denominated either from their different qualities or from the places where they are wrought. The most considerable is the London serge, which is now highly valued abroad.

The method of making the London serge we shall now describe. For wool, the longest is chosen for the warp, and the shortest for the woof. Before either kind is used, it is first scoured, by putting it into a copper of liquor somewhat more than lukewarm, composed of three parts of water and one of urine. After being kept long enough in it for the liquor to dissolve and take off the grease, it is stirred briskly about with a wooden peel, taken out of the liquor, drained, washed in a running water, and dried in the shade; it is then beaten with sticks on a wooden rack to drive out the coarser dust and filth, and picked clean with the hands. Thus far prepared, it is greased with oil of olives, and the longest part, destined for the warp, is combed with large combs heated in a small furnace. To clear off the oil again, the wool is put in a liquor composed of hot water with soap melted in it; whence being taken out, wrung, and dried, it is spun on the wheel.

As to the shorter wool, intended for the woof, it is only carded on the knee with small cards, and then spun on the wheel, without being scoured of its oil. It must be remarked, that the thread for the warp is always to be spun much finer, and better twisted, than that of the woof. The wool both for the warp and the woof being spun, and the thread divided into skains, that of the woof is put on spools fit for the cavity or eye of the shuttle, and that for the warp is wound on a kind of wooden bobbins to fit it for warping. When warped, it is stiffened with a kind of size, of which that made of the shreds of parchment is considered as the best, and when dry it is put on the loom.

Sergeant.

When mounted on the loom, the workman, raising and lowering the threads, which are passed through a reed, by means of four treddles placed underneath the loom, which he makes to act transversely, equally, and alternately, one after another, with his feet, in proportion as the threads are raised and lowered, throws the shuttle across from one side to the other; and, each time that the shuttle is thrown, and the thread of the woof is crossed between those of the warp, strikes it with the frame to which the reed is fastened; through those teeth the threads of the warp pass; and this stroke he repeats twice or thrice, or even more, till he judges the crossing of the serge sufficiently close. Thus he proceeds till the warp is all filled with woof.

The serge, now taken off the loom, is carried to the fuller, who scours it in the trough of his mill with a kind of fat earth called fuller's earth, first purged of all stones and filth. After three or four hours' scouring, the fuller's earth is washed out in fair water, brought by little and little into the trough, out of which it is taken when all the earth is cleared; then, with a kind of iron pincers, all the knots, ends, and straws sticking out on the surface on either side are pulled off; and then it is returned into the fulling trough, where it is worked with water somewhat more than lukewarm, with soap dissolved in it, for nearly two hours. It is next washed till such time as the water becomes quite clear, and there be no signs of soap left, when it is taken out of the trough, the knots again pulled off, and put on the tenter to dry, taking care as fast as it dries to stretch it out both in length and breadth, till it be brought to its just dimensions. When well dried, it is taken off the tenter, and dyed, shorn, and pressed.

SERGEANT, or SERJEANT, *at Law*, or of the Coif, is the highest degree, taken at the common law, as that of doctor is of the civil law; and as these are supposed to be the most learned and experienced in the practice of the courts, there is one court appointed for them to plead in by themselves, which is the Common Pleas, where the common law of England is most strictly observed. But they are not restricted from pleading in any other court, where the judges, who cannot have that honour till they have taken the degree of sergeant-at-law, call them brothers.

Sergean-tat-Arms, or *Mace*, an officer appointed to attend the person of the king, to arrest traitors and such persons of quality as offend, and to attend the lord high steward when sitting in judgment on a traitor.

There are four other sergeants-at-arms, created in the same manner; one, who attends the lord chancellor; a second, the lord treasurer; a third, the speaker of the House of Commons; and a fourth, the lord mayor of London on solemn occasions.

Common Sergeant, an officer in the city of London, who attends the lord mayor and court of aldermen on court days, and is in council with them on all occasions, within and without the precincts or liberties of the city. He takes care of orphans' estates, either by taking account of them, or by signing their indentures, before these pass the lord mayor and court of aldermen; and he likewise lets and manages the orphan estates, according to his judgment, to the best advantage.

Sergeant, in *War*, is an uncommissioned officer in a company of foot or troop of dragoons, armed with an halbert, and appointed to see discipline observed, to teach the soldiers the exercise of their arms, and to order, straighten, and form their ranks and files. He receives the orders from the adjutant, which he communicates to his officers. Each company has generally two sergeants.

SERGEANTY (*serjeantia*) signifies, in *Law*, a service that cannot be due by a tenant to any lord but the king; and this is either grand sergeanty or petit. The first is a tenure by which the one holds his lands of the king by such services as he ought to do in person to the king at his coronation, and may also concern matters military, or services of honour in peace. Petit sergeanty is where a man holds lands of the king to furnish him yearly with some small thing towards his wars, and in effect payable as rent. Though all tenures are turned into soccage by the 12th Car. II. cap. 24, yet the honorary services of grand-sergeanty still remain, being excepted in that statute.

SERIES, in general, denotes a continual succession of things in the same order, and having the same relation or connection with each other. In this sense we say, a series of emperors, kings, bishops, and the like.

In natural history, a series is used for an order or subdivision of some class of natural bodies; comprehending all such as are distinguished from the other bodies of that class, by certain characters which they possess in common, and which the rest of the bodies of that cast have not.

SERIES.

(1.) Series, in *Arithmetic* or *Algebra*, a rank or progression of quantities which succeed one another according to some determinate law. For example, the numbers

$$3, 5, 7, 9, 11, 13, 15, \text{ \&c.}$$

constitute a series, the law of which is, that each term exceeds that before it by a given number, viz. 2. Again, the numbers

$$3, 6, 12, 24, 48, 96, 192, \text{ \&c.}$$

constitute a series of a different kind, each term being the product of the term before it, and the given number 2.

(2.) As the law according to which the terms of a series are formed may be infinitely varied, there may be innumerable kinds of series. We shall enumerate a few of the most common.

1. *Arithmetical Series.* The general form of a series of this kind is

$$a,\ a+d,\ a+2d,\ a+3d,\ a+4d, \text{ \&c.}$$

and its law is, that the difference between any two adjacent terms is the same quantity, viz. d. The first of the two preceding examples is a series of this nature.

2. *Geometrical Series.* Its general form is

$$a,\ ar,\ ar^2,\ ar^3,\ ar^4, \text{ \&c.}$$

In this kind of series each term is the product of that which precedes it and a constant number r, which is called the common ratio of the terms. The second of the above examples is a particular case of a geometrical series.

3. *Harmonic Series* is that in which the first of any three of its consecutive terms is to the third, as the difference between the first and second to the difference between the second and third; hence we readily find, that putting a and b for its first two terms, its general form will be

$$a,\ b,\ \frac{ab}{2a-b},\ \frac{ab}{3a-2b},\ \frac{ab}{4a-3b}, \text{ \&c.}$$

If we suppose $a=1$ and $b=\frac{1}{2}$, we get

$$1, \tfrac{1}{2}, \tfrac{1}{3}, \tfrac{1}{4}, \tfrac{1}{5}, \tfrac{1}{6}, \text{ \&c.}$$

as a particular example of a harmonic series.

4. *Recurring Series.* Let its terms be denoted by

$$A, B, C, D, E, F, \text{ \&c.}$$

Then we shall form a recurring series if, m and n being put for given quantities, we take

$$C = mA + nB, \qquad E = mC + nD,$$
$$D = mB + nC, \qquad F = mD + nE.$$

For example, let us suppose $A=1$, $B=2x$, $m=4x^2$, $n=3x$; then $C=10x^2$, $D=38x^3$, $E=154x^4$, $F=614x^5$, so that the first six terms of the series are

$$1, 2x, 10x^2, 38x^3, 154x^4, 614x^5.$$

We have here supposed each term to be formed from the two which come immediately before it; but the name *recurring series* is given to every one in which the terms are formed in like manner from some assigned number of the terms which precede that sought. Thus, putting, as before, A, B, C, D, &c. for the terms of the series, and m, n, p, q, for given quantities, we shall have another recurring series, if we suppose them so related that

$$mA + nB + pC + qD = 0,$$
$$mB + nC + pD + qE = 0,$$
$$mC + nD + pE + qF = 0.$$

The two series of quantities sin. a, sin. $2a$, sin. $3a$, &c. and cos. a, cos. $2a$, cos. $3a$, &c. are both recurring, as is manifest from the law which connects the quantities one with another. (See Algebra, § 251.)

(3.) As in general it is the sum of the terms of a series which is the object of investigation, it is usual to connect them by the sign + or —, and to apply the name *series* to the expression thus formed. Accordingly,

$$1+3+5+7+9\cdots+\{1+2(n-1)\}$$

(where n denotes the number of terms) is called an arithmetical series; and in like manner

$$1+\tfrac{1}{2}+\tfrac{1}{4}+\tfrac{1}{8}\cdots+\frac{1}{2^{n-1}}$$

is a geometrical series.

(4.) A series may either consist of a definite number of terms, or their number may be supposed greater than any that can be assigned, and in this case the series is said to be *infinite.* The number of terms of a series may be infinite, and yet their sum finite. This is true, for example, of the series

$$\tfrac{1}{2}+\tfrac{1}{4}+\tfrac{1}{8}+\tfrac{1}{16}+, \text{ \&c.}$$

which is equivalent to unity, or 1.

(5.) We have already treated of several branches of the doctrine of series in the articles Algebra, Fluxions, and Logarithms; and, in particular, we have given four different methods for expanding a quantity into a series, viz.

1. By *Division* or *Evolution.*
2. By *the Method of Indeterminate Co-efficients.*
3. By *the Binomial Theorem.* (Algebra, sect. xvii.)
4. By *Taylor's Theorem.* (Fluxions, § 28.)

We shall here treat briefly of another branch of the theory, namely, how to find the sum of any proposed number of terms of certain series, or the sum of their terms continued *ad infinitum*, when that sum is finite.

(6.) There is a great analogy between the terms of a series and the ordinates of a curve which are supposed to stand upon the axis at equal distances from one another, the first ordinate reckoned from the extremity of the axis being analogous to the first term of the series, the second ordinate to the second term, and so on. From this analogy it follows immediately, that like as the nature of a curve is indicated by an equation expressing the value of an indefinite ordinate in terms of its corresponding abscissa, so also the nature of a series may be shown by an equation which shall express the relation between any term, and the number that denotes the place or order of that term in the series. In conformity to this method, putting the symbols $T_{(1)}$, $T_{(2)}$, $T_{(3)}$, &c., to denote the terms of any series whatever, we may express it generally thus,—

$$T_{(1)} + T_{(2)} + T_{(3)} \cdots + T_{(v)},$$

where the characters (1), (2), are meant to denote the place or order of the terms to which they are joined (the first term being supposed to have the place 1, the second term the place 2, and so on), and (v) is put for any indefinite number.

The nature of the arithmetical series

$$a + (a + d) + (a + 2d) + (a + 3d) +, \&c.$$

will be defined by the equation

$$T_{(v)} = a + (v - 1)d;$$

and, in like manner, the nature of the geometrical series

$$a + ar + ar^2 + ar^3 +, \&c.$$

will be expressed by the equation

$$T_{(v)} = ar^{v-1}.$$

(7.) As the expression for the value of the indefinite term $T_{(v)}$ becomes identical with all the terms of the series in succession, by substituting the numbers 1, 2, 3, &c. one after another, for v, that expression is called the *general term* of the series. In the series

$$a + b + \frac{ab}{2a - b} + \frac{ab}{3a - 2b} + \frac{ab}{4a - 3b} +, \&c.$$

the general term is evidently $\frac{ab}{(v-1)a - (v-2)b}$.

(8.) We shall investigate the sum of any number of terms of such series as have their general terms expressed by any one of the following algebraic functions.

$$v, \frac{v(v+1)}{1 \cdot 2}, \frac{v(v+1)(v+2)}{1 \cdot 2 \cdot 3}, \frac{v(v+1)(v+2)(v+3)}{1 \cdot 2 \cdot 3}, \&c.$$

Problem I. It is proposed to find the sum of n terms of the series of which the general term is the first function.

By putting 1, 2, 3, &c. to n successively for v, it appears that the series to be summed is

$$1 + 2 + 3 + 4 \cdots + n.$$

Now, as $v = \frac{v(v+1)}{2} - \frac{(v-1)v}{2}$, we have, by putting in this formula 1, 2, 3, $\cdots$ to n successively, for v,

$$1 = \frac{1 \cdot 2}{2} - 0,$$

$$2 = \frac{2 \cdot 3}{2} - \frac{1 \cdot 2}{2},$$

$$3 = \frac{3 \cdot 4}{2} - \frac{2 \cdot 3}{2},$$

$$4 = \frac{4 \cdot 5}{2} - \frac{3 \cdot 4}{2},$$

$$\cdots\cdot$$

$$n - 1 = \frac{(n-1)n}{2} - \frac{(n-2)(n-1)}{2},$$

$$n = \frac{n(n+1)}{2} - \frac{(n-1)n}{2}.$$

Let the sum of the quantities on each side of the sign = be now taken; then, observing that each of the fractions on the right-hand side, with the exception of $\frac{n(n+1)}{1 \cdot 2}$, occurs twice, once with the sign +, and again with the sign —, by which it happens that their aggregate is = 0, it is evident that we have

$$1 + 2 + 3 + 4 \cdots + n = \frac{n(n+1)}{1 \cdot 2}.$$

Prob. II. It is proposed to sum n terms of the series having for its general term the second function

$$\frac{v(v+1)}{1 \cdot 2}.$$

This series, by substituting 1, 2, 3, &c. successively for v, is found to be

$$\frac{1 \cdot 2}{1 \cdot 2} + \frac{2 \cdot 3}{1 \cdot 2} + \frac{3 \cdot 4}{1 \cdot 2} \cdots + \frac{n(n+1)}{1 \cdot 2}.$$

We now, following the mode of proceeding employed in last problem, put the expression $\frac{v(v+1)}{1 \cdot 2}$ under this form,

$$\frac{v(v+1)(v+2)}{1 \cdot 2 \cdot 3} - \frac{(v-1)v(v+1)}{1 \cdot 2 \cdot 3},$$

to which it is evidently equivalent, and, substituting 1, 2, 3, &c. successively for v, find

$$\frac{1 \cdot 2}{1 \cdot 2} = \frac{1 \cdot 2 \cdot 3}{1 \cdot 2 \cdot 3} - 0,$$

$$\frac{2 \cdot 3}{1 \cdot 2} = \frac{2 \cdot 3 \cdot 4}{1 \cdot 2 \cdot 3} - \frac{1 \cdot 2 \cdot 3}{1 \cdot 2 \cdot 3},$$

$$\frac{3 \cdot 4}{1 \cdot 2} = \frac{3 \cdot 4 \cdot 5}{1 \cdot 2 \cdot 3} - \frac{2 \cdot 3 \cdot 4}{1 \cdot 2 \cdot 3},$$

$$\frac{4 \cdot 5}{1 \cdot 2} = \frac{4 \cdot 5 \cdot 6}{1 \cdot 2 \cdot 3} - \frac{3 \cdot 4 \cdot 5}{1 \cdot 2 \cdot 3}$$

$$\cdots\cdots$$

$$\frac{n(n+1)}{1 \cdot 2} = \frac{n(n+1)(n+2)}{1 \cdot 2 \cdot 3} - \frac{(n-1)n(n+1)}{1 \cdot 2 \cdot 3}.$$

In this problem, as in the former, it appears that each quantity on the right side of the equations, except $\frac{n(n+1)(n+2)}{1 \cdot 2 \cdot 3}$, occurs twice, and with contrary signs; therefore, taking the aggregate of the terms on each side, we have

$$\frac{1 \cdot 2}{1 \cdot 2} + \frac{2 \cdot 3}{1 \cdot 2} + \frac{3 \cdot 4}{1 \cdot 2} + \frac{4 \cdot 5}{1 \cdot 2} \cdots + \frac{n(n+1)}{1 \cdot 2}$$
$$= \frac{n(n+1)(n+2)}{1 \cdot 2 \cdot 3}.$$

(9.) It will be obvious, by a little attention to the solutions of these two problems, that in each, the terms of the series to be summed are the differences betwixt the adjacent terms of another series, namely, that which has for its general term the function next in order to the general term of the series under consideration; that is, the terms of the series whose general term is v, are the differences betwixt those of the series having $\frac{v(v+1)}{1 \cdot 2}$ for its general term; and again, the terms of this last are the differences of the terms of the series having $\frac{v(v+1)(v+2)}{1 \cdot 2 \cdot 3}$ for its general term. Now, as the sum of the differences of any series of quantities whatever which begins with 0 must necessarily be the last term of that series,[1] it follows that the sum of all the terms of each of the series we have considered must be equal to the last term of the next following series; and this term is necessarily the expression formed by substituting n for v in its general term, that is, the sum of the series $1 + 2 + 3 \cdots + n$, which has v for its general term, is $\frac{n(n+1)}{1 \cdot 2}$; and the sum of the series

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[1] For example, let the quantities be $0, a, b, c, d$; then it is manifest that $(a - 0) + (b - a) + (c - b) + (d - c) = d$.

$$\frac{1\cdot 2}{1\cdot 2}+\frac{2\cdot 3}{1\cdot 2}+\frac{3\cdot 4}{1\cdot 2}\cdots + + \frac{n(n+1)}{1\cdot 2}$$

$$\text{is } \frac{n(n+1)(n+2)}{1\cdot 2\cdot 3}$$

The next series, which has $\frac{v(v+1)(v+2)}{1\cdot 2\cdot 3}$ for its general term, as well as all that succeed, will be found to have the very same property, as may be proved as follows. Let p denote any term of the series of natural numbers 1, 2, 3, &c. Then, because

$$1=\frac{v+p}{p+1}-\frac{v-1}{p+1},$$

if we multiply these equals by the product of all the factors $v, \frac{v+1}{2}\ \frac{v+2}{3}$, &c. to $\frac{v+p-1}{p}$, we get

$$\frac{v(v+1)(v+2)\cdots(v+p-1)}{1\cdot 2\cdot 3\cdots p}$$

$$=\begin{cases}\dfrac{v(v+1)(v+2)\cdots(v+p)}{1\cdot 2\cdot 3\cdots(p+1)}\\ -\dfrac{(v-1)v(v+1)\cdots(v+p-1)}{1\cdot 2\cdot 3\cdots(p+1)}.\end{cases}$$

Now, if in this identical equation we substitute the numbers 1, 2, 3, &c. to n successively, for v, the results obtained from its first member

$$\frac{v(v+1)(v+2)\cdots(v+p-1)}{1\cdot 2\cdot 3\cdots p},$$

will be a series having this function for its general term, and the terms of which will evidently be the difference between the terms of another series having the first part of the second member of the equation, viz.

$$\frac{v(v+1)(v+2)\cdots(v+p)}{1\cdot 2\cdot 3\cdots(p+1)},$$

for its general term: Hence it will happen, as in the two foregoing problems, that the sum of all the terms of the former series will be equal to the last term of the latter; which conclusion may be expressed in the form of a theorem, as follows:

THEOREM. *The sum of* n *terms of a series having for its general term the function*

$$\frac{v(v+1)(v+2)\cdots(v+p-1)}{1\cdot 2\cdot 3\cdots p},$$

is equal to

$$\frac{n(n+1)(n+2)\cdots(n+p)}{1\cdot 2\cdot 3\cdots(p+1)}.$$

Or, setting aside the denominators of the terms, we may express the theorem thus: *The sum of* n *terms of a series, having for its general term the expression*

$$v(v+1)(v+2)\cdots(v+p-1),$$

is equal to

$$\frac{n(n+1)(n+2)\cdots(n+p)}{p+1}.$$

We shall give a few particular cases of this formula.

I. $1+2+3+4\cdots+n=\frac{n(n+1)}{2}.$

II. $1\cdot 2+2\cdot 3+3\cdot 4+4\cdot 5\cdots+n(n+1)$

$$=\frac{n(n+1)(n+2)}{3}.$$

III. $1\cdot 2\cdot 3+2\cdot 3\cdot 4+3\cdot 4\cdot 5\cdots+n(n+1)(n+2)$

$$=\frac{n(n+1)(n+2)(n+3)}{4}.$$

(10.) By means of the above general theorem, we may find the sum of any number of terms of a series composed of the powers of the terms of an arithmetical progression, the general term of which will, in the simplest case, be v^p, p being a given number. The manner of doing this will appear from the following problems.

PROB. III. It is proposed to find the sum of n terms of the series of squares $1+4+9+16+25+$, &c. or $1^2+2^2+3^2+4^2+5^2+$, &c.

The general term of this series being v^2, we put it under this form, $v(v+1)-v$; hence we get, by substituting 1, 2, 3, &c. for v,

$$1^2=1\cdot 2-1,$$
$$2^2=2\cdot 3-2,$$
$$3^2=3\cdot 4-3,$$
$$4^2=4\cdot 5-4,$$
$$\cdots$$
$$n^2=n(n+1)-n.$$

Therefore, adding, we find

$$1^2+2^2+3^2+4^2\cdots+n^2$$
$$=\begin{cases}1\cdot 2+2\cdot 3+3\cdot 4+4\cdot 5\cdots+n(n+1)\\ -(1+2+3+4\cdots+n).\end{cases}$$

But by the general theorem (9.)

$$1\cdot 2+2\cdot 3+3\cdot 4\cdots+n(n+1)=\frac{n(n+1)(n+2)}{3},$$

$$\text{and } 1+2+3+4\cdots+n=\frac{n(n+1)}{2};$$

$$\text{therefore } 1^2+2^2+3^2+4^2\cdots+n^2$$
$$=\frac{n(n+1)(n+2)}{3}-\frac{n(n+1)}{2}$$
$$=\frac{n(n+1)(2n+1)}{6}.$$

We might have arrived at the same conclusion by considering, that since v^2, the general term of the series, is equivalent to $v(v+1)-v$, the series must be the difference between two others, one having $v(v+1)$ and the other v for its general term; for the sake of perspicuity, however, we have put down the terms of all the three series.

PROB. IV. It is proposed to find the sum of n terms of the series

$$1^3+2^3+3^3+4^3+5^3+, \&c.$$

The general term in this case is v^3; now, to transform this function, so as to deduce the sum of the series from the general theorem, we assume

$$v^3=v(v+1)(v+2)+Av(v+1)+Bv,$$

where A and B denote quantities which are to have such values as shall render the two sides of the equation identical, whatever be the value of v. Taking now the product of the factors, we have

$$v^3=v^3+(A+3)v^2+(A+B+2)v;$$

therefore, by the theory of indeterminate co-efficients (ALGEBRA, § 159),

$$A+3=0,\ A+B+2=0:$$

hence we find $A=-3$, $B=-A-2=1$; thus it appears that, v being any number whatever,

$$v^3=v(v+1)(v+2)-3v(v+1)+v.$$

Now, let S denote the sum of n terms of the series under consideration, which has v^3 for its general term, and put P, Q, R for the like sums of the three series whose general terms are the functions $v(v+1)(v+2)$, $v(v+1)$, and v respectively; then it is evident that $S=P-3Q+R$. But by the theorem (9.)

$$P=\frac{n(n+1)(n+2)(n+3)}{4},$$

$$Q=\frac{n(n+1)(n+2)}{3},$$

$$R=\frac{n(n+1)}{2};$$

$$\text{therefore } S = \frac{n(n+1)(n+2)(n+3)}{4}$$
$$-n(n+1)(n+2) + \frac{n(n+1)}{2},$$

and, by proper reduction,

$$S = 1^3 + 2^3 + 3^3 + 4^3 \cdots + n^3 = \frac{n^2(n+1)^2}{4},$$

Corollary. We have found (Prob. I.) that

$$1 + 2 + 3 + 4 \cdots + n = \frac{n(n+1)}{2};$$

therefore, comparing this with the result just now obtained, it is evident that

$$(1 + 2 + 3 + 4 \cdots + n)^2 = 1^3 + 2^3 + 3^3 + 4^3 \cdots + n^3.$$

This is a very curious and elegant property of numbers.

(11.) It is manifest that, by the mode of proceeding employed in last problem, we may investigate the sum of n terms of the series

$$1^m + 2^m + 3^m + 4^m +, \&c.$$

m being any whole positive number whatever; and indeed in the very same way we may find the sum of any number of terms of a series whose general term is

$$a + bv + cv^2 + dv^3 +, \&c.$$

where a and b, &c. denote given numbers; namely, by transforming it into a function of the form

$$A + Bv + Cv(v+1) + Dv(v+1)(v+2) +, \&c.$$

where A, B, and C, &c. denote constant quantities. Our limits, however, will not allow us to go into particulars.

(12.) The next class of series we shall consider, comprehends such as may be formed by the successive substitution of a, $a+1$, $a+2$, &c. (a being put for any given quantity whatever) in the series of functions

$$\frac{1}{v(v+1)}, \frac{1}{v(v+1)(v+2)}, \frac{1}{v(v+1)(v+2)(v+3)}, \&c.$$

We shall begin with the first of these.

Prob. V. It is proposed to find the sum of n terms of the series

$$\frac{1}{a(a+1)} + \frac{1}{(a+1)(a+2)} + \frac{1}{(a+2)(a+3)} +, \&c.$$

which is formed by substituting a, $a+1$, $a+2$, &c. successively for v in the general term $\frac{1}{v(v+1)}$.

Whatever be the value of v, we have

$$\frac{1}{v(v+1)} = \frac{1}{v} - \frac{1}{v+1};$$

therefore, proceding as in the foregoing problems, we get

$$\frac{1}{a(a+1)} = \frac{1}{a} - \frac{1}{a+1},$$
$$\frac{1}{(a+1)(a+2)} = \frac{1}{a+1} - \frac{1}{a+2},$$
$$\frac{1}{(a+2)(a+3)} = \frac{1}{a+2} - \frac{1}{a+3},$$
$$\cdots\cdots$$
$$\frac{1}{(a+n-2)(a+n-1)} = \frac{1}{a+n-2} - \frac{1}{a+n-1},$$
$$\frac{1}{(a+n-1)(a+n)} = \frac{1}{a+n-1} - \frac{1}{a+n}.$$

Here it is evident that the terms of the series to be summed are the differences betwixt every two adjoining terms of this other series,

$$\frac{1}{a} + \frac{1}{a+1} + \frac{1}{a+2} + \frac{1}{a+3} \cdots + \frac{1}{a+n};$$

hence it immediately follows, that the sum of all the terms of the former is the difference between the two extreme terms of the latter; that is,

$$\frac{1}{a(a+1)} + \frac{1}{(a+1)(a+2)} \cdots + \frac{1}{(a+n-1)(a+n)}$$
$$= \frac{1}{a} - \frac{1}{a+n}.$$

If we suppose the series to be continued *ad infinitum*, then, as n will be indefinitely great, and $\frac{1}{a+n}$ indefinitely small, the sum will be simply $\frac{1}{a}$; or, in other words, the fraction $\frac{1}{a}$ is a limit to the sum of the series.

Prob. VI. Let it be required to find the sum of n terms of this series,

$$\frac{1}{a(a+1)(a+2)} + \frac{1}{(a+1)(a+2)(a+3)}$$
$$+ \frac{1}{(a+2)(a+3)(a+4)} +, \&c.;$$

the general term in this case being $\frac{1}{v(v+1)(v+2)}$.

Because $\frac{2}{v(v+2)} = \frac{1}{v} - \frac{1}{v+2}$, therefore, multiplying by $\frac{1}{2(v+1)}$, we have

$$\frac{1}{v(v+1)(v+2)} = \tfrac{1}{2}\left\{\frac{1}{v(v+1)} - \frac{1}{(v+1)(v+2)}\right\};$$

and hence, by substituting a, $a+1$, $a+2$, &c. successively for v,

$$\frac{1}{a(a+1)(a+2)} = \tfrac{1}{2}\left\{\frac{1}{a(a+1)} - \frac{1}{(a+1)(a+2)}\right\},$$
$$\frac{1}{(a+1)(a+2)(a+3)} = \tfrac{1}{2}\left\{\frac{1}{(a+1)(a+2)}\right.$$
$$\left.-\frac{1}{(a+2)(a+3)}\right\},$$
$$\frac{1}{(a+2)(a+3)(a+4)} = \tfrac{1}{2}\left\{\frac{1}{(a+2)(a+3)}\right.$$
$$\left.-\frac{1}{(a+3)(a+4)}\right\},$$
$$\cdots\cdots$$
$$\frac{1}{(a+n-1)(a+n)(a+n+1)}$$
$$= \tfrac{1}{2}\left\{\frac{1}{(a+n-1)(a+n)} - \frac{1}{(a+n)(a+n+1)}\right\}.$$

Hence it appears that the terms of the series to be summed are the halves of the differences of the terms of the series

$$\frac{1}{a(a+1)} + \frac{1}{(a+1)(a+2)} + \frac{1}{(a+2)(a+3)} \cdots$$
$$+ \frac{1}{(a+n)(a+n+1)};$$

consequently, the sum of all the terms of the former is half the difference between the extreme terms of the latter, or is =

$$\tfrac{1}{2}\left\{\frac{1}{a(a+1)} - \frac{1}{(a+n)(a+n+1)}\right\}.$$

(13.) From these two particular cases it is easy to see how we may sum the series when the general term is

$$\frac{1}{v(v+1)(v+2)\ldots(v+p)},$$

p being any whole number whatever: for since

$$\frac{p}{v(v+p)}=\frac{1}{v}-\frac{1}{v+p},$$

therefore, multiplying the denominators by all the factors which are intermediate between v and $v+p$, we have

$$\frac{p}{v\,(v+1)\,(v+2)\ldots(v+p)}$$

$$=\frac{1}{v\,(v+1)\,(v+2)\ldots(v+p-1)}$$

$$-\frac{1}{(v+1)\,(v+2)\,(v+3)\ldots(v+p)}.$$

Now the latter side of this equation is a general expression for the difference between any two adjacent terms of a series whose general term is

$$\frac{1}{v\,(v+1)\,(v+2)\ldots(v+p-1)},$$

therefore the difference between the first and last terms of this series must be the sum of the series whose general term is the function on the other side of the equation, viz.

$$\frac{p}{v\,(v+1)\,(v+2)\ldots(v+p)},$$

Hence we have the following very general theorem.

THEOREM. *Let* a *denote any number whatever, and let* 1, 2, 3 . . . p *be a series of numbers, each of which exceeds that before it by unity; the sum of* n *terms of a series formed by substituting the numbers* a, a + 1, a + 2, &c. *to* a + n — 1 *successively for* v *in the function*

$$\frac{1}{v\,(v+1)\,(v+2)\ldots(v+p)}$$

is equal to

$$\frac{1}{p}\left\{\begin{array}{l}\dfrac{1}{a\,(a+1)\,(a+2)\ldots(a+p-1)}\\[2ex] -\dfrac{1}{(a+n)(a+n+1)(a+n+2)\ldots+(a+n+p-1)}.\end{array}\right.$$

COROLLARY. *The same series continued* ad infinitum *is equal to*

$$\frac{1}{p}\cdot\frac{1}{a\,(a+1)\,(a+2)\ldots(a+p-1)}.$$

(14.) We shall now give examples of the application of this theorem.

Example 1. Required the sum of n terms of the series

$$\frac{1}{2\cdot3\cdot4\cdot5}+\frac{1}{3\cdot4\cdot5\cdot6}+\frac{1}{4\cdot5\cdot6\cdot7}+,\ \&c.$$

The terms of this series are evidently produced by the successive substitution of the numbers 2 3, 4, 5, &c. for v in the function

$$\frac{1}{v\,(v+1)\,(v+2)\,(v+3)};$$

therefore, comparing this expression with the general formula, we have $a=2$, $p=3$, and the sum required

$$=\tfrac{1}{3}\left\{\frac{1}{2\cdot3\cdot4}-\frac{1}{(2+n)\,(3+n)\,(4+n)}\right\}.$$

Ex. 2. Required the sum of the series

$$\frac{1}{1\cdot4\cdot7}+\frac{1}{4\cdot7\cdot10}+\frac{1}{7\cdot10\cdot13}+\frac{1}{10\cdot13\cdot16}+,\ \&c.$$

continued *ad infinitum.*

By a little attention it will appear that its terms are produced by the substitution of the numbers $\frac{1}{3}$, $1\frac{1}{3}$, $2\frac{1}{3}$, &c. successively for v in the function

$$\frac{1}{3v\,(3v+3)\,(3v+6)}=\frac{1}{27v\,(v+1)\,(v+2)}.$$

In this case, $a=\frac{1}{3}$, $p=2$, therefore the sum is

$$\frac{1}{2}\times\frac{1}{27}\times\frac{1}{\frac{1}{3}\times1\frac{1}{3}}=\frac{1}{24}.$$

(15.) When the function from which the series is derived has not the very form required in the theorem, it may be brought to that form by employing suitable transformations, as in the two following examples.

Ex. 3. It is proposed to find the sum of the series

$$\frac{1}{1\cdot4}+\frac{1}{2\cdot5}+\frac{1}{3\cdot6}+\frac{1}{4\cdot7}+,\ \&c.$$

continued *ad infinitum.*

This series is evidently formed by the substitution of the numbers 1, 2, 3, &c. successively for v in the function $\frac{1}{v\,(v+3)}$. This expression, however, does not in its present form agree with the general formula, because the factors $v+1$, $v+2$ are wanting; therefore, to transform it, we multiply its numerator and denominator by $(v+1)$ $(v+2)$, and it becomes

$$\frac{(v+1)\,(v+2)}{v\,(v+1)\,(v+2)\,(v+3)}.$$

We next assume its numerator

$$(v+1)(v+2)=\mathrm{A}\,(v+2)(v+3)+\mathrm{B}\,(v+3)+\mathrm{C},$$

and by multiplying get

$$v^2+3v+2=\mathrm{A}v^2+(5\mathrm{A}+\mathrm{B})\,v+(6\mathrm{A}+3\mathrm{B}+\mathrm{C});$$

therefore, that v may be indeterminate, we must make

$$\mathrm{A}=1,\ 5\mathrm{A}+\mathrm{B}=3,\ 6\mathrm{A}+3\mathrm{B}+\mathrm{C}=2,$$

from which equations we get $\mathrm{A}=1$, $\mathrm{B}=3-5\mathrm{A}=-2$, $\mathrm{C}=2-6\,\mathrm{A}-3\,\mathrm{B}=2$, so that

$$\frac{1}{v\,(v+3)}=\frac{(v+2)\,(v+3)-2\,(v+3)+2}{v\,(v+1)\,(v+2)v+3)}$$

$$=\frac{1}{v\,(v+1)}-\frac{2}{v\,(v+1)\,(v+2)}$$

$$+\frac{2}{v\,(v+1)\,(v+2)\,(v+3)}.$$

Thus it appears that the proposed series is resolvable into three others, the general terms of which all agree with the theorem. Now the sum of the infinite series whose general term is $\frac{1}{v\,(v+1)}$ appears by the theorem to be $\frac{1}{a}$, or 1, because $a=1$, and the sum of the infinite series whose general term is $\frac{-2}{v\,(v+1)\,(v+2)}$ is in like manner found to be $\frac{-2}{2}+\frac{1}{1\cdot2}=\frac{-1}{2}$; and, lastly, the infinite series whose general term is $\frac{2}{v\,(v+1)\,(v+2)\,(v+3)}$ is $\frac{2}{3}\,\frac{1}{1\cdot2\cdot3}=\frac{1}{9}$; therefore, collecting these into one, the sum of the proposed series is $1-\frac{1}{2}+\frac{1}{9}=\frac{11}{18}$, the answer.

Ex. 4. Required the sum of the infinite series

$$\frac{1}{2\cdot3\cdot4}+\frac{2}{3\cdot4\cdot5}+\frac{3}{4\cdot5\cdot6}+\frac{4}{5\cdot6\cdot7}+,\ \&c.$$

The terms of this series are evidently formed by the substitution of the numbers 2, 3, 4, successively in the function

$$\frac{v-1}{v\,(v+1)\,(v+2)}.$$

Now $v-1=v+2-3$; therefore

$$\frac{v-1}{v\,(v+1)\,(v+2)}=\frac{1}{v\,(v+1)}-\frac{3}{v\,(v+1)\,(v+2)}.$$

Thus it appears that the proposed series is reducible to two others, one having its terms produced by the substitution of 2, 3, &c. for v in the function $\frac{1}{v(v+1)}$, and the other by a like substitution in the function $\frac{-3}{v(v+1)(v+2)}$. Now, by our theorem, the sum of the first of these is $\frac{1}{2}$, and that of the second is $\frac{-3}{2}\cdot\frac{1}{2\cdot 3}=-\frac{1}{4}$, therefore the sum of the proposed series is $\frac{1}{2}-\frac{1}{4}=\frac{1}{4}$.

From these examples it is sufficiently evident how the theorem is to be applied in other cases; and it appears also, that by means of it we can sum any series whatever whose general term is of the form

$$\frac{\text{A}}{v(1+v)}+\frac{\text{B}}{v(1+v)(v+1)}+\frac{\text{C}}{v(v+1)(v+2)(v+3)}+, \&\text{c.}$$

or admits of being reduced to that form.

(16.) It deserves to be remarked, that the series

$$\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+, \&\text{c.}$$

which is of a very simple form, and in appearance of the same nature as those we have summed, does not, however, admit of being treated in the same manner; and indeed if it be continued *ad infinitum*, its sum is infinite, that is, it exceeds any number which can be assigned. The truth of this assertion will be evident if we can show that a certain definite number of its terms, beginning with any proposed term, can always be found, the sum of which shall exceed an unit, or 1; for this being the case, as we can go on continually in assigning such sets of terms, we can conceive as many to be taken as there are units in any proposed number, however great; and therefore their sum, and much more the sum of all the terms of the series, from its beginning to the end of the last sets of terms, will exceed that number. Now, that this can always be done may be proved as follows:

Let the term of the series from which we are to reckon be $\frac{1}{a}$, then, if the thing be possible, and if n be the requisite number of terms, we must have

$$\frac{1}{a}+\frac{1}{a+1}+\frac{1}{a+2}+\frac{1}{a+3}\cdots+\frac{1}{a+n-1}>1.$$

Now, because

$$a\left(1+\frac{1}{a}\right)^2=a+2+\frac{1}{a},$$

$$a\left(1+\frac{1}{a}\right)^3=a+3+\frac{3}{a}+\frac{1}{a^2},$$

and in general,

$$a\left(1+\frac{1}{a}\right)^p=a+p+\frac{p\cdot p-1}{1\cdot 2}\frac{1}{a}+, \&\text{c.}$$

therefore, p being any whole number,

$$a\left(1+\frac{1}{a}\right)^p>a+p, \text{ and consequently}$$

$$\frac{1}{a+p}>\frac{1}{a\left(1+\frac{1}{a}\right)^p};$$

hence it follows, that the series

$$\frac{1}{a}+\frac{1}{a+1}+\frac{1}{a+2}\cdots+\frac{1}{a+n-1}$$

will be greater than the other series

$$\frac{1}{a}+\frac{1}{a\left(1+\frac{1}{a}\right)}+\frac{1}{a\left(1+\frac{1}{a}\right)^2}+\frac{1}{a\left(1+\frac{1}{a}\right)^3}\cdots$$

$$+\frac{1}{a\left(1+\frac{1}{a}\right)^{n-1}}.$$

Now, this last being evidently a geometrical series, of which the common ratio is $\frac{1}{1+\frac{1}{a}}$, its sum is

$$1+\frac{1}{a}-\frac{1}{\left(1+\frac{1}{a}\right)^{n-1}};$$

therefore the sum of the series

$$\frac{1}{a}+\frac{1}{a+1}+\frac{1}{a+2}+\frac{1}{a+3}\cdots+\frac{1}{a+n-1}$$

will always be greater than this expression; but if we suppose n so great that the quantity $\left(1+\frac{1}{a}\right)^{n-1}$ is equal to or exceeds a, which is evidently always possible, then the above expression for the sum of the geometrical series will be equal to 1, or will exceed 1; therefore the same number of terms of the series $\frac{1}{a}+\frac{1}{a+1}+\frac{1}{a+2}+\frac{1}{a+3}+$, &c. will always exceed 1; now this is the property of the series we proposed to demonstrate.

When $a=\left(1+\frac{1}{a}\right)^{n-1}$, then $a^2=a\left(1+\frac{1}{a}\right)^{n-1}$; but this quantity is greater than $a+n-1$, the denominator of the last term of the series

$$\frac{1}{a}+\frac{1}{a+1}+\frac{1}{a+2}+\frac{1}{a+3}\cdots+\frac{1}{a+n-1},$$

the sum of which, we have proved, will upon that hypothesis exceed unity; much more then will the sum exceed unity if we suppose the series continued until the denominator of its last term be equal to or greater than a^2. Hence, beginning with the term $\frac{1}{2}$, it appears that

$$\tfrac{1}{2}+\tfrac{1}{3}+\frac{1}{4=2^2}>1,$$

$$\tfrac{1}{5}+\tfrac{1}{6}\cdots+\frac{1}{25=5^2}>1,$$

$$\tfrac{1}{26}+\tfrac{1}{27}\cdots+\frac{1}{676=26^2}>1,$$

$$\tfrac{1}{677}+\tfrac{1}{678}\cdots+\frac{1}{458329=677^2}>1,$$

&c.

Although the sum of the series we have been considering is infinite, yet it evidently increases very slowly; indeed it is a limit to all such as have a finite sum; for every infinite series the terms of which decrease faster than the reciprocals of an arithmetical progression is always finite.

(17.) We have already explained what is meant by a *recurring series* (2.). We shall now treat briefly, first, of their origin; next, of the way in which they may be summed; and, lastly, of the manner of determining the *general term* of any particular series.

The series which is produced by the development of a rational algebraic fraction has always the property which constitutes the characteristic of the class called *recurring* (2.); and, on the other hand, any series having that property being proposed, an algebraic fraction may be found, by the expansion of which the series shall be produced.

The fraction $\frac{1+2x}{1-x-x^2}$, for example, by dividing the numerator by the denominator, is converted into the infinite series

$$1+3x+4x^2+7x^3+11x^4+18x^5+, \&\text{c.}$$

which is of such a nature that if T, T′, T″, denote any three of its succeeding terms, their relation to one another is expressed by the equation

$$T'' = T x^2 + T' x.$$

If we employ algebraic division to convert the fraction into a series, the law of its terms will not appear so readily as if we were to use the method of indeterminate co-efficients. By this method we assume the fraction equal to

$$A + B x + C x^2 + D x^3 + E x^4 +, \&c.;$$

and hence, multiplying by the denominator, and bringing all the terms to one side, as explained in ALGEBRA, § 159, we have

$$\left.\begin{matrix} A + B \\ -1 - A \\ -2 \end{matrix}\right\} x \left.\begin{matrix} + C \\ - B \\ - A \end{matrix}\right\} x^2 \left.\begin{matrix} + D \\ - C \\ - B \end{matrix}\right\} x^3 +, \&c. = 0;$$

and hence

$$\begin{array}{ll} A - 1 = 0, & C - B - A = 0, \\ B - A - 2 = 0, & D - C - B = 0, \\ & \&c. \end{array}$$

From these equations it appears that the law of the series is such as we have assigned.

The equation expressing the relation which subsists among a certain number of succeeding terms of a recurring series is called its *scale of relation.* The same name is also sometimes given to the equation expressing the connection of the co-efficients of the terms. Thus the scale of relation of the foregoing series is either

$$T'' = T x + T' x^2,$$

where T, T′, and T″ denote any three succeeding terms of the series; or it is

$$R = P + Q,$$

where P, Q, and R denote their numeral co-efficients.

(18.) We come next to show how the sum of any proposed number of terms of a recurring series may be found. Let the series continued to n terms be

$$T_{(1)} + T_{(2)} + T_{(3)} \ldots + T_{(n-2)} + T_{(n-1)} + T_{(n)},$$

where the characters $T_{(1)}$, $T_{(2)}$, &c. denote the successive terms, and the numbers (1), (2), &c. their order or place; and as, whatever number of terms is contained in the scale, the manner of summing the series is the same, we shall in what follows, for the sake of brevity, suppose that it consists of three, in which case it may be expressed thus,

$$pT_{(n-2)} + qT_{(n-1)} + rT_{(n)} = 0,$$

where p, q, r denote certain given quantities.

The scale of relation affords the following series of equations,

$$\begin{array}{l} pT_{(1)} + q\,T_{(2)} + rT_{(3)} = 0, \\ pT_{(2)} + qT_{(3)} + rT_{(4)} = 0, \\ pT_{(3)} + qT_{(4)} + rT_{(5)} = 0, \\ \ldots\ldots\ldots\ldots\ldots \\ pT_{(n-2)} + qT_{(n-1)} + rT_{(n)} = 0. \end{array}$$

Taking now the sum of these equations, we get

$$\left.\begin{array}{l} p\,\{T_{(1)} + T_{(2)} + T_{(3)} \cdots + T_{(n-2)}\} \\ +q\,\{T_{(2)} + T_{(3)} + T_{(4)} \cdots + T_{(n-1)}\} \\ +r\,\{T_{(3)} + T_{(4)} + T_{(5)} \cdots + T_{(n)}\} \end{array}\right\} = 0.$$

But, putting s for the sum of n terms of the series, this equation may manifestly be expressed thus,

$$\left.\begin{array}{l} p\,\{s - T_{(n)} - T_{(n-1)}\} \\ +\,q\,\{s - T_{(1)} - T_{(n)}\} \\ +\,r\,\{s - T_{(1)} - T_{(2)}\} \end{array}\right\} = 0.$$

Hence, after reduction, we find $s =$

$$\frac{p\{T_{(n-1)} + T_{(n)}\} + q\{T_{(1)} + T_{(n)}\} + r\{T_{(1)} + T_{(2)}\}}{p + q + r};$$

from which it appears that in this case the sum depends only on the first two and the last two terms of the series.

EXAMPLE. It is proposed to find from this formula the sum of n terms of the series

$$1 + 2x + 3x^2 + 4x^3 + 5x^4 +, \&c.$$

its scale of relation being

$$x^2\,T_{(n-2)} - 2x\,T_{(n-1)} + T_{(n)} = 0.$$

Here $p = x^2$, $q = -2x$, $r = 1$, therefore, observing that the last two terms of the series must be $(n - 1)\,x^{n-2}$ and nx^{n-1}, we have, after substituting and reducing,

$$s = \frac{1 - (n + 1)\,x^n + x^{n+1}}{1 - 2x + x^2}$$

This formula will not apply in the case of $x = 1$, because then the numerator and denominator are each $= 0$: but in such cases as this we may find the value of the function which expresses the sum by what is delivered at § 55, FLUXIONS.

(19.) The process by which we have determined the value of n terms of the series $T_{(1)} + T_{(2)} + T_{(3)} +$, &c. will also apply to the finding the rational fraction from which the series may be deduced, which is also the sum of the series continued *ad infinitum.* For in this case the equation from which we have deduced the sum being

$$\left.\begin{array}{l} p\,\{T_{(1)} + T_{(2)} + T_{(3)} +, \&c.\} \\ +q\,\{T_{(2)} + T_{(3)} + T_{(4)} +, \&c.\} \\ +r\,\{T_{(3)} + T_{(4)} + T_{(5)} +, \&c.\} \end{array}\right\} = 0,$$

that is,

$$ps + q\,\{s - T_{(1)}\} + r\,\{s - T_{(1)} - T_{(2)}\} = 0,$$

we have $$s = \frac{\{q + r\}\,T_{(1)} + r\,T_{(2)}}{p + q + r}.$$

For example, let it be required to find the fraction which, being developed, produces the series

$$1 + 2x + 3x^2 + 4x^3 +, \&c.$$

the scale of relation of which is

$$x^2\,T_{(n-2)} - 2x\,T_{(n-1)} + T_{(n)} + 0.$$

Here $p = x^2$, $q = -2x$, $r = 1$, $T_{(1)} = 1$, $T_{(2)} = 2x$; therefore, substituting in the formula, we get

$$\frac{1}{1 - 2x + x^2} = \frac{1}{(1 - x)^2}$$

for the fraction required, or for the sum of the series continued *ad infinitum.*

(20.) We come now to the last branch of the theory of recurring series which we proposed to consider, namely, how to find in any case the *general term.*

We shall begin with the most simple, and suppose the fraction to be $\frac{a}{1 - px}$, which being expounded into a series by division, is

$$a + apx + ap^2\,x^2 + ap^3\,x^3 +, \&c.$$

Here it is immediately manifest that the general term is $ap^{n-1}\,x^{n-1}$.

Next let us suppose the fraction to be $\frac{a + bx}{1 - \alpha x - \beta x^2}$. Let the two roots of the quadratic equation $1 - \alpha x - \beta x^2 = 0$ be $x = \frac{1}{p}$, $x = \frac{1}{q}$, so that $1 - px = 0$, and $1 - qx = 0$; therefore $1 - \alpha x - \beta x^2 = (1 - px)\,(1 - qx)$; thus we have

$$\frac{a + bx}{1 - \alpha x - \beta x^2} = \frac{a + bx}{(1 - px)\,(1 - qx)}.$$

Let us assume this expression equal to

$$\frac{P}{1 - px} + \frac{Q}{1 - qx},$$

where P and Q denote quantities which are to be independent of x; then, reducing to a common denominator, we have

$$\frac{a + bx}{(1 - px)\,(1 - qx)} = \frac{P + Q - (qP + pQ)\,x}{(1 - px)\,(1 - qx)}.$$

Hence, that x may remain indeterminate, we must make

$$P + Q = a,\ qP + pQ = -b,$$

and from these equations we get

$$P = \frac{ap + b}{p - q},\ Q = -\frac{aq + b}{p - q}.$$

Now, by the operation of division, we find

$$\frac{P}{1 - px} = P + Ppx + Pp^2x^2 +, \&c.$$

$$\frac{Q}{1 - qx} = Q + Qqx + Qq^2x^2 +, \&c.;$$

therefore, since $\frac{a + bx}{1 - \alpha x - \beta x^2} = \frac{P}{1 - px} + \frac{Q}{1 - qx}$, it follows that the development of the fraction $\frac{a + bx}{1 - \alpha x - \beta x^2}$, which proceeds according to the powers of x, is

$$(P + Q) + (Pp + Qq)\,x + (Pp^2 + Qq^2)\,x^2 + (Pp^3 + Qq^3)\,x^3 +, \&c.$$

And here it is evident that the general term is $(Pp^{n-1} + Qq^{n-1})\,x^{n-1}$.

Let us take as a particular example the fraction $\frac{1 - x}{1 - x - 2x^2}$, which when expanded into a series, becomes

$$1 + 0x + 2x^2 + 2x^3 + 6x^4 + 10x^5 + 22x^6 + 42x^7 + 86x^8 +, \&c.$$

Here, from the equation $1 - x - 2x^2 = 0$, we get $x = \frac{1}{2}$ and $x = -1$, so that $1 - 2x$ and $1 + x$ are divisors of the function $1 - x - 2x^2$, that is, $1 - x - 2x^2 = (1 + x)(1 - 2x)$; hence $p = -1$, $q = 2$; and since $a = 1$, $b = -1$, therefore $P = \frac{2}{3}$, $Q = \frac{1}{3}$, and the general term $(Pp^{n-1} + Qq^{n-1})\,x^{n-1}$ becomes, by substituting,

$$\left\{\frac{2}{3}(-1)^{n-1} + \frac{1}{3}\,2^{n-1}\right\} x^{n-1} = \frac{2^{n-1} \pm 2}{3}\,x^{n-1},$$

where the sign $+$ is to be taken when n is an odd number; but the sign $-$ when n is even.

Sometimes the values of p and q will come out imaginary quantities; these, however, will be found always to destroy one another when substituted in the general term.

Let us next suppose the fraction which produces a recurring series to be

$$\frac{a + bx + cx^2}{1 - \alpha x - \beta x^2 - \gamma x^3}.$$

Let $x = \frac{1}{p}$, $x = \frac{1}{q}$, $x = \frac{1}{r}$ be the three roots of the cubic equation $1 - \alpha x - \beta x^2 - \gamma x^3 = 0$, then the denominator of the fraction will be the product of the three factors

$$1 - px,\ 1 - qx,\ 1 - rx.$$

We must now assume the fraction equal to the expression

$$\frac{P}{1 - px} + \frac{Q}{1 - qx} + \frac{R}{1 - rx};$$

in which P, Q, R denote quantities which are independent of x.

The three terms of this expression are next to be reduced to a common denominator and collected into one, and the co-efficients of the powers of x in the numerator of the result are to be put equal to the like powers of x in the proposed fraction; we shall then have

$$P + Q + R = a,$$

$$(q + r)\,P + (p + r)\,Q + (p + q)\,R = -b,$$

$$qrP + prQ + pqR = c,$$

and by these equations the values of P, Q, R may be found.

Let $\frac{P}{1 - px}$, $\frac{Q}{1 - qx}$, $\frac{R}{1 - rx}$ be now resolved into series by division: then, adding the like powers of x in each, we have

$$(P + Q + R) + (Pp + Qq + Rr)\,x + (Pp^2 + Qq^2 + Rr^2)\,x^2 +, \&c.$$

for the series which is the development of the fraction

$$\frac{a + bx + cx^2}{1 - \alpha x - \beta x^2 - \gamma x^3}$$

and here the general term is evidently

$$(Pp^{n-1} + Qq^{n-1} + Rr^{n-1})\,x^{n-1};$$

and in the very same manner may the general term be found in every case in which the denominator of the fraction admits of being resolved into unequal factors.

(21.) Let us now suppose the fraction to have the form $\frac{a + bx}{(1 - px)^2}$, the denominator being the product of two equal factors; this fraction cannot be decomposed into other fractions the denominators of which are the simple factors of its denominator. We may, however, transform it into two, which shall have their numerators constant quantities by proceeding as follows: Assume the numerator $a + bx = P + Q\,(1 - px)$, then, that x may remain indeterminate, we must have $P + Q = a$, $-pQ = b$, therefore

$$Q = -\frac{b}{p},\ P = a + \frac{b}{p}.$$

The assumption of $a + bx = P + Q\,(1 - px)$ gives us therefore

$$\frac{a + bx}{(1 - px)^2} = \frac{P}{(1 - px)^2} + \frac{Q}{1 - px}.$$

Now, putting the first term of the latter side of this equation under the form $P\,(1 - px)^{-2}$, it is resolved by the binomial theorem into the series

$$P\,(1 + 2px + 3p^2x^2 + 4p^3x^3 +, \&c.);$$

the other fraction, $\frac{Q}{1 - px}$, being expanded into a series, is

$$Q + Qpx + Qp^2x^2 +, \&c.$$

Therefore the complete development of $\frac{a + bx}{(1 - px)^2}$ is

$$P + Q + (2P + Q)\,px + (3P + Q)\,p^2x^2 +, \&c.$$

and here the general term is manifestly $(nP + Q)\,p^{n-1}\,x^{n-1}$, or, substituting for P and Q their values,

$$\{npa + (n - 1)\,b\}\,p^{n-2}\,x^{n-1}.$$

(22.) In general, whatever be the form of the fraction from which a recurring series is derived, to determine the general term we must decompose the fraction into others which may be as simple as possible; and provided it be rational, and the highest power of x in the numerator at least one degree less than the highest power in the denominator, it may be always decomposed into others having one or other of these two forms

$$\frac{P}{1 - px},\ \frac{Q}{(1 - qx)^n},$$

in which expressions P, Q, p, and q, denote quantities independent of x. Each partial fraction gives a recurring series, the general term of which will be sufficiently obvious; and as the series belonging to the original fraction is the sum of these series, so also its general term will be the sum of all their general terms.

We have now treated of some of the more general methods of summing series which admit of being explained by the common principles of algebra; but the subject is of great extent, and to treat of it so as to give a tolerable notion of its various branches, would require more room than could with propriety be spared in such a work as ours.

(23.) The method of fluxions or differential calculus affords a method, almost the only general one we possess, of summing series. The general principles upon which it is applied may be stated briefly as follows. Since the integral of any differential containing one variable quantity may always be expressed by a series, on the contrary, every series may be regarded as the expression of an integral: when any series then is proposed, we must endeavour to find the differential expression of which that series is the integral; and as we can always find the integral of a differential, at least by approximation, within given limits, we may thence determine, if not the exact, at least the approximate value of any infinite series. We shall now show how this principle may be applied in some particular cases.

Problem I. It is proposed to find the sum of n terms of the series

$$x + 2x^2 + 3x^3 + 4x^4 \cdots + nx^n.$$

Let the sum be denoted by s. Then, multiplying all the terms by $\frac{dx}{x}$, we have

$$\frac{sdx}{x} = dx + 2xdx + 3x^2dx \cdots + nx^ndx.$$

Let the integral of both sides be now taken, and the result is

$$\int \frac{sdx}{x} = x + x^2 + x^3 + x^4 \cdots + x^n.$$

Now the series on the right-hand side of this equation is a geometrical progression, the sum of which is known to be $\frac{x - x^{n+1}}{1-x}$ (Algebra, § 56). Therefore

$$\int \frac{sdx}{x} = \frac{x - x^{n+1}}{1-x},$$

and, taking the differentials,

$$\frac{dx}{x} = \frac{dx - (n+1)x^ndx + nx^{n+1}dx}{(1-x)^2},$$

Hence we find

$$s = \frac{x - (n+1)x^{n+1} + nx^{n+2}}{(1-x)^2}.$$

This result agrees with that formerly found (17) of this article.

Problem II. It is proposed to sum the infinite series

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \frac{1}{11} +, \&c.$$

We may consider this series as a particular case of the more general series

$$x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} +, \&c.$$

namely, that in which $x = 1$. Putting therefore the sum $= s$, and taking the differentials, we have

$$ds = dx\,(1 - x^2 + x^4 - x^6 +, \&c.).$$

Now the series in the parenthesis is obviously the development of the rational fraction $\frac{1}{1+x^2}$, therefore $ds = \frac{dx}{1+x^2}$, and taking the integral $s = \text{arc}\,(\tan. = x) + c$, radius being unity. (Fluxions, § 139.) Now, when $x = 0$, all the terms of the series vanish, so that in this case $s = 0$; and as when $x = 0$, arc $(\tan. = x) = 0$; therefore c, the constant quantity added to complete the fluent, is 0, and we have simply $s = \text{arc}\,(\tan. = x)$, and when $x = 1$, then $s = \frac{1}{2}$ a quadrant $= {\cdot}7853982$.

Problem III. Required the sum of the infinite series

$$\frac{x}{1 \cdot 2} + \frac{x^2}{2 \cdot 3} + \frac{x^3}{3 \cdot 4} + \frac{x^4}{4 \cdot 5} +, \&c.$$

Putting s for the sum, and taking the differentials, we get

$$ds = \frac{dx}{x^2}\left(\frac{x^2}{2} + \frac{x^3}{3} + \frac{x^4}{4} + \frac{x^5}{5} +, \&c.\right)$$

Now the series in the parenthesis is evidently equal to $-x -$ Nap. log. $(1-x)$, (see Algebra, sect. xix.); therefore

$$ds = -\frac{dx}{x} - \frac{dx}{x^2} \times \text{Nap. log. } (1-x).$$

To find the integral, let us put v for the function $\frac{1}{x}$ log. $(1-x)$, then, taking its fluxion, we have

$$dv = -\frac{dx}{x^2} \times \log.\,(1-x) - \frac{dx}{x(1-x)},$$

and $-\frac{dx}{x^2} \times \log.\,(1-x) = dv + \frac{dx}{x(1-x)}$;

therefore, substituting, we get

$$ds = dv + \frac{dx}{x(1-x)} - \frac{dx}{x}$$

$$= dv + \frac{dx}{1-x};$$

and taking the integrals,

$$s = v - \log.\,(1-x) + c$$

$$= \frac{\log.\,(1-x)}{x} - \log.\,(1-x) + c.$$

To determine the constant quantity c, let us take $x = 0$; then in this case all the terms of the series vanish, so that $s = 0$, also $\log.\,(1-x) = \log.\,1 = 0$; and since in general $\frac{\log.\,(1-x)}{x} = \frac{1}{x}\left(-x - \frac{x^2}{2} - \frac{x^3}{3} -, \&c.\right) = -1 - \frac{x}{2} - \frac{x^2}{3} -$, &c. when $x = 0$, then $\frac{\log.\,(1-x)}{x} = -1$; therefore $0 = -1 + c$, and $c = 1$; hence it appears that

$$s = \frac{\log.\,(1-x)}{x} - \log.\,(1-x) + 1$$

$$= \frac{(1-x)\log.\,(1-x)}{x} + 1.$$

Example. Let $x = \frac{1}{2}$, then our formula gives $\frac{1}{1 \cdot 2 \cdot 2} + \frac{1}{2 \cdot 3 \cdot 2^2} + \frac{1}{3 \cdot 4 \cdot 2^3} + \frac{1}{4 \cdot 5 \cdot 2^4} +, \&c. = 1 -$ Nap. log. $2 = {\cdot}3068528$.

Problem IV. Let the series to be summed be

$$1 + \frac{m}{n}x + \frac{m+1}{n+1}x^2 + \frac{m+2}{n+2}x^3 +, \&c.$$

Putting s for this series, let all its terms be multiplied by x^{n-1}, so that the exponent of x in each may be identical with its denominator; the result is

$$sx^{n-1} = x^{n-1} + \frac{m}{n}x^n + \frac{m+1}{n+1}x^{n+1} + \frac{m+2}{n+2}x^{n+2} +, \&c.$$

and hence, taking the differentials

$$x^{n-1}ds + (n-1)sx^{n-2}dx = (n-1)x^{n-2}dx + mx^{n-1}dx + (m+1)x^ndx + (m+2)x^{n+1}dx +, \&c.$$

Let both sides of this equation be now multiplied by x^{m-n}, and it becomes

$$x^{m-1}dx + (n-1)sx^{m-2}dx = (n-1)x^{m-2}dx + mx^{m-1}dx + (m+1)x^mdx + (m+2)x^{m+1}dx +, \&c.$$

Putting now the single character dp for the fluxional expression which forms the first member of this equation, we get, by taking the fluents of both sides,

$$p = \frac{n-1}{m-1}x^{m-1} + x^m + x^{m+1} + x^{m+2} +, \&c.$$

$$= \frac{n-1}{m-1}x^{m-1} + x^m(1 + x + x^2 + x^3 +, \&c.);$$

but the series in the parenthesis is the development of $\frac{1}{1-x}$, therefore

$$p = \frac{n-1}{m-1}x^{m-1} + \frac{x^m}{1-x}.$$

Taking now the fluxions, and substituting instead of dp the expression it was put to represent, we get

$$x^{m-1}ds + (n-1)\,sx^{m-2}dx$$
$$= (n-1)\,x^{m-2}dx + \frac{mx^{m-1}dx}{1-x} + \frac{x^m dx}{(1-x)^2};$$

and this, after reduction, becomes

$$ds + \frac{n-1}{x}\,sdx = \frac{(n-1)dx}{x} + \frac{mdx}{1-x} + \frac{xdx}{(1-x)^2}.$$

This fluxional equation being of the first degree and first order, its primitive equation may be found (from the general formula given in Fluxions, § 171) to be

$$s = \frac{1}{x^{n-1}} \times \int \left\{ (n-1)\,x^{n-2}dx + \frac{mx^{n-1}dx}{1-x} + \frac{x^n dx}{(1-x)^2} \right\};$$

and this again, by remarking that $\int (n-1)x^{n-2}dx = x^{n-1}$, and that

$$\int \frac{mx^{n-1}dx}{1-x} = \frac{mx^n}{n(1-x)} - \int \frac{mx^n dx}{n(1-x)^2},$$

may be reduced to

$$s = 1 + \frac{mx}{n(1-x)} + \frac{n-m}{nx^{n-1}} \int \frac{x^n dx}{(1-x)^2},$$

The remaining fluent $\int \frac{x^n dx}{(1-x)^2}$ may be found by § 101, Fluxions, and it must be so taken, that after being multiplied by $\frac{n-m}{nx^{n-1}}$, it shall vanish when $x = 0$; for then this hypothesis will make the whole function which expresses the value of s vanish, except its first term 1, as it ought to do.

Example. Let us suppose $n = 2$, then

$$\int \frac{x^2 dx}{(1-x)^2} = x + \frac{x}{1-x} + 2\log.(1-x),$$

and

$$\frac{2-m}{2x} \int \frac{x^2 dx}{(1-x)^2} = \frac{(2-m)\,x}{2(1-x)}$$
$$+ \frac{2-m}{x}\log.(1-x),$$

the fluent being here taken as directed. In this case, after collecting the terms, we get s, or

$$1 + \frac{m}{2}x + \frac{m+1}{3}x^2 + \frac{m+2}{4}x^3 +, \&c.$$
$$= \frac{1}{1-x} + \frac{(2-m)}{x}\log.(1-x).$$

(24.) There is a branch of the doctrine of series which is of considerable importance in pure mathematics, as well as in many physical inquiries, and in the science of astronomy; it is called the *Interpolation* of series.

To interpolate a series is to interpose among its terms others which shall be subject to the same law, or which shall be formed in the same manner as the original terms of the series; or, in other words, it is to find the value of one or more terms by means of others which are given, and which may be either at equal or unequal intervals from one another, the places of the given terms as well as of those sought being supposed known.

It is easy to see that this problem may be applied to the construction of logarithmic tables; for we may regard the logarithms of the natural numbers 1, 2, 3, 4, &c. *ad infinitum,* as the terms of a particular series of which the numbers themselves are the indices; thus having given the logarithms of some numbers, we may by interpolating deduce from them the logarithms of others.

Again, in astronomy we may consider the numbers which express the successive observed positions of a celestial body as the terms of a series, their indices being the intervals of time between the observations and some assumed epoch, and the problem we are considering will enable us to determine the position at any instant different from the times of actual observation, provided the intervals between the observations be small, and the instant for which the position is sought not very remote from those at which the observations were made.

(25.) To illustrate the nature of the problem to be resolved, let us consider some particular case, as, for example, the arithmetical series

$$a,\ a+d,\ a+2d,\ a+3d,\ a+4d,\ \&c.$$

Let t and t' be two given terms of the series which are at any distance from one another, and let n and n' be their indices, or numbers which denote their places in the series. Also let y be any term whatever, and x its index. Then, by the nature of an arithmetical series,

$$t = a + (n-1)d,\ t' = a + (n'-1)d,$$
$$y = a + (x-1)d.$$

Now, as there are here three equations, each involving the quantities a and d, we may eliminate both these quantities by the common rules (Algebra, sect. vii.); and this being done, we get

$$(x-n')(t'-t) = (n'-n)(y-t');$$

and hence we find this expression,

$$y = \frac{x-n'}{n-n'}t + \frac{x-n}{n'-n}t',$$

which is a general formula for interpolating any arithmetical series; and it is observable, that it is entirely independent both of the first term and common difference.

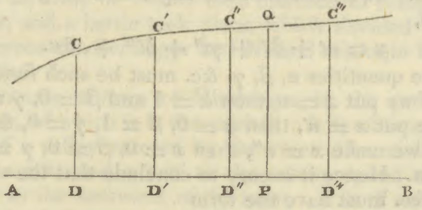
Example. The 7th term of an arithmetical series is 15, and the 12th term is 25: it is required to find the 10th term.

Here $n = 7,\ n' = 12,\ x = 10;$
$t = 15, t' = 25,\ y$ is sought.

Therefore, by the formula,

$$y = \frac{2}{5} \times 15 + \frac{3}{5} \times 25 = 21, \text{ the answer.}$$

(26.) The mode of investigation by which we have found a formula for the interpolation of an arithmetical series will apply also to others, if the law according to which the terms are formed be known; in general, however, the law of a series to be interpolated is either not known, or it is not taken into account, and we only consider the absolute magnitudes of certain terms, and the numbers expressing their places in the series. To resolve the problem generally with these *data*, it is usual to proceed as follows: Let a straight line AB, and a point A in it, be assumed as given in position, and let there be taken the segments AD, AD′, AD″, AD‴, &c., proportional to the numbers denoting the places of the terms of a series reckoned from any term assumed as a fixed origin; and at the points D, D′, D″, let there be erected perpendiculars proportional to the terms themselves. Let us now suppose a curve to pass through C, C′, C″, C‴, &c.; then, if it be so chosen that its curvature may vary gradually in its progress from point to point, without any abrupt changes of inflection, and, moreover, if the terms (which we may suppose to be either at equal or unequal distances) are pretty near to one another, it is easy to conceive, that if AP be taken equal to the number expressing



the place of a term between C″D″, C‴D‴, any two others, the term itself will, if not exactly, at least be nearly, expressed by PQ, the ordinate to the curve.

As an infinite variety of curves may be found that shall pass through the same given points, in this respect the problem is unlimited; it is, however, convenient to assume such as are simple and tractable. The parabolic class possess these properties, and accordingly they are commonly employed.

Let us then express the ordinates CD, C′D′, C″D″, C‴D‴, &c. which are the given terms of the series, by

$$t,\ t',\ t'',\ t''',\ \&c.$$

and the abscissæ AD, AD′, AD″, AD‴, or the numbers denoting the order of the terms, by

$$n,\ n',\ n'',\ n''',\ \&c.$$

Put y for PQ, a term to be interpolated, and x for AP its place. Then, considering x and y as indefinite co-ordinates, a parabolic curve that shall pass through the points C, C′, C″, C‴, &c., will have for its equation

$$y = \mathrm{A} + \mathrm{B}x + \mathrm{C}x^2 + \mathrm{D}x^3 +, \&c.$$

the number of terms on the right-hand side being supposed equal to that of the given points, and A, B, C, &c. being put to denote constant quantities. To determine these, we must consider that when $x = n$, then $y = t$, and that when $x = n'$, then $y = t'$, and so on; therefore, substituting the successive corresponding values of x and y, we get

$$\begin{aligned}
t &= \mathrm{A} + \mathrm{B}n + \mathrm{C}n^2 + \mathrm{D}n^3 +, \&c. \\
t' &= \mathrm{A} + \mathrm{B}n' + \mathrm{C}n'^2 + \mathrm{D}n'^3 +, \&c. \\
t'' &= \mathrm{A} + \mathrm{B}n'' + \mathrm{C}n''^2 + \mathrm{D}n''^3 +, \&c. \\
t''' &= \mathrm{A} + \mathrm{B}n''' + \mathrm{C}n'''^2 + \mathrm{D}n'''^3 +, \&c. \\
&\&c. \qquad\qquad \&c.
\end{aligned}$$

This series of equations must be continued until their number be the same as that of the co-efficients A, B, C, D, &c. If we now consider t, t', t'', &c. and n, n', n'', &c. as known, and A, B, C, &c. as unknown quantities, we may determine these last by eliminating them one after another from the above equations, as is taught in ALGEBRA. And the values of A, B, C, &c. being thus determined and substituted in the general equation, we shall have a general expression for y in terms of x, the number denoting its place and known quantities; and this is in substance the solution originally given of the problem by Sir Isaac Newton, who proposed it in the third book of his *Principia*, with a view to its application in astronomy.

A celebrated foreign mathematician (Lagrange) has, in the *Cahiers de l'Ecole Normale*, given a different form to the expression for y. He has observed that since, when x becomes n, n', n'', n''', &c. successively, then y becomes t, t', t'', t''', &c. It follows that the expression for y must have this form,

$$y = \alpha t + \beta t' + \gamma t'' + \delta t''' +, \&c.$$

where the quantities α, β, γ, &c. must be such functions of x, that if we put $x = n$, then $\alpha = 1$ and $\beta = 0$, $\gamma = 0$, &c. and if we put $x = n'$, then $\alpha = 0$, $\beta = 1$, $\gamma = 0$, &c.; and again, if we make $x = n''$, then $x = 0$, $\beta = 0$, $\gamma = 1$, &c. and so on. Hence it is easy to conclude that the values of α, β, γ, &c. must have the form

$$\alpha = \frac{(x-n')\,(x-n'')\,(x-n''')}{(n-n')\,(n-n'')\,(n-n''')}, \&c.$$

$$\beta = \frac{(x-n)\,(x-n'')\,(x-n''')}{(n'-n)\,(n'-n'')\,(n'-n''')}, \&c.$$

$$\gamma = \frac{(x-n)\,(x-n')\,(x-n''')}{(n''-n)\,(n''-n')\,n''-n''')}, \&c.$$

$$\delta = \frac{(x-n)\,(x-n')\,(x-n''')}{(n'''-n)\,(n'''-n')\,(n'''-n'')}, \&c.$$

$$\&c.$$

and here the number of factors in the numerator and denominator must be each equal to the number of given points in the curve. This formula would be found to be identical with that which may be obtained by the method indicated in last article, if we were to take the actual product of the factors and arrange the whole expression according to powers of x. It possesses however one advantage over the other, viz. that of admitting of the application of logarithms.

We shall now show the application of this formula.

Ex. 1. Having given the logarithms of 101, 102, 104, and 105, it is required to find the logarithm of 103.

In this case we may reckon the terms of the series forward from the first given term, viz. log. 101, so that we have

$$\begin{aligned}
t &= \text{log. } 101 = 2{\cdot}0043214, & n &= 0, \\
t' &= \text{log. } 102 = 2{\cdot}0086002, & n' &= 1, \\
y &= \text{log. } 103 = \text{term sought}, & x &= 2, \\
t'' &= \text{log. } 104 = 2{\cdot}0170333, & n'' &= 3, \\
t''' &= \text{log. } 105 = 2{\cdot}0211893, & n''' &= 4.
\end{aligned}$$

Substituting now in the general formula, we get

$$\alpha = \frac{1\times-1\times-2}{-1\times-3\times-4} = -\frac{1}{6},\quad \gamma = \frac{2\times1\times-2}{3\times2\times-1} = \frac{2}{3},$$

$$\beta = \frac{2\times-1\times-2}{1\times-2\times-3} = \frac{2}{3},\quad \delta = \frac{2\times1\times-1}{4\times3\times1} = -\frac{1}{6},$$

$$\begin{aligned}
\text{Therefore } y &= -\frac{t}{6} + \frac{2t'}{3} + \frac{2t''}{3} - \frac{t'''}{6} \\
&= \tfrac{2}{3}(t'+t'') - \tfrac{1}{6}(t+t''') \\
&= 2{\cdot}0128372, \text{ the answer.}
\end{aligned}$$

Ex. 2. Given a comet's distance from the sun on the following days in December, at twelve at night, to find its distance December 20.

December 12. distance 301, Dec. 24. distance 715,
21. 620, 26. 772.

Here we shall estimate the places of the terms from the time of the first position, viz. December 12. Therefore

$$\begin{aligned}
t &= 301, & n &= 0, \\
y &\text{ is sought}, & x &= 8, \\
t' &= 620, & n' &= 9, \\
t'' &= 715, & n'' &= 12, \\
t''' &= 772, & n''' &= 14.
\end{aligned}$$

In this case the general formula gives us

$$\alpha = \frac{1}{63},\ \beta = \frac{6}{45},\ \gamma = -\frac{2}{3},\ \delta = \frac{8}{35},$$

therefore

$$\begin{aligned}
y &= \frac{t}{63} + \frac{64t'}{45} - \frac{2t''}{3} + \frac{8t'''}{35}. \\
&= 586{\cdot}3, \text{ the answer.}
\end{aligned}$$

We shall conclude this article with a brief enumeration of the best works on the subject which we have been treating of.

Bernoulli, *Ars Conjectandi*; Newton, *Methodus Differentialis*; Taylor, *Methodus Incrementorum*; Stirling, *Methodus Differentialis, sive Tractatus de Summatione et Interpolatione Serierum*; Euler, *Institutiones Calculi Differentialis*; Emerson's Method of Increments; Emerson's Differential Method; De Moivre, *Miscellanea Analytica*; Lagrange, *Théorie des Fonctions Analytiques*; *Traité des Différences et des Séries*, a sequel to Lacroix's work on the *Calcul Différentiel*; Dr Hutton's Mathematical and Philosophical Tracts; Spence's Essay on the Theory of the various orders of Logarithmic Transcendents, with an Inquiry into their Applications to the Integral Calculus, and the Summation of Series.

nagur.

SERINAGUR, a principality or province of Northern Hindustan, situated chiefly between the 30th and 31st degrees of north latitude, and between the 77th and 79th of east longitude. It is divided from Thibet by the great mountain-wall of the Himalaya that bounds Hindustan on the north; it has the great plain of the Ganges on the south; on the east the rivers Dauli, Alcananda, and Ramgunga form its limits; and on the west it is bounded by the stream of the Jumna. It is estimated to be a hundred and forty miles in length by sixty in breadth, and to contain an area of nine thousand square miles. It contains two geographical divisions, namely, Gurwal proper, which occupies the whole of the lower ranges of hills and the sources of the Ganges, comprehending the hilly and mountainous region from which that river springs. In former times this principality also included Kumaon. In 1814 the Ghoorkhas possessed the whole country extending northward to the dependencies of China. Since their expulsion a new division has been effected, by which it has been separated into two distinct portions; the British government having retained the Deyrah Doon, the passes of the Ganges, and the Jumna, at either extremity of that valley, as also all the country to the eastward of the Alcananda and Bhagirathi, which last-mentioned tract has been annexed to Kumaon, and the remainder restored to the expatriated rajah. The territories to the eastward are therefore at present bounded by the Alcananda, from Radraprayag until its conjunction with the Bhagirathi, and thence to the plains by the united streams of the Ganges, and above Radraprayag, where the Alcananda receives the Mandakeri by the latter river. All the territories to the east of that line have been permanently annexed to Kumaon.

The whole face of this country towards Lalldong southward forms one vast assemblage of steep and lofty hills, of the rudest forms, and jumbled together in all directions. They are sometimes disposed, with an appearance of regularity, in parallel chains of no great extent, and shut in at their termination by narrow ridges running across the valleys at right angles. The summits are sharp and narrow, rising abruptly; and the distance between each range being very short, the valleys are in consequence so confined that it would be difficult in many of them to find room for an encampment of a thousand men. The aspect of these mountainous regions is very different. There are many of the ridges stony and naked, affording no shelter for birds or wild animals, while others are covered with trees, and always green, being covered with a luxuriant carpeting of shrubs and fragrant flowers. The eastern parts of the country to the Ganges consist of lower ranges of hills, extending eastward to an undefined extent, and covered with extensive forests of oak, holly, horse-chestnut, fir, and beds of strawberries, equalling in flavour those in Europe. Over this extensive and mostly desert country inhabitants are very thinly scattered, a great proportion of it being left in the undisturbed possession of the wild animals, such as the elephant, which is, however, greatly inferior in size and quality to the Chittagong elephant, on which account it is seldom domesticated; the tiger, the leopard, and generally all the other animals which are found to range among the tropical forests. The country is chiefly watered by the Ganges, and its head streams the Bhagirathi and Alcananda, by the junction of which it is formed at Devaprayaga. The latter is a considerable river, and is joined by its tributaries the Mandakini, the Pinden, the Mandaioki, the Birke, and the Dauli; while the Bhagirathi is joined by the Bilhang. Some of these rivers bring a large accession of water to the main stream; and they have most of them their remote sources in the Himalaya Mountains. None of these streams being fordable, and, besides, descending with all the violence of mountain-torrents, and their channel being too much encumbered with rocks and stones to admit the use of boats, they are crossed by rope and platform bridges at the most convenient points of communication; while the roads are merely footpaths running along the slope of a mountain in the direction of the principal streams and water-courses, and being only practicable in many places for hill-porters. (See the article HINDUSTAN.) Sheep and goats are also trained to traverse the difficult road, and to act as beasts of burden. They are loaded with small bags, containing twelve pounds of grain each, and are despatched in flocks of from 150 to 200, under the charge of two or three shepherds with their dogs. A steady old well-trained ram is extremely serviceable in carrying goods in these mountainous countries, particularly grain, which forms a principal article of commerce. From the higher region salt is brought back.

Serinagur.

In 1796, while Serinagur or Gurwal included Kumaon, and was an independent principality, the revenues amounted to five lacs of rupees per annum, which sum was made up of the duties on imports and exports, the land-rents, the working of mines and washing of gold. The other sources of revenue arose from a tax on the importation of rock-salt and borax from Bootan; of musk in pods, chowries, hawks, and male and female slaves from the countries bordering on Bhadrinath; of cotton cloths of all descriptions from the province of Oude; and of salt from Lahore.

Gold is found among the sands of most of the mountain-streams. The principal places where it is gathered are Carnaprayaga, Pacenkoonda, Devaprayaga, Rickercase, and Lakherighaut. There are in the mountains mines of copper, which in 1816 were let out for one year at 1850 rupees. Prior to the Ghoorkha invasion these mines were said to yield 52,000 rupees. During the confusion consequent on that event some of them have been choked up with rubbish; and to recover them from their present condition would require more capital than any native ever possesses. At Nagpoor and Dhunpoor, to the north and north-east of Serinagur, are two copper-mines, which are said to produce fifty per cent. At Dessouly, a considerable distance to the east, there is a lead-mine; and iron is produced in many parts of the country. Near Jarachi Ghaut, in the eastern quarter of the province, there is a quarry of very fine marble.

The ancient name of this province was Gurwal; and while it was an independent state the rajah's forces were estimated at 5000 men, armed with matchlocks, bows and arrows, and swords and shields, but without discipline. In 1791 the Nepaulese made an attempt to reduce this country, but met with such unexpected resistance, that they desisted from the attempt. From this date, however, the Serinagur rajah became tributary to the Ghoorkhali dynasty. In 1803 an army of 10,000 men marched to complete the conquest, and a battle took place, which decided the contest between the Serinagur and Nepaul rajahs in favour of the latter.

SERINAGUR, a town of Hindustan, in the province of Serinagur, of which it is the capital. It is situated in the centre of a valley watered by the river Alcananda, which extends a mile and a half to the eastward, and the same distance to the westward, of the town. It is of an elliptical form, being in length about three quarters of a mile, and much less in breadth. The houses are built of rough stone and mud, generally raised to a second floor, and covered with slate. They are remarkably crowded together; and the streets are so narrow as scarcely to leave room for two persons to pass. The house of the former rajahs is in the middle of the town, and is the largest, being raised to a fourth story, and built of a coarse granite. The town is now in a ruinous condition, having been reduced to poverty and insignificance by a variety of causes; by the invasion of the Nepaulese at the end of the year 1803, the earthquake which took place in the same year, the encroachments annually made by the Alcananda, and, finally, by the oppressive government under its Ghoorkhali rulers. The inhabitants are chiefly Hindus, the number of Mahommedan families not exceeding sixty or seventy, and most of these being petty shopkeepers. The Hindu inhabitants are chiefly the descendants of emigrants from the Doab and province of Oude. Serinagur is the seat of an inconsiderable trade, the most profitable branch of which consists of a traffic in silver and specie, which is carried on to a considerable amount by the leading persons in the town, who are agents of the great banking-houses at Najibabad and in the Doab, and who are employed in the sale of merchandise and coins. The other articles of trade are the produce of the hills, consisting of coarse hempen cloth, hemp, lead, copper, drugs, gums, wool, and a sort of flannel made of wool. From Bootan are imported cow-tails, musk, saffron, borax, salt, drugs of different kinds, and a few shawls that are sent circuitously from Cashmere. Hawks are also brought from the hills. The articles received in exchange are coarse cotton and woollen cloths, silk, spices, Lahore salt, sugar, and tobacco. The air of Serinagur is unfavourable to strangers, on which account many of the merchants forsake it during the rainy season. Long. 79. 18. E. Lat. 30. 11. N.

SERINGAPATAM, a celebrated city of Hindustan, in the province of Mysore, of which it is the capital. Its situation is remarkable, being at the upper end of an island four miles in length by one and a half in breadth, formed by the Cavery, which is here a large and rapid river, having a broad channel, that is, however, impeded by rocks and fragments of granite. The proper name of this city is Siri Runga Patan, or the city of Sri Ranga, corrupted in common language into Patana. It has been known as a fortress from a very early period; the fort is situated at the west end of the island; its area is about a mile, and it is an immense mass of building, unfinished, and its defences injudiciously constructed. The fortifications exhibit the long straight walls and square bastions of the Hindus; and the glacis is in many parts so high that it sheltered the assailants. The suburbs occupy the middle and highest part of the island, and are about half a mile square. The streets are, like those of most eastern towns, narrow and confused; nor are there any public buildings which are noted for elegance or splendour in the eyes of Europeans. They have all a mean appearance. Hyder's palace, named the Lolbang, which was finished in 1780, when he was occupied in the wars of the Carnatic, and to which he never returned, is situated at the east end of the island. It is two stories in height, and, according to Lord Valentia, by whom it was visited, it is by no means an inelegant building, though mud is the material of which it is constructed. The ground-floor was very public, and seems to have been occupied by the attendants. Above are excellent apartments, and balconies opening into courts in which the sultan usually sat and gave audience. It was prettily painted, but, owing to the want of windows, was too gloomy for a European habitation, and has accordingly been altered and improved by the British residents. It is situated in a garden, which was beautiful, but was destroyed during the siege of the city. Adjoining to this building is the tomb of Hyder, where now rests all that was royal of this Mussulman dynasty, namely, Hyder, his wife, and Tippoo, under tombs of black marble elevated about eighteen inches from the ground, and covered with rich cloths, which have a canopy over them. The whole building, with its dome, its brilliantly polished black marble columns, and its mosque annexed, has a handsome effect. In the verandah are buried several of the family; and on the outside, upon an elevated platform which goes round the whole building, are the tombs of several faithful servants. The British government allow 2000 pagodas annually to the Moulahs for reading the Koran, and for musicians to perform the nobut. The palace in the city is a very large building, surrounded by a massy and lofty wall of stone and mud, and of a mean appearance. All the buildings are now converted to very different uses from those for which they were originally intended. Hyder's palace is the residence of a surgeon; his seraglio is converted into a European hospital; and Tippoo's seraglio has become a barrack for artillery. His private abode is occupied by the resident, and his public apartments by European troops. There is a palace built by Tippoo near the town, which was the residence of General Wellesley. The upper floor consists of one central room, with four others at the corners, and verandahs below them, all very curiously painted; a verandah below covers each side, on the walls of which is painted the famous battle with Colonel Baillie. Other paintings adorn the walls, in which Hyder and Tippoo are represented as conquerors, and subject princes are painted below.

In 1610, Seringapatam was taken from the fallen dynasty of Bijanagur by the rajah of Wadeyar, and made the capital of Mysore. The town was increased and the fortifications improved by his successors. But it was Hyder and his son Tippoo who took pleasure in strengthening and embellishing this the capital of their dominions. It was then that it arrived at that degree of splendour and strength which attracted the cupidity and afterwards foiled the attempts of the neighbouring powers. It was afterwards besieged by the Mahrattas and by the nizam's troops, and was rescued from their attacks by Hyder consenting to pay large sums of money for its security. In 1800, according to a register of the houses, the fort or city contained 4136 houses and 5900 families, and the suburbs 2216 houses and 3335 families. Estimating five persons to each house, the city and suburbs will be found to contain 31,895 persons, independently of a strong garrison and its numerous followers. During the reign of Tippoo, the island of Seringapatam was estimated to contain 150,000 inhabitants. They were greatly diminished during the siege, and after the storming of the place; but many have since been attracted to the rajah's residence at the city of Mysore, and many Mahommedans who originally came from the Carnatic have returned, after the destruction of Hyder's dynasty. The manufactures of Seringapatam and its vicinity were never considerable, and principally consisted of military stores and camp equipage. Timber sells here at a high price, being brought principally by land-carriage from the Western Ghauts. Bread is also dear, which compels the Europeans to subsist upon rice. Good vegetables and excellent meat are, however, to be had in abundance. In February 1792, Seringapatam was invested by a formidable British force, amounting to 400,000, including followers of every description. Tippoo had not the means of withstanding this numerous host; and his intrenched camp being stormed with great loss, he was compelled to yield to the humiliating terms imposed upon him by his conquerors, to relinquish half his dominions, and to pay to them the sum of three and a half millions. In 1799, war being again declared by the British against Tippoo, an immense force, under General Harris, advanced against the capital, which was invested by the British and the nizam's forces on the 14th of April, and was stormed, with a great slaughter of the garrison, in the afternoon of the 4th of May. Tippoo himself was killed under a gateway, by a party, it is supposed, of the twelfth regiment of foot, but by whom is not known, no individual having ever appeared to claim the honour; nor was it discovered who obtained possession of his valuable necklace of pearls. The British have ever since retained possession of the island, which now forms one of the collectorships under the Madras presidency. The travelling distance from Madras is 200 miles, from Hyderabad 406, from Poonah 525, from Bombay 622, from Nagpoor 727, from Calcutta 1170, and from Delhi 1321 miles. Long. 76. 51. E. Lat. 12. 26. N.

SERINGHAM, an island formed by the Cavery, opposite to Trichinopoly, in the Carnatic. The river separates into two branches, and about thirteen miles eastward these branches again approach; but the northern, which is at this place twenty feet lower than the southern branch, is permitted to run waste into the sea, and is termed the Coleroon; whilst the southern, which retains the name of Cavery, is led into a variety of channels to irrigate the province of Tanjore. Near the east end of the island is formed an immense mound, to prevent the waters of the Cavery from descending into the Coleroon. This island is celebrated for two Hindu temples, the largest of which is situated about a mile from the western extremity of the island, and is surrounded by seven square enclosures built of brick, the walls of which are twenty-five feet in height and four feet in thickness. These enclosures are at the distance of 350 feet from each other, and have each four gates opposite the cardinal points. The outward wall is nearly four miles in circumference, and its gateway to the south is ornamented with pillars, several of which are single stones thirty-three feet in length and five in diameter. The British pay so much deference to the Hindu superstitions, that no European has yet entered this temple. It is resorted to from all parts of India by pilgrims seeking absolution for their sins. A tax is levied on them; and this fund, besides supporting a number of dancing girls, who are prostitutes to the Brahmins, yields a revenue to the British government. In 1751, during the siege of Trichinopoly, the French and their allies took possession of the island of Seringham. In 1752, the French force was compelled to surrender to Major Laurence. The Hindu sanctuaries in these temples were respected by the troops of both nations, neither of whom sought access into the temples.

SERINO, a city of Italy, in the Neapolitan province of Ulteriore. It stands between two hills, and contains ten parish churches, with 7500 inhabitants, who are employed in making woollen goods and in spinning silk. There is also a very large annual fair held at Serino; and near to it are the ruins of the ancient Roman city Sabatia.

SERLE'S ISLAND, in the Southern Pacific Ocean. It is seven or eight miles long, and four or five broad, with a lagoon in the middle. Long. 223. E. Lat. 18. 18. S.

SERMATTA, an island in the Eastern Seas, about twenty-two miles in length and six in breadth. Long. 129. 13. E. Lat. 8. 9. S.

SERONGE, a town of Hindustan, in the Mahratta territories, and province of Malwah. It is situated in a fine open country, well cultivated, and has the remains of ancient prosperity and greater population than at present. The bazaars are strong, and built of stone; and a large caravanserai still remains. The adjacent country is an open plain. It was formerly the scene of the Pindarie plunderers; and the villages are in consequence mostly in ruins. It is 165 miles north-east from Oojain, 389 from Benares, 595 from Bombay, 849 from Calcutta. Long. 78. E. Lat. 24. 8. N.

SERPENS, in *Astronomy*, a constellation in the northern hemisphere, called more particularly *Serpens Ophiuchi*. The stars in the constellation Serpens are, in Ptolemy's catalogue, eighteen; in Tycho's, thirteen; in Hevelius's, twenty-two; and in the British catalogue, sixty-four.

SERPENTS, OR OPHIDIAN REPTILES.

IN our article REPTILIA (see *Encyclopædia Britannica*, vol. xix. p. 150) we deemed it advisable to postpone the consideration of the Ophidian order, in the hope that our readers might be benefited by the termination of MM. Dumeril and Bibron's work, the most complete and careful publication by which the history of the reptile race has been as yet illustrated.[1] But having been disappointed in that expectation, we proceed to fill up our sketch of the class in question from other equally authentic sources. The student will bear in mind that our present treatise, relating to the third great order of reptiles, called OPHIDIA (from ὄφις, *a serpent*), interpolates at the page above referred to, and connects, in the natural system, the SAURIA, or lizard-like reptiles, with the BATRACHIA or frogs, sirens, and salamanders. We also take leave to remind our readers (and this the more emphatically, seeing that the imperfect treatise now put forth is the last of the zoological essays for this work likely to proceed from the present pen), that the study of nature is a high and solemn calling, for the proper performance of which, according to the measure of each capacity, men are as accountable to their Creator as they are for the discharge of all other duties, whether moral, intellectual, or professional. We may not say to him who desires an entrance into that magnificent temple which God has erected in his works, "Take off thy shoes, for the place on which thou standest is holy ground;" but we shall say, "Divest yourself of arrogance, conceit, and self-delusion; worship closely, continuously, and fervently; and ever bear in mind that you are yourself a reptile, debarred by the very constitution of your nature from seeing any thing otherwise than in a glass darkly." Should not this feeling act as a monitor in favour of humility and distrust? From whence come contentions among you? From ignorance and folly, from the blinding effect produced by the undue importance which every man is apt to attach to his own small doings, and the frequent absence of that kindly consideration with which each Christian observer should view the labours both of predecessor and contemporary. It is indeed woful to think that those to whom God has given a taste for pursuits in themselves so pleasing and consolatory should so often disgrace their lofty calling by meanness and malice, and that irritability and "all uncharitableness" should in any way arise among men who, when not willingly blinded, may perceive at least a glimpse of what the divine Milton (with how much of inward light, though himself so "dim-suffused!") has beautifully called "the bright countenance of truth shining amid the still air of delightful studies." If naturalists are the priests of nature, then let them bear in mind that theirs is no vain or selfish ministration, and so conduct themselves

> As ever in their great task-master's eye.

The exact lines of demarcation which separate the primary orders of the reptile race are somewhat difficult to draw, as in truth must always be the case wherever there are strong affinities of form and habits. *Natura non facit saltum*, is a saying the truth of which the student of her manifold wonders must ever remember; and in our present department especially, there are several very singular creatures, which so combine the characters of two contiguous orders, that well-instructed naturalists differ as to whether they should terminate the one or commence the other. Thus Baron Cuvier's last *Ophidian* genus is *Cæcilia*, which Professor Bell regards as a Batrachian reptile, or rather as belonging to his separate class Amphibia, which, after the example of Blainville and Latreille, he constitutes by means of the entire Batrachian order.[1] Thus also *Lacerta apoda* of Pallas, though furnished on each side with a small bone analogous to the femur, and pertaining to an actual pelvis concealed beneath the skin, is yet classed by the great French anatomist with the Ophidians, being, so to say, the "very head and front of their offending;"[2] while several systematic writers range our *Anguis fragilis*, and other snakes commonly so called, among the lizards. An American reptile, *Anguis ventralis* of Linn., now forms Daudin's genus *Ophisaurus*, the name of which (derived from ὄφις, *serpent*, and σαῦρος, *lizard*) implies the peculiar combination now referred to. The Saurian genus *Seps*, described at the conclusion of our former treatise, is characterized by Cuvier as having an elongated body, "tout-à-fait semblable à celui d'un orvet" (*Anguis*); and, on the other hand, the same author enters upon his Ophidian order by means of the *Anguidæ*, or slow-worms, which he simply describes as "des seps sans pieds." These, and other examples which it would be easy to adduce, demonstrate the close connection which subsists between the Saurian and Ophidian orders.

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[1] *Erpétologie Générale, ou Histoire Naturelle complète des Reptiles*, four vols. 8vo, with plates (containing hitherto only the Chelonian and a large portion of the Saurian orders). Paris, 1834–38.

It has indeed been customary to class among serpents whatever reptiles combined the absence of limbs with an extremely lengthened form of body; but a more rigorous observation will demonstrate that several species which, in accordance with that principle, will take their place as serpents, are yet in their prevailing organic structure removed from them in most essential points, the chief resemblance being that of the external and extremely lengthened form. Now this attenuated aspect, and absence of all the ordinary locomotive members, are likewise exhibited by several Saurian reptiles, and of course in an increased degree as they actually approach the serpent or Ophidian tribes; but the two characters just mentioned do not convert them from one order to another, being still held, as it were, in subordination to the general structure.[3]

We bring forward these observations at present, chiefly that the reader may understand why we commence our treatise on serpents by a brief sketch of several species which in truth we can scarcely regard as serpents at all, however raised "to that bad eminence" by many noted writers. We might have placed them at the termination of the Saurian order of our former article Reptilia; but the fact being that we did not do so, we feel it incumbent on us, before proceeding to the serpents properly so called, to present a short notice of their names and nature. In doing this we shall follow for a space the arrangement of Baron Cuvier, presuming that the reader will now understand our views regarding the doubtful nature of all those genera which precede the true serpents, of the advent of which due notice will be given.

The French anatomist defines serpents as,—reptiles without feet, which advance by means of sinuous movements of the body. He divides them into three great groups,—the Anguidæ or slow-worms,—the true serpents (subdivided into, 1st, double movers, *i. e.* the genera *Amphisbæna* and *Typhlops;* 2dly, serpents properly so called, containing all the actually Ophidian species),—and the naked serpents, composed of the single genus *Cæcilia*.

We commence, then, with the

ANGUIDÆ, OR SLOW-WORMS.

These still exhibit the bony head, the teeth, the tongue of *Seps*, and the eye is furnished with three eyelids. They correspond to the ancient unrestricted genus Anguis of Linnæus, and are characterized externally by imbricated scales covering the whole body. The species now form four minor genera, of which the first three still exhibit beneath the skin certain small bones corresponding to those of the shoulder and pelvis.

Genus Pseudopus, Merrem. Tympanum visible externally. A prominence on each side of the anus, containing a small bone analogous to the femur, and appertaining to a true pelvis hid beneath the skin. Rudiments of the anterior extremities barely manifested by an inconspicuous fold, containing no interior humerus. One of the lungs is a quarter less than the other. The scales are thick and imbricated, and between those of the back and belly are some smaller scales, which produce a longitudinal furrow on either side.

Of the species, the earliest known is *P. Pallasii*, Cuv., *Lacerta apoda*, Pallas,—discovered in the south of Russia by the naturalist last named.[4] It measures from one to two feet in length, and the colours are ferruginous above, pale yellow beneath. The scales of the back are smooth, those of the tail carinated. This species occurs also in Hungary and Dalmatia, and the specimen figured by Dr Shaw[5] was procured in Greece by Dr John Sibthorpe, the professor of botany in the university of Oxford. M. Durville discovered another species (which bears his name) in the Archipelago.[6] See Plate CCCCXLIII. fig. 1.

Genus Ophisaurus, Daudin. No external appearance even of the hinder extremities, but the tympanum is still apparent, and the scales exhibit a plication or folding upon each side of the trunk. The smaller lung only equals a third of the greater.[7]

The best known species is *Oph. ventralis*,—*Anguis ventralis*, Linn.,—an American reptile, common in the southern states of the union. It is of a greenish yellow, spotted above with black. Its tail is longer than its body, and the creature itself is so brittle and easily broken, even in the living state, as to be known by the name of glass serpent. According to Catesby, "a small blow of a stick causes the body to separate, not only at the place struck, but at two or three other places, the muscles being articulated quite through the vertebræ."[8]

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[1] *Encyclopædia of Anatomy and Physiology*, part i. p. 91. These amphibian orders are as follows: 1st, *Amphipneurta*, containing the Sirens and Proteans; 2d, *Anoura*, the frogs and toads; 3d, *Urodela*, the salamanders; 4th, *Abranchia*, the genera Menopoma and Amphiuma; and, 5th, *Apoda*, the genus Cæcilia. "It is easy," adds Mr Swainson, "to perceive that this last passes into the first by means of the dipod Sirens, and thus the whole form a circular group more or less perfect in its connecting links." (*Cabinet Cyclopædia*, vol. cxvi. p. 86.)

[2] See *Règne Animal*, ii. 69.

[3] "Un examen comparatif," observes M. Schlegel, "des objets m'a démontré que ces Sauriens anomaux, c'est-à-dire, à formes alongées et à extrémités rudimentaires, appartiennent toujours par l'ensemble de leur organisation à quelque espèce de l'une ou l'autre des familles de cet ordre, parmi lesquelles ils doivent être distribués. On ne peut nier, par exemple, qu'il y a un passage graduel des Scinques à l'Anguis et aux Acontias, par l'intermède des Scinques brachypus, decreensis, serpens, seps, du Pygodactyle et du Bipes,—êtres moins différens entre eux par leur organisation que par leurs formes, et qui ne composent qu'une seule famille, celle des Scincoïdes, de laquelle on ne saurait exclure ni les Ablephares ni les Gymnophthalmes. Le même passage graduel existe dans la famille des Lézards, des genres Lacerta et Tachydromus au Monodactyle; on y peut ajouter comme espèce anomale le Pygopus. On pourrait rapprocher dans la méthode le Tetradactyle, le Chalcis, le Pseudopus, et l'Ophisaurus. Viennent enfin la famille des Amphisbènes,—Chirotes, Leposternon, Amphisbæna, et celle des Typhlops,—Typhlops, Rhinophis, Uropeltis." (*Physiognomie des Serpens*, i. p. 2.)

[4] *Nov. Com. Petrop.* xix. plate 9, fig. 1.

[5] *General Zoology*, iii. plate 86.

[6] Griffith's *Animal Kingdom*, ix. 307.

[7] Of the cranium of this genus, Cuvier has remarked, "C'est une vraie tête de Saurien." *Règne Animal*, iii. 430.

[8] *Carolina*, ii. plate 59.

Amphisbænidæ.

Genus Anguis, Cuv. No extremities visible externally. Tympanum concealed beneath the skin. Maxillary teeth compressed and hooked,—no teeth upon the palate. Body surrounded by imbricated scales, without plication on the sides. One of the lungs is a half less than the other.

The English slow-worm, *Anguis fragilis*, is common over a great part of Europe.[1] It is very smooth, of a shining brownish-gray above, inclining to reddish on the sides, and bluish-black upon the under surface. It rarely measures more than a foot in length. It lives on insects and small mollusca, excavates circuitous holes in the earth, of several feet in extent, and with more than one issue. It is an innocent and gentle creature, remarkable for stiffening itself so much when seized as sometimes to break in two. Hence its specific name of *fragilis*.

Genus Acontias, Cuv. No osseous pieces corresponding to the sternum and pelvis, the shoulder-blades and clavicles. Anterior ribs united to each other inferiorly by cartilaginous prolongations. Teeth small and conical: "Je crois," says Cuvier, "leur en avoir aperçu quelques-unes au palais."[2] Muzzle enclosed in a kind of mask. One lung of medium size, and another of very small dimensions.

To this genus belongs the speckled slow-worm of Shaw, *Anguis Meleagris*, Linn., a native of the Cape of Good Hope.[3] Its tail is much shorter and more obtuse than that of the British slow-worm. Its upper surface is spotted longitudinally with brown. Africa produces other species, one of which, according to Cuvier (*Ac. cæcus*), is entirely blind.

We now reach Baron Cuvier's second great division, the **True Serpents**, consisting of all those genera which exhibit no vestige of either shoulder or sternum, but have a great portion of the circumference of the body surrounded by the ribs. The vertebræ articulate by means of a convex facette at one end, entering into a concave facette of that which follows. (See Plate CCCCXLIV. fig. 2*a* and 2*b*.) The third eye-lid and the tympanum are wanting, but the osselet of the ear exists beneath the skin, and its handle passes behind the tympanic bone. Several still manifest a remnant of the posterior members hid beneath the skin, or even showing themselves externally under the form of small hooks.[4] The first two genera are scarcely entitled to the designation of *True Serpents;* and Baron Cuvier has himself drawn a line between them and those which he names *Serpents properly so called*, although the two terms seem not particularly distinctive. The reptiles in question form the tribe *Double Marcheurs* of Cuvier, and may be named

AMPHISBÆNIDÆ, OR BLIND-WORMS.

The lower jaw still continues, as among the preceding groups, supported by a tympanic bone, articulated directly to the cranium, the two branches of that jaw being soldered together anteriorly, while those of the upper one are fixed to the cranium and the intermaxillary bone. This formation both produces an equality of dimension between the head and the rest of the body, and also prevents that peculiar power of dilatation for which the genuine serpents are so remarkable. (See Plate CCCCXLIII. fig. 1*a*.) Their general form, according to Cuvier, "leur permet de marcher également bien dans les deux sens," a fact, however, which that great observer does not seem to state as from the "ocular proof," and for the confirmation of which we have sought in vain in the work of any well-instructed traveller. The bony frame-work of the orbit is incomplete behind, the eye is extremely small, and the body is covered with scales. The windpipe is elongated, the heart placed far backwards, and the anus situate close to the extremity of the body. None of the known species is venomous. Of the two genera, the one is closely related to *Chalcis* and *Chirotis*, the other to *Anguis* and *Acontias*.

Genus Amphisbæna, Linn. The entire body covered by circular ranges of quadrangular scales. A range of pores anterior to the anus. Teeth of a conical form, numerous on the jaws, none upon the palate; only a single lung.

The species are South American reptiles, to which an ancient classical name has been, with no great propriety, applied. (See Plate CCCCXLIII. fig. 2.) The white one, *Amph. alba*, Linn., measures from a foot and a half to two feet in length, and is proportionably of a bulky form.[5] It inhabits Brazil, where its native name of *Ibriaram* signifies Lord of the Earth. It was first described by Maregrave, who, however, states erroneously that it is venomous, and will wound either with head or tail. It preys on insects, and is often found near ant-hills. Another species, from Martinique (*Amph. cæca*, Cuv.), is stone-blind.

It may be observed in passing, that the genus *Lepostemon* of Spix is composed of Amphisbænæ, of which the anterior part of the body is furnished below with several plates, which interrupt the ranging of the circular rings. They have no pores anterior to the anus, the head is short, and the muzzle slightly projecting. Example, *Lep. microcephalus*, Spix,—*Amph. punctata* of Prince Maximilian (Neuwied).

Genus Typhlops, Schneider. Body covered with small imbricated scales (as in *Anguis*, with which group the species were for a long time combined). Muzzle advanced, furnished with plates. Tongue long and forked; eye in the form of a minute point, scarcely visible through the skin; anus almost terminal; one lung four times larger than the other.

These, as Cuvier remarks, are small serpent-like creatures, which bear a great resemblance to earth-worms. They inhabit the warmer countries both of America and the old world. Some have the head obtuse, and of equal diameter with the body. Such is *T. braminus*, Cuv., the punctulated slow-worm of Shaw, and *rondos talooloopam* of Dr Russel.[6] It is a diminutive reptile, measuring about six inches in length, with the thickness of a hen's quill. It is of a cream-colour, powdered over with innumerable black dots. It is common in Vizagapatam, and, according to the author last named, is vulgarly reputed mischievous. It is described as moving with great swiftness; and a specimen immersed in spirits remained alive for more than ten minutes. Others (and these the majority) have the muzzle depressed and obtuse, and furnished anteriorly with several plates. Example, *T. reticulatus*.[7] A few have the front of the muzzle covered by a single broad plate. Such is *T. subargenteus* (*Anguis lumbricalis*, Linn. and Lacép.), the silvery snake of Brown.[8] Finally, there are one or more peculiar species, in which the muzzle terminates in a small conical point, and the posterior extremity is enveloped by a horny buckler of an oval form. We here place *T. Philippinus*, Cuv., which measures about eight inches in length, and is entirely of a black colour. We presume that Dr Shaw's snouted slow-worm, *Anguis nasuta* (*A. rostrata* of Weigel[9]), though differing in colour, is nearly allied, and ought to be placed in the same genus.

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[1] Lacépède, *Quadrupèdes Ovipares*, ii. plate 19, 1.

[2] *Règne Animal*, ii. 70.

[3] *Thesaurus*, ii. tab. 21, fig. 4. It is not found in the East Indies, as both Seba and Shaw supposed.

[4] Naturalists, as we shall afterwards take occasion to notice, differ in their views regarding the exact nature of these outward appendages. They are described by M. Mayer, in the twelfth volume of the *Academia Naturæ Curiosorum* of Bonn.

[5] Lacép. ii. pl. 21, 1.

[6] *Serpents of the Coast of Coromandel*, p. 48, pl. 43.

[7] Scheuchzer, *Physica Sacra*, pl. 747, 4.

[8] *Civil and Natural History of Jamaica*, p. 460, pl. 44, fig. 1.

[9] *Berlin Transactions*, iii. p. 190.

We now arrive, "by lingering steps and slow," at the genuine serpents, or

OPHIDIAN REPTILES, PROPERLY SO CALLED.

The principal characteristic of the serpent race consists in an extremely elongated body, clothed with scales, destitute of limbs, and furnished with a tail, or caudal extremity. Locomotion is effected by lateral undulations, aided by the scales externally, and by the ribs within. Although the general form, viewed in relation to its transverse dimensions, is concentred to an extremely small diameter, the different parts are capable of great enlargement, which admits in many cases of their swallowing bodies bigger than themselves. In conformity with this peculiar structure, even the bony portions of the head are not so knit together as in other animals, but, with the exception of the parts which protect the brain, are capable of a certain degree of separation. (See Plate CCCCXLIII. fig. 1*b*.) The development of the tympanic bones; their mode of attachment; the mobility which they enjoy from not being fixed to the cranium by their lower extremity; finally, the structure of the under jaw, the two branches of which are capable of separation in consequence of being united by elastic ligaments instead of symphysis; all combine to produce the vast swallowing powers of these reptiles. The entire absence of limbs is accompanied by an equal absence of those solid portions, such as the sternum and pelvis, which unite the limbs with the body. The ribs are free for the same reason, and thus readily admit both of the occasional enlargement of the intestinal cavity, and of that extreme pliancy of form for which all the species are remarkable, whether they creep, climb, or swim. To facilitate these various movements, the general envelope is minutely subdivided into numerous compartments, the scales of the lower surface being usually much larger than those of the upper, and subserving the place of feet, the ribs being attached to the lateral margin of the inner surface of these abdominal plates. The space of bare skin between the scales is greater among serpents than other reptiles, and on the throat this bare expanse forms a longitudinal cleft, known by the name of gular furrow.

The true Ophidians are closely connected to the Saurian order by the preceding genera *Amphisbæna* and *Typhlops*, which certainly form a passage from one of those great ordinal groups to the other. It is these connecting links that render precise definitions, drawn from a few apparent characters, so difficult, if not impossible. "Il est très facile," observes M. Schlegel, "de se faire une idée d'un serpent, lorsqu'on prend pour type une des espèces où tous les caractères de l'ordre se trouvent réunis ; mais il est difficile de consigner des marques distinctives qui separent d'une manière tranchée les Ophidiens des Sauriens."[1] Thus the gular furrow which characterizes all serpents except the genus *Acrochordus*, exists also among lizards, and several other Saurian reptiles. A few Ophidians even exhibit vestiges of the hinder extremities, analogous to what we may observe among the so-called apodal Saurians, although there is reason to suspect that the parts alluded to represent, in the latter the pelvis, in the former the actual extremities.[2] Perhaps the characters deduced from the bones of the cranium would afford the best distinctions between the two orders, were it not that in these, too, certain species of the genera *Typhlops* and *Uropeltis* make a near approach to the true Ophidians. It may be well, however, to state briefly the distinguishing features in the cranial osteology of the latter order. The bones of the face in serpents never form a fixed mass perforated by the nostrils, and incased by sutures in each other; and the intermaxillary bone, trigonal, and compressed in its form, is always free, and to a certain extent moveable, that is, never soldered by sutures to the maxillaries on either side. The maxillaries themselves, when united to the anterior frontals, are so merely by a narrow attachment, always preserving a certain mobility; and the lateral margins of the nasal bones are free throughout their whole extent. No Ophidian reptile has thick conical teeth perpendicularly incased; they rather resemble hooks curved backwards, with sharp points; and we believe that all serpents, with the exception of the genus *Oligodon*, have the palate armed with teeth resembling those on the maxillæ, whilst in the Saurian order the palatine teeth exist only in the form of small irregular asperities.

From the preceding brief sketch it may be inferred, that the most peculiar character of serpents consists in their mode of locomotion, and their extraordinary powers of deglutition. These conditions modify their entire organization, for the former determines the general shape of the body, and the latter that of the internal parts. On examining the position of the intestines, we find that these organs, which in the majority of other vertebrated beings occupy several spacious cavities, are in the Ophidians enclosed within a long and narrow cylinder. It is obvious that this disposition cannot prevail without great changes in the form of the viscera; and the disturbance alluded to is even destructive of bilateral symmetry. We thus find the heart sometimes far removed from, at others closely approached towards, the head, according as the stomach is more or less extended; it is thus also that most frequently there is only a single lung, sometimes extending in front of the heart, but usually placed behind that organ, and almost always terminated by a species of sack of greater or less extent, and serving as a reservoir of air. The liver, for the same reason, assumes a narrow ribbon shape, extending from the heart to the pylorus. The gall-vessel, that it may not be interrupted in its functions by the repletion of the stomach, is removed from the liver, and placed in the same curve of the duodenum as that which receives the pancreas and the spleen. The stomach resembles a lengthened narrow cylinder. Then follow the intestines, of which the numerous inflections are filled with fat, and which, after descending in a straight line, terminate in the cloaca. The lower portion of the abdominal cavity not being sufficiently spacious for the reception of the rest of the organs, there thence results an anomalous disposition of the kidneys, testicles, and ovaries. "La verge enfin, et un organe sécréteur, sont logés dans la queue." These peculiar forms, however, of the majority of the internal parts of serpents exercise no influence over their functions; for, on more minute investigation, we find that they vary not only in distinct species, but in different individuals of the same species.

The disposition of the external organs, on the contrary, present much more constant forms; but these parts are modified by the habits of the species, whether arboreal, terrestrial, or aquatic. The mode of locomotion is, however, very uniform, the movement being nearly the same which aids a serpent while gliding on the surface of the ground, traversing the depths of lakes and rivers, or climbing around the umbrageous branches of forest-trees. The lateral undulations of the body suffice for these progressions; and it is chiefly the sea-snakes that make use of their tails, which are expressly organized for that special purpose, acting as a scull. The degree of rapidity depends in a great measure on the nature of the surface in which the motion is

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[1] *Essai sur la Physiognomie des Serpens*, par H. Schlegel. La Haye, two vols. 8vo, 1837. Of this, the most recent and complete work on our present department with which we are acquainted, we have availed ourselves largely in the following treatise.

[2] We have exhibited these parts as they exist in the genus Boa. See Plate CCCCXLIV. figs. 1, 1*a*, and 1*b*.

Ophidian Reptiles.

exercised. Serpents drag themselves along with difficulty over glass or any polished body, but make their way with great alacrity over any earthy irregular surface, or through tangled vegetation. For the exercise of these movements it is of course necessary that the bones and muscles should be fitly disposed; and every one who has examined a properly prepared serpent, must have been struck at once by the multiplicity and uniformity of its parts. The ribs and vertebræ are almost all alike in their formation, and it is only towards the caudal extremity that the bones diminish in bulk.

As all the vertebræ of serpents carry ribs, the usual distinctions of cervical, dorsal, and lumbar, do not exist; and it follows, that the number of ribs always corresponds to that of vertebræ. Moreover, as the scaly articulations of the skin always correspond to the ribs, which are their levers, so the number of abdominal plates agrees with the amount of ribs and vertebræ. This number varies not only with the species, but the individuals, and to so surprising an extent, that we not unfrequently find a difference in the same species, amounting to thirty or even fifty vertebræ. The number of vertebræ of the body, properly so called, rarely exceeds 300, and is never fewer than 100; the vertebræ of the tail, on the contrary, are sometimes reduced to five, although in other cases they amount to from 150 to 200. The ribs are more numerous in serpents than in any other class of created beings, several having above 500,—that is 250, or upwards, on each side of the spinal column. We here figure the skeleton of the common ringed snake of England,—*Tropidonotus natrix*. See Plate CCCCXLIV. fig. 2.

The muscles exhibit various modifications in the different species. In some they are remarkable for their considerable size, and for the extraordinary development of tendons, especially among the venomous kinds. This organization is necessary for the production of that force and energy with which their undulating movements are often executed. The muscles which produce these effects are situate along the sides of the back, and on the anterior face of the vertebræ; but as the ribs likewise exercise the function of locomotive organs, the numerous muscles which are attached to these parts greatly facilitate the lateral movements. The muscles of serpents being greatly interlaced, it becomes difficult to describe them singly, and their comparison with analogous parts in the higher orders is by no means easy. These anatomical details, however, are not to be expected in the present publication. We therefore refer the reader to the works of Home,[1] Hübner,[2] Dugès,[3] Duvernoy,[4] Meckel,[5] and Schlegel.[6]

The muscles of serpents, as of other reptiles, preserve their irritability for a long time after what we may regard as the actual death of the animal; for these creatures, although deprived of their head, and divested of their skin, will continue to exhibit muscular movements for several weeks, if kept in a moist condition. Swammerdam, in his *Biblia Naturæ*, has proved, both by his figures and descriptions of frogs, that even at that early period (1666), that peculiar galvanic effect was demonstrated in the muscles of these reptiles, which at a future period gave rise to such important discoveries regarding the phenomena of Voltaic electricity.

A few words may be said regarding the supposed vestiges of the hinder extremities observable in certain serpents. Several species exhibit on each side of the anus a small hook or crotchet, half concealed by scales. The existence of these parts has been long recognised, but we believe it is to Professor Mayer of Bonn that we owe a more precise knowledge of their nature. The only Ophidian genera in which they have been hitherto precisely observed, are *Tortrix*, *Python*, and *Boa*. They are most developed among the Boas, and the huge size of these reptiles admits of a more satisfactory examination. (See Plate CCCCXLIV. figs. 1, 1*a*, and 1*b*.) These vestiges, then, consist of an assemblage on each side, of three principal osseous pieces, and of two small accessory portions attached at the point of articulation of the tibia and tarsus. The terminal bone, which alone appears externally, is in the form of a crotchet, covered by a hard and scaly skin. When a longitudinal incision is made in the flesh, we find that the interior piece, which is the most developed, more or less S shaped, and comparable to the tibia, is prolonged with its free extremity into the abdominal cavity. The middle portion, on the contrary, which seems to represent the tarsus, is thick, short, slightly arched, and completely concealed within the flesh. This apparatus is moved by flexor and extensor muscles of a sufficiently simple structure. The use of these vestiges of the posterior members is still unknown. Their feeble development debars the idea of their contributing in any way to locomotion. Certain observers maintain that they are prehensile organs, which give firmness of position on whatever bodies are embraced by the circumvolutions of the tail and trunk; or that they may even subserve the generative process. They exist in both sexes.

When in a state of entire repose, the majority of serpents love to roll themselves into a spiral mass, with the head in the centre, slightly raised above the other portions. Possessing the power of bending their bodies in almost all directions, we at the same time frequently find them simply extended on the ground or herbage in a sinuous curve. To produce progressive motion, they merely unrol the body, and bending it into successive lateral sinuosities, bring into play the numerous points of contact presented by the anterior extremities of the ribs, and thus push along with great facility. These reptiles are frequently observed to raise the anterior portion of their body into an erect position, supporting themselves on the tail and part of the abdomen, as if with a view to survey the scene around them. The body, itself, is then usually quite stiff and straight, although some assume a more curved attitude, besides exhibiting a peculiar swelling or enlargement of the neck. When suspended perpendicularly from the branch of a tree, the great Boas exhibit scarcely any sign of life or motion. They descend simply by dropping themselves downwards, their peculiar form and great elasticity of structure preventing their receiving any injury from the fall; and when they reach the ground, this rapid movement, so far from proving hurtful, aids by its impulsion their terrestrial progress.

Frequent mention has been made by vague observers, of serpents which could execute a retrograde movement,—gliding backwards as easily as in an ordinary direction. This fact has not been established on the authority of any instructed naturalist, and may well be doubted, notwithstanding what the ancients have said of the Amphisbæna (αμφὶς and βαίνειν, *marching both ways*), a reptile alleged to have a head at either end, and supposed to be endowed with the faculty of progressing in both directions.[7] The name, originally applied to a species of the ancient world, probably the *Eryx*, has been erroneously bestowed by modern naturalists (following the example of the Portuguese) on a tribe of serpents peculiar to America,—a country which knew not Aristotle.

The majority of serpents (both of the innocent and the colubriform venomous kinds) defend themselves against the

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[1] *Phil. Trans.* vol. x.; and *Lectures on Comp. Anat.*

[2] *De Organis motoriis Boœ caninœ.*

[3] *Ann. des Sciences Nat.* vol. xii.

[4] *Ibid.*

[5] *Vergl. Anat.* vol. iii. p. 130, et suiv.

[6] *Physiognomie des Serpens*, vol. i. p. 18.

[7] *Plin.* 8, 35; *Ælian*, 9, 23.

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attack of their enemies by darting upon them, with the head elevated, so as to enable them to bite with greater energy. A few, such as the Najas, raise a considerable portion of the anterior of the body, so as to assume a very singular position. Most of them give utterance to a sharp hissing sound as a prelude to battle; and they also produce a peculiar blowing, by forcing the air rapidly through the nostrils. Several species throw themselves upon their prey with a great and sudden bound, usually seizing it by the throat; while others encircle it by a tortuous embrace, thus pressing it to death by sinewy folds. The venomous kinds make use of the same means to obtain their food as they do to defend themselves from threatened danger. Quietly stretched along the earth, they will attack indifferently whatever incommodes them; but knowing the potency of their empoisoned fangs, they are satisfied by the infliction of a murderous bite, without recourse to muscular pressure.

As snakes swallow their food entire, and without mastication, their teeth serve merely to wound and retain their prey, or to instil into it the envenomed fluid. This deadly matter is the product of certain glands of the head. These are of two kinds; the one composed, like the salivary glands of quadrupeds and birds, of numerous small granules, which secrete a fluid analogous to saliva, and destined to prepare the food for digestion; the other, of a very different nature, forming a thick sack, of which the interior is divided into numerous compartments, and distilling a liquid which, by its fatal effects on the principle of life, becomes a dreadful instrument of destruction. The salivary glands are common alike to all Ophidian reptiles, but scarcely a fourth of the entire species are provided with those which secrete the poison. The teeth which conduct this fatal fluid into the wound are hollow and pierced at each extremity. They are always situate towards the anterior end of the maxillary bone, are covered by the gums, which there form a kind of sheath, and are always kept bent when in repose. The rest of the teeth, and the whole of those of the innocuous kinds, are solid, with the exception of the hollow which contains the nutritive organ of the tooth. Although these large anterior fangs are characteristic of the poisonous kinds, we yet find a considerable number of innocuous species, of various genera, which have the jaws armed with one or two teeth larger than the others, and usually furrowed by a cleft extending along the anterior face. These grooved teeth are always situate at the base or posterior extremity of the maxillaries, and it is but seldom that we perceive a second on the middle portion of the jaw. Their sole function is believed to be the pouring into their wounded prey an abundant supply of saliva secreted by the posterior part of the salivary glands, which are most voluminous in the region occupied by the teeth in question. The organization of these posterior glands entirely resembles that of the ordinary salivary ones; and recent observation has demonstrated, that the bite of species belonging to the genera ***Dryophis***, ***Dipsas***, and others with furrowed teeth, is followed by no fatal results, at least to the human race.[1]

In studying in detail the teeth of the Ophidian reptiles, we may perceive a gradation from the solid to the hooked teeth. Each tooth in fact consists, in its earliest development, of a kind of lamella with curved margins, so as to open as it were on its anterior face. In the so-called solid teeth, this opening has become filled by the union of the margins at an early period; it continues open for a longer time in the hooks of the most venomous kinds, but in the completed state they exhibit only the two orifices destined for the entrance and emission of the poison,—the lower one continuing to preserve the character of a longitudinal cleft. In other poisonous species we find analogous fangs, but with a continuing vestige of the groove which formerly united the two orifices. Finally, the furrow in the lengthened posterior teeth of certain innocuous species, is nothing more than the permanence of the groove now mentioned.

The solid teeth occur indifferently in all Ophidian reptiles; but their number, form, and position, vary in the different species. With the exception of the genus *Oligodon*, which is unprovided with palatine teeth, there are always four rows of teeth in the upper jaw (see Plate CCCCXLIII. fig. 1*c*), and two in the lower. Intermaxillary teeth are not observable, except in the genus ***Python***, and occasionally in ***Tortrix scytale***,—the number rarely exceeding four (see figure last referred to). These solid teeth are usually all of equal length; but in the Boas they enlarge towards the extremity of the muzzle (fig. 11), while the reverse is the case in several species of ***Coluber***, ***Tropidonotus***, &c. The ***Lycodons*** exhibit some teeth more largely developed than the others at the anterior extremity of the maxillaries; those of ***Dryophis*** and ***Psammophis*** are rather unequal, several being even greatly elongated towards the centre of the jaw; those of certain species of ***Dipsas***, ***Homalopsis***, &c. are often furrowed; while other genera, such as ***Xenodon***, ***Coronella***, and several kinds of ***Homalopsis***, have the base of the maxillaries armed with a strongly developed tooth of a solid structure. The number of teeth, in general, obviously varies in relation to the development of the maxillaries, and of the dental bone of the lower jaw.

The poison-gland, which forms so peculiar a character of the noxious kinds, is enclosed in a thickish tendinous envelope, hard and tenacious to the touch, and diminishing backwards into the form of a narrow ribbon, by which it is attached to the articulation of the lower jaw. Anteriorly this envelope is also restricted to a canal-shaped space, which stretches along the maxillaries, and then descends towards the orifice already mentioned, of the anterior face of the base of the hooked fang. (See Plate CCCCXLIII. fig. 10). Among the poisonous serpents properly so called, this canal is folded when the fangs are in a state of repose, but easily extends in conformity with the movement of the maxillary bones. The interior of the poison-gland is subdivided into a great number of minute cells, produced by very slender partitions, which cross each other at an angle more or less acute. To this peculiar structure, so dissimilar to that of the salivary glands, is due the secretion called poison, from its fatal effect when mingled with the blood of any living creature. It is true, that the bite of even the most innocent animal may sometimes produce the most disastrous results, by a concourse of peculiar circumstances, such as the temperature of the climate, the psychological or pathological condition of the creature bitten, or the rabid fury of that which has aggressed, and for this reason the bite of innocuous serpents may have sometimes proved fatal even to the human race; but the poison of the injurious kinds holds its noxious qualities in its very nature, although the circumstances just alluded to may render more deadly its destroying powers.

The poison of snakes, when fresh, may be described as a transparent limpid fluid, of a greenish-yellow colour, slightly gluey, viscous, adhering to other objects when dried, and evaporating without burning when exposed to fire. It sinks in water, and when mingled with it by shaking, produces a troubled and somewhat whitish appearance. It partakes greatly of the nature of mucus; and when placed in contact with any re-active substance, we discover that it is neither acid nor alkaline; there is nothing peculiar in its odour, and when applied upon the tongue it produces a sensation resembling that of fresh fat. Our recorded notices on the subject are, however, somewhat contradictory. Dr Mead and his associates, in certain experiments on the poison of the viper, inform us that that fluid, "when diluted with a little warm water, was very sharp and fiery when tasted with the tip of the tongue, as if the tongue had been struck through with something scalding or burning; this sensation went off in two or three hours; and one gentleman who would not be satisfied without trying a large drop undiluted, found his tongue swelled, with a little inflammation, and the soreness lasted two days." The Abbe Fontana, on the contrary, describes it as of no particular acrimony of taste, but rather resembling oil or gum; and Dr Russel makes the same statement regarding the poison even of the Cobra de Capello, a species much more venomous than any viper. The accounts of its effect upon the stomach, when taken internally, also show that doctors differ. It is long since Celsus said, "nam venenum serpentis non gustu sed in vulnere nocet." Boerhaave quotes the well-known case of Jacob Sozzi, who, at the court of the Duke of Tuscany, is alleged to have taken three drams of this poison, without experiencing any bad consequences; while Fontana affirms, that although its internal effect is not like that of a bite or puncture, it cannot be swallowed with impunity. On this point the older authors, as Dr Shaw informs us, also disagree. Matthiolus asserts, that even when sucked from a wound it has proved fatal; while others confirm the prevailing opinion of ancient writers, and the experience of Cato's soldiery, that it is harmless when so received. The practice, indeed, of the Psylli and Marmarides of old,

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[1] The glands in the head of serpents have been discussed in numerous publications. See, among others, Ranby, *Phil. Trans.* No. 401, p. 377; Tiedemann, *Mém. de l'Acad. de Munich*, 1813, p. 25; Cloquet, *Mém. du Mus.*, vii. p. 62; Demoulins ap. Magendie, *Journ. de Physiol.* iv. p. 274; Meckel, *Archiv*, i. 1; and Duvernoy, *Ann. des Sciences Nat.* xxvi. and xxx. Various observations bearing on the subject will also be found in the well-known writings of Redi, Mead, Fontana, and other physiologists.

> Tame, at whose voice, spell-bound, the dread Cerastes lay,

probably proceeded upon this principle of suction. These Psylli were African tribes, and were employed, according to Lucan, by Cato, for the recovery of such of his men as had been bitten by serpents during their march among the Libyan deserts. The heroic Roman is also said to have assured his followers, who feared to drink, even in "a dry and desert land," of the translucent fountains, lest they too should be infected by serpents, that, however noxious might be the bite of these envenomed reptiles, yet the poison must lose its effects when mingled with so pure an element.

> And now with fiercer heat the desert glows,
> And mid-day gleamings aggravate their woes;
> When, lo! a spring amid the sandy plain
> Shews its clear mouth to cheer the fainting train.
> But round the guarded brink in thick array
> Dire Aspics roll'd their congregated way,
> And thirsting, in the midst, the dreadful Dipsas lay.
> Blank horror seized their veins, and at the view
> Back from the fount the troops recoiling flew.
> When, wise above the crowd, by cares unquell'd,
> Their awful leader thus their fears dispell'd:
> Let not vain terrors now your minds enslave,
> Nor dream the serpent brood can taint the wave;
> Urged by the fatal fang their poison kills,
> But mixes harmless with those bubbling rills.
> Dauntless he spoke, and bending as he stood,
> Drank with cool courage the suspected flood.

The poison of the viper, according to Boerhaave, is rendered inactive by digestion in the stomach and bowels, so that it will not afterwards exert its fatal influence on the blood; "for a whole ounce of this venom taken by the mouth will not kill an animal, while at the same time a small needle only dipped in the same fluid, and taking up perhaps not more than the hundredth part of a drop, when thrust into the blood of a living creature, almost infallibly destroys."[1] The following is Bruce the traveller's well-known but extraordinary narrative. "I will not hesitate to aver that I have seen at Cairo (and this may be seen daily, without trouble or expense) a man who came from above the catacombs, where the pits of the mummy-birds are kept, who has taken a cerastes with his naked hand from a number of others lying at the bottom of the tub, has put it upon his bare head, covered it with the common red cap he wears, then taken it out, put it in his breast, and tied it about his neck like a necklace; after which it has been applied to a hen, and bit it, which has died in a few minutes; and, to complete the experiment, the man has taken it by the neck, and beginning at the tail, has ate it as one would do a carrot or a stock of celery, without any seeming repugnance."

This opinion, however, that the poison of snakes may be taken internally without producing any troublesome effects, has been recently contradicted by the experience of Dr Hering, at Surinam. This traveller took at different times various doses of the poison of a rattle-snake (*Crotalus mutus*) mixed with water, and suffered from its effects for upwards of eight succeeding days. These manifested themselves by pains in the larynx and other parts of the body, by an increased secretion of mucus in the membranes of the nose and œsophagus, and by frequent diarrhœa, accompanied by pain in the rectum. To these symptoms were added several others of a rather curious kind, attributable to the influence which this poison seemed to exercise even over the moral faculties.

By far the most deleterious effect, however, of this subtle fluid is produced by its mingling with the blood, through the medium of an inflicted wound. It then shows its morbid influence with a rapidity often frightful, and usually proportioned to the quantity of the poison instilled, and to the abundance with which the wounded part is furnished with those vessels which bear the stream of life. For this reason, of course, the bite of a large snake is more dangerous than that of a small one; and so also a wound in the tongue, or in any vein, is almost always mortal, while it not unfrequently happens, that when a hard or callous part is bitten, no injurious results are found to follow. Cold-blooded animals are much less affected by the bite of a snake than are quadrupeds or birds; and in the majority of invertebrated tribes it produces no effect whatever. Generally speaking, however, the smaller the victim, the more deadly are the consequences of a wound. In Europe, the human race scarcely ever suffers fatally from the bite of a viper; and it is supposed that the poison of several would be required to kill a bullock or a horse. So at least say many modern writers; yet we cannot help remembering what Boerhaave tells us regarding a viper, which, "being enraged by the members of the Tuscan Academy," and then suffered to bite the nose of a strong bull, the ponderous creature died in a very short time. A small quadruped dies rapidly from an infliction of the slightest wound. In tropical countries, however, where the poisonous species are often of considerable size, and their venom is both more abundant and in a state of higher concentration, the effects are fatal both to man and beast. The activity of the poison, in truth, increases with the temperature of the climate.

Various experiments have been tried, with a view to ascertain the strength of this animal poison in different species of serpents, and the best means of arresting its fatal influence. The observations of Laurentius, Fontana, Russel, Davy, and Lenz, are familiar to the student of physiology, but less satisfactory in their results than might be desired, from the modifying effects of special circumstances. To obtain well rectified general inferences, it would be necessary that numerous experiments should be tried with serpents of corresponding size, existing under similar circumstances, and in relation to victims of the same constitution; and by repeating these experiments with various kinds of serpents, and taking the average effect of each kind as a result, we might in a measure ascertain the different characters of these animal poisons, of which we have as yet but a meagre knowledge.

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[1] See Shaw's *General Zoology*, iii. p. 371.

The effect of a serpent's bite usually manifests itself without delay. A sharp pain is felt in the part pierced by the fangs, although the puncture is extremely minute, and scarcely a drop of blood may flow; swelling follows, and inflammation soon declares itself. The progressive effects upon other parts of the system are exhibited by a general feebleness; walking becomes painful, and respiration laborious and constrained; the patient suffers from ardent thirst, followed by nausea, vomiting, glimmering of the sight, and other symptoms, which, combined with acute bodily pains, often deprive the victim of his senses. Livid spots sometimes surround the wound, the dread precursors of that fatal gangrene which, spreading more extensively, ere long puts a period to existence. "His strength is poured out like water, and all his bones are out of joint; his heart is like wax, it is melted in the midst of his bowels. His strength is dried up like a potsherd, and his tongue cleaveth to his jaws, and he is brought unto the dust of death." Then, instead of the bloom of youth, the power of manhood, or the pride of beauty, we behold but a bloated corpse, the sad repulsive remnant of humanity. It may be remarked, however, that the poison of these subtle reptiles seems to deprive us of life under a considerable variety of aspects. A lethargic torpor without pain is said to follow the bite of the asp; and hence, we presume, its preference by that luxurious queen for whom Antony "lost the world." The fact, though doubted by medical observers, seems in a great measure confirmed by the examples adduced by Captain Gowdie, as recorded by Dr Russel.[1] Lucan of old has distinguished the poisonous serpents that infested the march of the Roman army over the deserts of Libya, by the various symptoms which they produced; but his dreadful catalogue should perhaps be regarded rather as a piece of poetical embellishment than as an historical relation. Yet it seems now believed, that however the symptoms may vary, the nature and action of the poison is the same in all, and is in most cases to be counteracted by the same means. The virulence of the bite even of individuals of the same species probably varies according to the season of the year, just as their manners and external aspect also vary, as so beautifully described by Virgil.

> Postquam exhausta palus, terræque ardore dehiscunt;
> Exilit in siccum, et flammantia lumina torquens
> Sævit agris, asperque siti, atque exterritus æstu.
> Ne mihi tum molles sub dio carpere somnos,
> Neu dorso nemoris libeat jacuisse per herbas:
> Cùm positis novus exuviis nitidusque juventu,
> Volvitur, aut catulos tectis aut ova relinquens,
> Arduus ad Solem, et linguis micat ore trisulcis.[2]

The excessive rapidity with which death was frequently produced by the bite of venomous serpents, induced Dr Mead to conclude that its fatal influence affected the nervous rather than the circulating system. But the experiments of Fontana go far to demonstrate that the venom of the viper is perfectly innocent when applied to the nerves only; but that it acts immediately upon the blood, and through the medium of that fluid destroys the irritability of the muscular fibre, and so produces death. A different idea has been more recently proposed; that the poison of serpents acts upon the blood by attracting the oxygen which it contains, and which is believed to be essential to its vital functions. The human heart, and in general the heart of all animals with warm blood, has two ventricles or cavities; and the blood, before it is returned to the right ventricle, has to perform two circles, a lesser between the heart and the lungs, and a greater between the heart and the rest of the body. While the blood passes through the lungs, it undergoes a very remarkable change of colour, and of other properties. A certain portion of atmospheric air is attracted and absorbed, while the remainder carries off by expiration whatever ingredient of the blood is either unnecessary or injurious. The atmosphere we respire is a compound fluid, of which one portion is oxygen or pure air, and another and much larger is noxious or azotic air; and it is the former ingredient only which is attracted by the blood in its passage through the lungs, and contributes to the maintenance of animal life. From this combination, the heat of animals, and the brilliant colour of the blood, are supposed to be derived.

The preceding observations will enable the reader to comprehend more clearly the theory of the action of poisons proposed by Mr Boag. He adduces the following arguments in its support: 1. Man and other warm-blooded animals, exposed to an atmosphere deprived of oxygen, quickly expire. The poison of a serpent, when introduced into the blood, also causes death; but carried into circulation by a wound, and in very small quantity, its operation is comparatively slow and gradual. 2. The appearances on dissection are very similar in both cases, the blood becoming of a darker hue, and coagulating about the heart and larger vessels. The destruction of the fibrous irritability, and tendency to rapid putrefaction, are also remarkable in each. 3. Although Dr Mead mingled the venom of a viper with healthy blood *out* of the body without perceiving it produce any change in its appearance, this is presumed to arise from his having mixed a very small portion of poison with a large portion of blood; but if two or three drops of venom be mixed with forty or fifty drops of blood, it immediately loses its vermilion colour, becomes black, and incapable of coagulation. 4. It is, moreover, a remarkable circumstance, that the poison of serpents has most power over those animals in which the blood is the warmest and the action of the heart the most lively, while it is but a tardy and altogether uncertain instrument of death to the majority of cold-blooded creatures. Of this the reason is, as Mr Boag supposes, that cold-blooded animals do not require a large quantity of oxygen to preserve their lives; a fact otherwise sufficiently obvious from the conformation of their heart and respiratory organs. Fontana's experiments with a view to the prevention of the fatal effects of poison, may be here stated in a few words. He applied lunar caustic, which is a preparation of silver in nitric acid, and found on so doing, that not only was the venom thereby rendered innocuous, but the corroding power of the caustic greatly diminished. He next wounded a variety of animals by means of envenomed teeth, and scarifying the wounds, he washed them in a solution of lunar caustic and water, and by this means saved the lives of the greater number, although they belonged to species which he knew to be easily killed, while the death of others was greatly retarded. These experiments, it may be added, neither proceeded upon nor led to any theory.

Now the application of the following admitted facts is presumed by Mr Boag to explain the efficacy of Fontana's treatment, and to illustrate the accuracy of his own views. 1. Oxygen enters into the composition of all acids, and is the principle, as its name imports, on which their acidity depends. 2. Metals are united with oxygen under various circumstances, but chiefly in two ways; the first is by burning them in an open fire, or, to speak more philosophically, by the contact of heat and air, when they are converted into metallic oxides; the second is by the decomposition of acids, when they form compound salts. 3. Oxygen is attracted by different metals with different degrees of force; those which attract it with the least force are the more perfect metals, such as platina, gold, and silver, which cannot be converted into oxides, except at very high temperatures; whereas arsenic, and many other substances, attract it strongly, and are usually found in combination with it even in the bowels of the earth. If, therefore, the mortal effects which arise from the bite of a serpent result, as stated by Mr Boag, from the subtraction of oxygen from the blood, it is natural to suppose that the most efficient cure must consist in the renewal of that vital ingredient; and the most obvious and easy mode of accomplishing this will be, to employ such substances as are known to contain oxygen in the greatest abundance, and to give it up with the greatest facility. This is precisely the character of lunar caustic, which is made by dissolving silver in nitric acid, and afterwards evaporating and crystallizing the solution.[1]

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[1] In his work on the *Serpents of the Coast of Coromandel.*

[2] *Geor.* lib. iii. l. 432.

In further illustration of this singular subject, we may here give a brief account of the effect produced by the bite of some remarkable salt-water snakes, belonging to the genus *Hydrus* (*Hydrophis* of our present treatise). Soon after the opening of the bar in the month of October 1815, reports prevailed at Madras that a great shoal of sea-snakes had entered the river, and that many natives while crossing had been bitten, and had died in consequence. A reward was offered for each of these creatures captured and carried to the superintendent of police. Pandauls were erected opposite to the two principal fords, and skilful natives, under the direction of Dr M'Kenzie (to whom we are indebted for the information), were provided with eau-de-luce and other remedies, and ordered to afford immediate aid to those who might be bitten. Many were bitten accordingly (the snakes seeming in no way loathe to expedite the result), and all exhibited the symptoms usually consequent upon the action of a powerful animal poison; but none died. We shall state a couple of cases, with the mode of treatment. A native woman, while crossing near the custom-house, was seen, on emerging from the water, to shake off something from her foot. This to several spectators appeared to be a water-snake. The woman, after advancing a few paces from the river, fell down, and was immediately carried insensible to the pandaul. On examining her feet, two small but distinct wounds were perceived on the ankle of the right leg; her skin was cold, her face livid, her breathing laborious, her pulse scarcely perceptible. A ligature was immediately placed above the wound, which had been previously enlarged with a lancet, and a piece of the carbonate of ammonia well moistened with pure nitric acid applied, while thirty drops of the eau-de-luce were administered nearly at the same time in a glass of water. In five minutes more a similar dose was poured down the throat, which seemed rather to increase the spasmodic affection of the chest; but the pulse at the wrist became distinct, though feeble. A third dose was repeated in three minutes more, on which she uttered a scream, and began to breathe more freely. Ten minutes had now elapsed since she had been carried to the pandaul, and in about three minutes more a tea-spoonful of the eau-de-luce was given, which almost immediately produced violent nausea, and a profuse perspiration. When a little salt was put into her mouth, she declared it was not salt, but sugar; and this the natives deemed an infallible sign of still-continued danger. She soon, however, entirely recovered, and merely complained for three or four days of a numbness in the limb above the wound. Another case was that of a Lascar, who was bitten by a snake while in the middle of the river. He advanced a few paces after quitting the bank, and then fell down in violent convulsions. When brought in, his breathing was laborious, his skin cold and clammy, his countenance livid, and his pulse feeble at the wrist, but distinct at the temples. A quantity of froth and foam was ejected from between his closed teeth. He too recovered, after a similar mode of treatment; but he complained for many days *that he had no left leg*. On another occasion a large healthy chicken was exposed to the bite of a *Hydrus major*, four feet long. It was bit in the foot, and in about ten minutes began to droop, and to show a slight convulsive flutter of both wings. In three minutes more it became convulsed, and at the end of seventeen minutes from the infliction of the wound it suddenly dropped down dead.[2]

Dr Russel has figured and described forty-three of the most common serpents of Hindustan, and of these he found only seven that were provided with poison-fangs. He informs us, that a quantity of warm Madeira taken internally, with an outward application of eau-de-luce on the punctures, was generally successful in curing the bite of even the most venomous species. He also states that the medicine called the Tanjore pill was equally efficacious. On comparing the effects of the poison of five of the oriental species on brute animals, with those resulting from the rattle-snake and European viper, Dr Russel remarked, that they all produced morbid symptoms nearly the same, although they might differ in the degree of their deleterious power, and the rapidity of its operation.

The tongue of serpents is remarkable for its great extensibility. It is protected by a rather firm skin, becomes very slim towards the anterior extremity, where it divides into two slender filaments, and is capable of being withdrawn into a kind of sheath, which opens in front of the glottis. The position of these parts varies in the different species, being placed, for example, very near the muzzle in the genus *Hydrophis*, but much further backwards among both the terrestrial and the tree serpents. The tongue of the Ophidians in general, though extremely similar to that of certain Saurians, such as *Monitor*, *Tejus*, and other genera, yet differs in the far greater simplicity of the harder parts by which it is supported; for we find, in place of a hyoid bone, composed of several pieces, merely a simple cartilaginous thread attached to the internal face of the general integument of the gular region, with its two extremities prolonged greatly backwards. This cartilage is sometimes, as in *Boa*, intimately united to the muscles of the throat, of which it intersects the fibres, its posterior extremity being then attached to the skin on the sides of the neck; but in the majority of cases, the horns of the hyoid are free, closely approached, and prolonged into the cavity of the chest, even as far as the heart. The tongue of these reptiles seems in truth, by its construction, to be a genuine organ of touch, and serving neither for taste nor deglutition, being during the latter act enclosed within its sheath. A little notch-like aperture at the end of the muzzle, which exists in most serpents, except the aquatic kinds, admits the protrusion of the tongue without the necessity of opening the mouth. This movement is usually made very leisurely, although with extreme rapidity when the individual is excited either by fear or passion.[3]

The use of the tongue in serpents is not exactly known. Its narrow and cylindrical form would render it unapt to aid the process of mastication, even were the teeth of a nature to perform that process. They are continually lancing it into the air, and may possibly in this way also gather moisture from grass or other herbage. It is, however, believed that they never drink. "On ignore," says M. Schlegel, "si les serpens boivent, et s'il est juste d'opiner pour la negative; toutefois on n'a jamais aperçu des fluides dans ceux dont on a examiné l'estomac."[1] Other authors, however, are of a somewhat different opinion. "Tout au plus," say MM. Dumeril and Bibron, "cette langue fort longue sert-elle, comme on l'a observé quelquefois, à faire pénétrer un peu de liquide dans la bouche, car nous avons vu nous-même des couleuvres laper ainsi l'eau que nous avions placée auprès d'elles dans la cage où nous les tenions renfermées pour les observer à loisir."[2]

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[1] See a paper *On the Poison of Serpents*, by W. Boag, Esq., *Asiatic Researches*, vol. vi. p. 103; and *Edinburgh Cabinet Library* (Zoology of India), vol. viii. p. 117.

[2] *Asiatic Researches*, vol. xiii. p 329.

[3] See Helmann, *Uber den Tastsinn der Schlangen.*

The alimentary canal of the Ophidians is remarkable for its great simplicity.[3] The œsophagus and stomach form a continuous canal, to the special parts of which it is difficult to assign precise limits. The pancreas, according to M. Schlegel, is always placed "dans la première courbure qui fait l'intestin à partir du pylore," and varies in different species both as to size and form. The spleen is of an oval or somewhat globular shape, of a rather firm consistence, and frequently concealed among the lobes of the pancreas, with which it is sometimes intimately united. The liver in Ophidian reptiles assumes a long ribbon-shaped form, more slender at either end, sometimes imperfectly divided into a couple of lobes, and extending along the œsophagus and stomach, from the heart as far as the pylorus. The hepatic canal descends from its interior face towards the pancreas, to conduct the bile into the small intestine. The gall-bladder, which is abundantly supplied, discharges its fluid by a short conduit, which joins the hepatic canal at an angle more or less acute. The kidneys, remarkable for their lengthened form and symmetrical position, are divided into a great number of small lobes, adhering to each other by means of the cellular tissue.

Digestion, notwithstanding the activity of the gastric juice, is sufficiently slow in serpents. It would appear, in fact, that the juice in question exercises its influence chiefly in the regions near the pylorus; for it has been found that an animal withdrawn from the abdomen of a snake is always decomposed towards its lower extremity, while the portion lying nearer the œsophagus continues unconsumed. Indigestible portions, such as hair, feathers, &c. are said to be sometimes ejected by the mouth; and, according to M. Dieperink, when a serpent in a wild state is pursued soon after it has swallowed a considerable prey, it will disgorge it to facilitate the means of escape. In regard to the digestive faculty of serpents, one of the most remarkable characters consists in the strong absorbing power of the intestines. When we examine their fecal remains, we find that these exhibit as it were a dry extract of the entire prey, of which the parts incapable of liquefaction remain not only unaltered, but occupying precisely the same relative positions which they held in the living animal. If, for example, a rat has been swallowed, we find, in what at first appears a dry and unformed heap, the muzzle, the long hairs upon the cheeks, the down which covers the thin cartilage of the ears, the hair, of various length and colour, which has clothed the back, abdomen, and especially the tail, and finally the nails, in a perfectly entire state. All fleshy or softer substances have been completely absorbed; and the earthy salts, which by their union with the gelatine give consistence to the bones, still indicate by their colour the position formerly occupied by these osseous portions. The most complete natural analysis has been effected by means of dissolution, compression, and absorption,—and of this the desiccated mass already mentioned is the sole residuum.[4] The infrequent meals of serpents are thus in a measure compensated by the great profit which they derive from each.

The mode in which these reptiles swallow their food is sufficiently simple. They commence by getting the head within their throat, and while the teeth of one jaw adhere to the prey, the other jaw makes a forward movement, and, fastening its teeth, draws the object inwards, till by this alternate action of the jaws, and chiefly of the under one, deglutition is effected. The jaws, as we have already hinted, are capable of a certain separation from each other even at their basis, and an abundant supply of saliva being at the same time poured out upon the victim, a body larger in bulk than the snake itself is sometimes swallowed; and as in this case the process is slow, and but a small portion can enter the throat at a time, the reptile reposes for a considerable period, even till, with distended mouth, it seems gorged with putrefaction, presenting a hideous and disgusting picture of gluttony and sloth. When the venomous kinds swallow their prey, they do not use their poison-fangs, but lower these beautiful and highly-finished instruments of destruction into the hollow of the gums,—"sheathing them as a sword."

The heart of Ophidian reptiles is usually of an elongated form, and is remarkable for its distant position from the head. It is composed of two spacious auricles, separated from each other by a membranous division; the ventricle, on the contrary, is imperfectly divided into two rather narrow cavities, by a partition which takes its origin from the base of the heart, and loses itself amid the fleshy fibres of that region. The walls of the auricle, although fleshy, are slender,—those of the ventricle are of considerable thickness, especially on the left side of that portion which extends in the form of a conical appendage beneath the left auricle. Each auricle communicates with the ventricle by means of a broadish opening, susceptible of being closed by a valve. The right auricle receives all the veins, which form, with the exception of the left jugular, prior to passing through the wall of the auricle, a kind of sac of greater or less extent, which, in addition to the ordinary tunics, exhibits a distinct muscular coat. Two large valves serve to close the common entrance of the veins into this auricle. When the blood has attained the right chamber of the ventricle, it is driven into the pulmonary artery, of which the embouchure offers two valves; comprised at its base in the common trunk of the aortas, this artery curves itself beneath the left aorta, and approaches the lung, of which it margins the posterior face before entering the interior of that organ. A single pulmonary vein, piercing the lung behind the artery of the same denomination, carries the oxydised blood into the left auricle, which is of a conoid form, and less spacious than the right one. This oxydised blood, after having passed into the left cavity, is pushed towards the right side, where we find the embouchures of the two aortas, of which each exhibits a pair of semicircular valves, even when these openings are united into one.

We shall now devote a few lines to the respiratory organs. When we observe a serpent in a state of repose,—

as on the grassy herb
Fearless, unfeared, he sleeps,—

we may see that its body alternately dilates and contracts by the play of the ribs, and that this movement is repeated slowly, yet at regular intervals. But we may also perceive, that the nostrils are closed for a longer, and consequently an unconforming period, during one of which the body is contracted and dilated perhaps thirty times. It results from this observation, that the lungs of Ophidians, besides their ordinary function, fulfil that of serving as reservoirs of atmospheric air, which, though replenished only by a single inspiration, contain a quantity sufficient to admit a continuous oxydation of the blood by the contraction of the lungs. When the oxygen is totally absorbed, expiration takes place, and a supply of fresh air is drawn in. The configuration of the lungs undergoes many modifications in the different races of Ophidian reptiles. The form is usually that of a simple conical sac, extending from the heart toward the lower regions of the stomach, where it ends in a membranous pouch. The trachea, composed of numerous demi-rings united anteriorly by a membrane, terminates in the origin of the lungs by an oblique opening. The latter organ is divided more or less completely into two bronchiæ in *Boa*, the majority of *Tortrix*, the genus *Dipsas*, and others; and in these we may perceive the vestige of a second lobule of the lung, sometimes half as large as that on the other side. A singular peculiarity is observable among the sea-serpents. In *Hydrophis colubrinus*, for instance, the tracheal pipe is prolonged into the hypochondriac region, where it terminates in a membranous sac, extending to within a couple of inches of the anus; but in place of a membrane uniting the rings of the trachea, it is the lung itself that envelopes that tube throughout its whole length.

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[1] *Physiognomie des Serpens*, i. 97.

[2] *Erp. Gen.* i. 135.

[3] The digestive organs are described by Duvernoy in *Ann. des Sciences Nat.*, and by Meckel in his *Vergl. Anat.*

[4] *Erp. Générale*, i. 145.

The small size of the brain in serpents is obvious in all, and becomes very conspicuous in relation to the size of the head, when we select for observation any of those species in which the organs of manducation are strongly developed. The two hemispheres are prolonged by restriction into the olfactive lobule, so that the latter part is borne, as it were, upon a pedicle. We observe the optic lobules on their posterior face, and passing beneath the hemispheres towards the eye, to form the optic nerve. The cerebellum is a very small organ, situate behind the optic lobules, almost uniform with the spinal cord, or offering but an inconsiderable enlargement. The grand sympathetic nerve is interlaced at so many points with the par vagum, that it is next to impossible to trace its origin with any certainty.

As to the intellectual faculties of these reptiles, we know that Satan found

> The serpent subtlest beast of all the field;

and we doubt not that, even in our own days, they may be placed at least upon an equality with the Saurian and Chelonian orders. The reproductive power with which their separate parts are said to be endowed has probably been the subject of some exaggeration; and it seems certain that when the tail or other important portion has been destroyed by mutilation, it is altogether incapable of being reproduced. The sense of smell is believed to be by no means acute in these reptiles. The nostrils vary in the different genera in respect to form, size, and position. It may, however, be stated as a constant rule, that the purely aquatic species have the nostrils small, directed upwards, and for the most part susceptible of being closed by means of a valve, while those of the terrestrial and arboreal kinds are usually lateral and open. Among the burrowing serpents these openings are almost always of an orbicular form, and of very small dimensions. In the genera *Trigonocephalus* and *Crotalus* there is a cavity on each side of the muzzle, behind the nostrils, of which the use is still unknown. The eye is probably defective in the power of distant vision, though sufficiently acute for all the ordinary purposes of a serpent's life. It is covered over by the external skin, of which, however, the tunics are in that quarter extremely thin and diaphanous, and present themselves under the form of a hemispherical lamella adhering to the scaly plates which surround the orbit. There is thus no apparent eye-lid to the visual organs of serpents, a slight edging of the skin forming their only protection.[1] The supposed absence of this part was presumed by the ancients, and has been recorded in the writings even of modern anatomists of the greatest skill. But more recent researches, undertaken by M. Cloquet, and verified by Baron Cuvier and M. Dumeril, have demonstrated that the eye of Ophidians is covered by a single lid, large though immoveable, and incased in a projecting frame, which forms around the orbit a series of scales, variable in number, though usually amounting to seven or eight. When the general covering is renewed, we find that a delicate coating of the eye is likewise thrown off as a portion of the exuviæ. The structure of the ear in serpents seems to demonstrate that these creatures are dull in their sense of hearing.

The general envelope of Ophidian reptiles forms a kind of cuirass, which enables them to withstand the influence of the elements and the effects of external accidents. To conform to the movements of the body, and the occasional enlargement of its parts, this covering, we need scarcely say, is composed of a multiplicity of separate compartments, of which the smaller are called scales, the larger plates. These parts are composed of much thicker layers of the integument than the intervening portion, which consists of a delicate skin, seldom visible except when the body is more than usually distended, and for this reason almost always colourless, being unsubjected to the influence of light. In certain species of the genus *Tropidonotus*, however, the mucous membrane of the neck is so tinted as to exhibit a beautiful vermilion-red between the scales; and the scales themselves in many species exhibit colours, both fixed and iridescent, of great brilliancy:—

> With burnished neck of verdant gold, erect
> Amidst their circling spires.

The general tinting depends in a great measure upon the condition of the epidermis, and is always freshest and purest immediately after the casting of the slough or superficial skin. The total amount of longitudinal rows of scales is almost always an unequal number, there being a single range rather larger than the rest along the centre of the dorsal region, with an equal number on either side; but to this rule *Herpetodryas carinatus* forms an exception (the only one perhaps throughout the order), there being a double central row of scales along the back. The form of the scales is greatly varied, some being rounded on the margins, others truncated at the extremity, or prolonged into a sharpish point. The greater number are what naturalists call *imbricated*, that is, lying slightly over each other like the tiles of a house; but almost all sea-serpents have the scales of a hexagonal form, with the epidermis very thin.

The median line of the lower parts is usually covered by a range of broad scaly plates, of much larger dimensions than the ordinary lateral and dorsal scales; and the caudal plates are generally different from those of the abdomen. The latter form a single uniform range from the anus to the throat, where they disappear. They are sometimes narrow, as in the genera *Boa*, *Tortrix*, &c., and in such cases resemble the scales of the back; but in the far greater number they are so broad as to encroach even on the flanks, and thus occupy a large proportion of the circumference of the body. The plates beneath the tail do not form a single central range, except in *Boa*, *Eryx*, and a few other Ophidians, the majority of the order having the part in question provided with a double row of plates. We may add, that the terminal plates of the abdomen also not unfrequently partake of this divided character.

The head of Ophidian reptiles is rarely clothed with scales of a character similar to those of the body. They are larger, and of a more determinate and symmetrical form; and as they offer distinctive characters of easy application, they have received from M. Schlegel various names, in accordance with the position they occupy, such as vertical, occipital, superciliary, frontal, rostral, labial, ocular, frenal, temporal, mental, and gular.[1]

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[1] " Nous avons dèja dit qu'il n'y avait pas de paupières apparentes dans les serpens, et que ces animaux semblent, par cela même, avoir l'œil fixe, et être toujours éveillés." (*Erp. Gén.* i. 102.)

The system of coloration which prevails among these insidious creatures is very varied, and admits of numerous exceptions to any general laws which we might attempt to establish in its illustration. In numerous species there is a beautiful accordance between the tinting of the body and the colour of the places they inhabit; thus many tree-serpents are of a uniform greenish hue, exactly similar to that of the foliage by which they are overshadowed, while several kinds of *Dendrophis* and *Dryophis* seem rather to imitate the small and leafless branches. In the genus *Dipsas* the colours recall to mind those of the mossy trunks of ancient trees; fresh-water snakes are usually of a sombre uniform hue; while the marine species partake of those clearer tints of green and blue which beautify the pellucid billows of the up-heaving sea. Such as dwell in dry and desert lands are often to be scarcely distinguished from the parched sand by which they are surrounded; while others, which affect a more varied soil and richer vegetation, are adorned with the gay and gorgeous colouring of flowers, or the metallic splendour of the mineral kingdom. Several have their bodies encircled by alternate bands of crimson and black upon a pearly-white or delicate yellow ground, and present an aspect as richly adorned as any we can discover throughout the entire range of the animal world.

> Lovelier not those that in Illyria changed
> Mermione and Cadmus, or the God
> In Epidaurus, nor to which transformed
> Ammonian Jove, or Capitoline was seen :
> He with Olympias, this with her who bore
> Scipio, the height of Rome.

Among the more beautiful may be mentioned *Coronella venustissima* and *coccinea*, *Lycodon formosus*, several species of *Tortrix* and *Heterodon*, the majority of the genus *Elaps*, *Naja lubrica*, *Dendrophis ornata*, and *Dipsas macrorhina*. Numerous other species are equally remarkable, both for the splendour and diversity of colour by which they are adorned; but as these bright hues are subject to numerous causes of variation, from age, sex, and season, it results, that among no order of created beings is the always uncertain character of colour to be less depended on than among the subjects of our present dissertation. It seems, however, established as a general law, that the younger individuals have the liveliest and most distinct tints, and that these in more aged examples are not unfrequently effaced, or fade away, as we find in *Coluber canus* and *melanurus*, *Homalopsis buccata*, *Xenodon severus*, and others. The power of speedy and spontaneous change of colour does not, however, seem to be a possession of the Ophidian order, as it is of so many of the Saurian tribes. Yet a few of the arboreal serpents have been occasionally observed to modify their living tints from time to time.

The natural colours of these creatures can scarcely be judged of from specimens imported to our cabinets from foreign climes. The spirit in which they are preserved is not the spirit of beauty. Black, brown, ochry-yellow, and several other tints, do not altogether lose their lustre; and *Calamaria arctiventris* and *brachyorrhos*, *Tortrix maculata* and *xenopeltis*, *Coronella rufula*, *Lycodon hebe* and *subcinctus*, *Coluber constrictor*, *Æsculapii*, and *melanurus*, and several kinds of *Naja*, *Homalopsis*, and *Vipera*, may be named among those which are most easily preserved. But green speedily tarnishes after death, loses its vivacity, and becomes bluish; it even communicates its tint to spirit of wine. White almost always loses its purity, and becomes of a soiled or yellowish aspect, while pale yellow passes into dingy white. The brilliant hues of red and orange with which so many species are adorned, almost entirely disappear, and are converted into dingy or brownish yellow. Blue, which is rather a rare colour among Ophidian reptiles, also quickly fades away, and the more exposed the specimens are to the influence of light, the more rapidly are these and other changes effected.

In discussing the various branches of natural history, it is the practice of authors to state the *uses* of each particular tribe of animals to the human race. We fear, that in relation to our present subjects, a single paragraph may suffice. Serpents certainly confer benefit by destroying other injurious creatures, such as small mammiferous vermin, worms, insects, and mollusca of various kinds. They were formerly used in medicine, though that practice, we believe, is now confined to the ignorant and superstitious; yet it has been recently stated, that Dr Marikrosky, of Rosenau, in Hungary, has employed the gall of serpents with success in epileptic cases.[2] It is well known that the flesh of the viper has been highly esteemed, both by ancient and modern physicians, as a restorative and strengthening diet. This idea, as Dr Shaw has well observed, seems to have originated from the reptile casting its skin, a natural process, viewed by the vulgar as a renovation of youth; and a snake being made the emblem of health, and consecrated to Æsculapius, may have depended on the same idea. The flesh of the viper was used by the ancients in leprous and other cases. "The Greek physician Craterus, mentioned so often by Cicero in his Epistles to Atticus, cured, as Porphyrius relates, a miserable slave, whose skin in a strange manner fell off from his bones, by advising him to feed on vipers' flesh in the manner of fish. Antonius Musa, physician to Octavius Cæsar (Augustus), is said by Pliny to have ordered the eating of vipers, in the case of otherwise incurable ulcers, which by this method were quickly healed; and Galen says, that those who are afflicted with elephantiasis are wonderfully relieved by eating vipers' flesh dressed like eels."[3] According to Lopez, the negroes of the coast of Congo eat roasted adders, and regard them as delicious food. It is well known that the credulous Sir Kenelm Digby, with a view to recover his wife, the Lady Venetia, from consumption, caused her to feed on capons fattened with vipers. But we need not detain our readers with more of these, at best, ambiguous views. To proceed with our natural history.

In European countries, the copulation of serpents usually takes place, in fine weather, during the months of April and May, and three or four months elapse before the eggs are laid. Incubation is effected within the body of the female; for, on opening an egg immediately after exclusion, we almost always find a fœtus more or less developed, sometimes entirely formed. In the latter case, the so-called shell is merely a delicate membrane, through which the young can force their way, even at the moment of parturition. In the greater number of species, however, the eggs are composed externally of a resistant covering resembling parchment, the young being very imperfectly formed at the period of deposition, and requiring sometimes a month or more before they are hatched. It is merely this difference in the times of final exclusion that constitutes the distinction between the viviparous and oviparous kinds, these being otherwise essentially the same. All Ophidians are in truth oviparous; and those naturalists are in error who compare this seemingly viviparous generation to that of mammiferous animals, in which the young are nourished by the placenta of the mother. According to M. Herholdt,[4] the conditions most favourable to the development of these embryons are humidity, produced by a feeble vegetable fermentation, with a proportional temperature (between + 20° and + 6° R.), and under circumstances likely to favour absorption and evaporation through the external tunic of the egg. Hence their love of dunghills, or heaps of leaves piled up in places open to the sun.

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[1] See *Physiognomie des Serpens*, i. 60.

[2] Hufeland, *Journ. Ann.* 1831, cah. 10.

[3] *General Zoology*, iii. 372.

[4] *Oversigt.* 1830, p. 4.

The supposition entertained by many is incorrect, that poisonous serpents always produce living young, and that the innocuous kinds as constantly deposit eggs. This diversity in the generative process does not seem to bear any relation to the organization of the species; at least we find the two modes exemplified in nearly-related species of the same genus. Thus the harmless *Coronella lævis* produces young as lively as those of the common viper; *Boa murina* is also viviparous, while the deadly *Najas* and several others lay eggs. The number of young ones varies in different species. M. Schlegel did not find above ten in several kinds of *Calamaria*, from twenty to twenty-five in the genus *Coluber*, and above thirty in *Trigonocephalus atrox*. The offspring usually differ from their parents in being of more lively colours, with the head blunter and rounder, the eyes larger, and the scales and other appendages of the epidermis less raised. They are, however, furnished with teeth exactly like those of their respective parents, and of which they do not fail, when occasion offers, to make speedy use. The venomous kinds instinctively elevate and depress their poison-fangs, as if ready from the first to defend themselves against that persecution to which their race is subjected. The European kinds are known to change their skins about five times every summer, that is, once a month from the end of April to the beginning of September. They are capable of long-continued abstinence, independent of the lethargic state into which the northern species fall in winter. A *Boa constrictor* sent from Surinam to Holland fasted continuously for six months. The age to which serpents attain is to us unknown.

We shall now devote a few pages to a branch of our subject of peculiar interest, which we have seldom altogether neglected in relation to other departments of zoology in the course of the present work, and which, so far as concerns the singular beings now under more particular consideration, has never been at all discussed in any work accessible to the English reader,—we mean the distribution of serpents over the earth's surface.

A knowledge of the geographical distribution of reptiles may be regarded, not only as highly interesting in itself, but as extremely important in relation to the general subject of the location of organized life. Numerous diversifying agents tend to alter the original position of plants. Their seeds are carried hither and thither both by winds and waves, the human race have transported them to and from many distant regions, and artificial culture has so changed their natural characters, that the very earth which bore them can no longer recognise her offspring. A vast majority of living beings are created with the means of transporting themselves, with more or less facility, from one country to another. Many quadrupeds are continually extending the sphere of their original habitation; birds of powerful flight wing their buoyant way from clime to clime; while the liquid depths of ocean offer a vast continuous space, within which the finny tribes may exercise their migratory movements. But it is far otherwise with the race of reptiles, especially the footless tribe of serpents. Destitute of the power of long-continued locomotion, they never attempt to travel far from the places of their birth, and thus, even in our own days, they still represent more accurately than do the other classes of the animal kingdom the positions in which they may be supposed to have been originally placed. Such as inhabit northern countries, and are at the same time incapable of enduring cold, having no power to flee from the rigours of winter, escape its effects by falling into a state of lethargic repose.

It is obvious, then, that the geographical distribution of serpents presents a peculiar interest, inasmuch as it tends to make us acquainted with the true and natural relations which exist between these creatures and the places they inhabit, and thus in a measure presents us with a picture of the primitive state of matters, before man's intermeddling, and other supervening agents, had altered the local relations of animal life.

One of the most curious general facts in the distribution of serpents, is their apparent absence (at least so far as the land species are concerned) from the numerous islands of the vast Pacific Ocean,—a circumstance not altogether to be accounted for by the isolation of these various groups, seeing that those of the Indian Archipelago particularly abound with serpents. Another fact seems still more firmly established, that the reptiles of the New World are all specifically different from those of the Old,—a peculiar feature in the history of their class, in so far as many quadrupeds and birds are common to both countries. At the same time it may be borne in mind, that it is only the species of very northern portions of the two continents which are in any case identical, and that as these northern portions are almost, if not entirely, destitute of reptile life, the field is greatly narrowed, so far as that form of existence is concerned. The snakes of South America are in general very distinct from those of the northern portions of the New World, although a few are identical. Several of the southern species inhabit the West Indies and the warmer parts of the United States, where they form what may be termed *climatic varieties*. Other species more characteristic of a large extent of North America, reach as far south as Mexico and the Antilles. America in general, especially its equatorial districts, is almost as rich in snakes as the Indian islands. It is otherwise with New Holland, where these reptiles are by no means numerous, but where the species, excepting perhaps a few of its more northern kinds, are peculiar to the country. The serpents of Japan seem, without exception, to belong to particular species not hitherto observed in other quarters of the world. The numerous islands of the great Archipelago of the Indian Ocean produce in several instances identical species, and these, moreover, are not unfrequently the same as those of Malacca, Bengal, Hindustan, and Ceylon. If we may judge from the few known species, the serpents of Madagascar may be regarded as peculiar to that vast island. Africa, compared with other great equatorial continents, cannot be said to be very rich in these reptiles. Its southern portions produce species entirely different from those of Europe and of other countries; but these species have a wide range in Africa itself, being in many cases spread over all its intertropical regions, and even its northern parts. These comparatively northern countries, in addition to some peculiar species, produce several others which likewise inhabit the shores of both sides of the Mediterranean. Many of our European serpents are found over a large portion of temperate Asia,—a region which appears to produce but a small proportion of peculiar species.

The geographical distribution of families and genera,—these being viewed as representing various leading forms,—affords an equally curious subject of observation. We may notice, in the first place, that the venomous sorts are distributed, with the exception of a few islands, over whatever countries produce serpents of any kind. These venomous species bear no determinate co-relation, as is often supposed, to intense heat; for they occur in cold and temperate countries equally with the innocuous kinds. But their aggregate number is much more limited than that of the latter; for while we reckon the total number of known Ophidians at 263,[1] we do not find above fifty-seven of these endowed with injurious attributes,—that is, the proportion is not much more than one to five. This proportion, however, is not maintained throughout the various countries of the globe,—the venomous kinds seeming to be comparatively more numerous in open sterile countries. Of this, Africa and New Holland furnish examples,—the venomous species of the former continent being to the innocuous kinds as one to two or three, while of the ten species (or thereabouts) of ascertained New Holland species, not fewer than seven are venomous. In general, the number of individuals of each species is much more limited among the venomous kinds, as these live in an isolated manner, and rarely multiply so as to become abundant. Local circumstances sometimes favour an exception to this rule, as in the case of the *Trigonocephalus lanceolatus* of Martinique and St Lucia, and that of the Dalmatian *Viperus ammodytes*. The sea-snakes, all of which are poisonous, are likewise of a gregarious nature.

Excepting the anomalous group called *Tortrix*, there does not seem to exist any genus of serpents which is spread over all countries capable of maintaining reptile life; and this restriction seems to illustrate the intimate relation which subsists between the organization of these beings, and the countries they inhabit. For example, the Colubers properly so called, which are destined to dwell in countries which are either well wooded, or marshy with abundant vegetation, have not yet been observed in New Holland, and are so rare in South Africa that only a single species has been found there, and that of a somewhat anomalous nature, in so far as its characters exhibit an approach to those of species which dwell by preference in sandy deserts. A similar observation applies nearly to the genus *Coronella*, composed of species which inhabit marshy plains, or such as are covered by brushwood. None of these occur in New Holland (which is noted for its frequent want of water), while the South African kinds differ from the typical species of the genus. The *tree-serpents* are characteristic of equatorial countries, inhabiting of course only those portions which fulfil the conditions of their existence, that is, are well wooded. The three genera which compose the family are found both in the Old and New World; but it is noticeable that the species of the genus *Dipsas* of America do not attain to so great a size as the majority of those of India; while the genus *Dryophis* in America forms a true geographical division of the group, in so far as the dental system and muzzle are less developed, and the pupil of the eye is orbicular. The fresh-water snakes, comprised in the genera *Tropidonotus* and *Homalopsis*, occur abundantly in countries rich in permanent lakes, and watered by continuous rivers. They are thus well known in Asia, America, and even Europe, but are extremely rare in Africa, and unknown in New Holland. The genus *Homalopsis*, indeed, which contains the essentially aquatic species, does not occur in Africa, but predominates in the New World, so rich and unrivalled in its mighty reservoirs of water.

The geographical distribution of the *Boas* exhibits some facts worthy of record. The whole are peculiar to warm countries. The genuine species are confined to South America; their analogues in the ancient world being the *Pythons* of India, although in the latter country we also find several serpents very similar to Boas, but of very small size, and of which none exists in the western world, except a single representative in the island of Cuba. The genus *Acrochordus* forms a limited group, entirely confined to the East Indies. Of the venomous serpents, it is chiefly the vipers, and perhaps a few rattle-snakes, which make their way into temperate or colder countries, the majority of the genera occurring in intertropical regions. Of the colubriform venomous serpents, the genus *Elaps* is the only one which occurs in both worlds; and it is not improbable that the American species will be found to constitute a geographical group, distinguished by their peculiar coloration, and certain small distinctions even in form. The Indian species of the genus last named are longitudinally striped, instead of being ringed with red and black, while those of New Holland present some anomalous features. The genus *Bungarus* is proper to the East Indies, where also are found certain *Najas*, although the majority of these prefer a drier and more sandy soil,—a circumstance which explains their greater predominance in Africa and New Holland. The fact does not seem to admit of easy explanation, that *salt-water serpents* should be found almost exclusively in the Indian seas, from Malabar to the great Pacific Ocean. In regard to the venomous kinds properly so called, of the three genera of which that division is composed, it may be observed, that one, *Viperus*, is proper to the ancient world; that another, *Crotalus*, is confined to the new; while a third, *Trigonocephalus*, occurs in both. These last-named reptiles dwell in great forests, or in well-wooded countries, and for that reason are not observed either in Africa or New Holland, where they are replaced by vipers; but it may be mentioned, that the viper of New Holland is an anomalous species, while such as inhabit Europe equally depart from the typical form, and tend towards that of *Trigonocephalus*. In the genus just named two divisions may be established, one composed of species with the head clothed with scales, and which inhabit more particularly tropical countries; another formed of species with the head covered by scaly plates, and which extend into temperate regions.

The preceding are a few of the most general facts in the distribution of Ophidian reptiles. We shall now notice some of those peculiarities which distinguish particular continents,—and, first, of Europe. We here find no species of the genera *Calamaria*, *Heterodon*, or *Lycodon*, no genuine tree-serpents, no species of *Homalopsis* or *Boa*. We never meet in Europe with any salt-water serpents, nor with any of the colubriform venomous kinds; and the poisonous tribes in general are represented merely by a few vipers. That the entire order of Ophidian reptiles has its great centre of dominion in sultry regions, is made manifest by the fact,

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[1] We here follow the computation of M. Schlegel, who probably proceeds upon the idea that the actual species have been nominally multiplied by the misapplication (and duplication) of various names. The amount must have been considerably greater in M. Humboldt's opinion, as that illustrious writer incidentally states that equatorial America produces 115 serpents out of the 320 which form the Ophidian order. Daudin, even in his time, described about 313 supposed species, of which eighty were regarded as venomous and 233 as innocuous, which gives a greater proportion to the former than they are at present entitled to. Nearly 400 different kinds of serpents are believed to exist in the Paris Museum, although we know not with what degree of critical accuracy that enumeration has been made.

We do not ourselves possess the means of ascertaining the total number of reptiles now known to naturalists; but the following table exhibits the amount (as in 1834) in the National Museum of Paris, compared with the number described in the works of three principal writers on the class in question :—

	Lacépède, 1790.	Daudin, 1805.	Merrem, 1820.	French Museum, 1834.
Chelonians	24	62	62	97
Saurians	56	88	83	168
Ophidians	172	315	348	391
Batrachians	40	91	87	190
	292	556	580	846

We may conclude this note by observing, that the unfortunate Wagler, in his *Naturliches System der Amphibien*, four vols. Munich, 1830, with folio Atlas of plates, has described no fewer than 248 *genera* of the reptile race.

that the temperate and northern parts of Europe produce no peculiar species, that is, no species which do not occur equally, if not more abundantly, in the southern districts of the continent, where we likewise find several kinds native to the neighbouring countries of Asia and Africa. Limits, however, may be assigned to several species, and this circumstance naturally gives rise to some curious observations. The common viper, for example, inhabits all the central parts of Europe, and is even spread over temperate Asia as far as Lake Baikal. It is well known in Sweden, spreads westwards into Britain, is frequent in Jura, Islay, and some others of our western islands, but is unknown in Ireland. The western boundary, however, of the great mass of individuals of this species may be stated to be the river Seine, while the Alps appear to form its southern limit.[1] In the southern portion of western Europe our viper is replaced by another species called the aspic (*Vipera aspis*), which spreads from Trieste over Italy into Sicily, through Switzerland and over France, passing beyond the Seine towards the Pyrenees, and probably into Spain. The southern parts of the east of Europe produce a third species of this genus, *Vipera ammodytes*, which we find to spread from Styria as far as the south of Hungary, and into Greece, Dalmatia, Sicily, and probably likewise Calabria. This distribution of so nearly-allied species seems modified by, if not dependent on, the nature of the territories which each inhabits. The first prefers, in general, heathy lands and places of a rather moist and wooded character, the second affects a dry and arid country, while the third rejoices in a rocky region. No local or climatic varieties of these vipers have been yet observed; but it is otherwise with several other snakes, which have a widely extended distribution over Europe; for example, *Coronella lævis*, and *Tropidonotus natrix* and *viperinus*. These species, of which the former two inhabit almost the whole of northern and central Europe, the last not extending further than the fiftieth degree of north latitude, occur equally in the south of Europe, where they form well-marked local varieties. Thus, in Spain, *Trop. viperinus* has the back longitudinally rayed; and a corresponding character occurs in Sardinia in relation to a species common in that island, while the Sicilian individuals present some slight additional disparities. *Coronella lævis* forms in Italy a peculiar climatic variety, of a paler hue than usual, which extends as far north as Marseilles. *Coluber Æsculapii*, which inhabits the south of Germany, is also found in Dalmatia, Italy, and Provence. *Col. viridiflavus* has been observed over all the south of Europe, Greece, Hungary, Dalmatia, Italy, Sicily, Sardinia, and as far north as France and Switzerland. *Col. hippocrepis* occurs in Spain and Sardinia, while *Col. leopardinus* is a native of Sicily, Dalmatia, and Greece; but, so far as known, neither of these kinds is met with in Italy. Neither has *Psammophis lacertina*, so common in Dalmatia, in Spain, and a large portion of France, been ever found either in Italy or the adjacent islands. The southern countries of Europe produce several serpents which are not characterized by a great extent of distribution. Such are *Xenodon Michahellis* of Spain, and *Psammophis Dahlii* of Dalmatia (the latter, however, which approaches the tree-serpents in its slenderly elongated form, being found also in Greece), and *Tortrix eryx*, confined to Greece as a European species, but elsewhere well known amid African and Asiatic deserts.

A careful and more extended study of the distribution of animal life in Africa would be found to illustrate many curious relations both in descriptive zoology and physical geography. No other continent furnishes more striking proofs of the connection between the natural characters of a country and its animal inhabitants. Thus, after acquiring some knowledge of the physical constitution of Africa, we might almost predicate the prevailing features of its natural history. The leading character of this continent is the presence of vast sandy plains or deserts, and elevated plateaus, of which the vegetation is either entirely extinguished, or held by a precarious tenure. Acted upon continually by a burning sun, the flat unvaried surface is altogether unfit for the production of those vapours which, in a state of atmospheric condensation, produce our refreshing showers of frequent moisture, and the more stormy accessories of hail and snow. The great mountain ranges being few and far between, the intermediate regions possess no perennial fountains of refreshing water, no "clouds of morning dew," to clothe their arid wastes with verdure. Hence the absence of that mighty power which in America slumbers amid the most unpeopled wilderness, and makes, when aided by the hand of man, the "desert blossom as the rose." It results from the fact of so large a portion of Africa being destitute of rivers, and consequently of forests and other lowlier vegetation, that we there find but a small number of those animals which inhabit woods and fresh waters, while such as are fitted to scour over vast plains occur in great abundance. Hence the absence of stags and the existence of vast troops of antelopes; hence also the scarcity of squirrels and other wood-haunting Rodentia, and the increase of certain swift-footed terrestrial kinds. The characters of reptile life exhibit an equal conformity with the spirit of these observations. Africa produces perhaps a greater number of land-tortoises than all other portions of the world combined; but the fresh-water kinds, with the exception of a single *Emys*, and one or two species of the genus *Trionyx*, are nearly unknown, while frogs and toads are also few in number. The same observation applies in reference both to the aquatic serpents and the wood-loving kinds. The genera *Dryophis* and *Homalopsis* are entirely wanting, and not more than one or two species are known of each of the genera *Dipsas*, *Dendrophis*, and *Tropidonotus*. In so vast a continent, however, in spite of its prevailing character of aridity, there must be numerous exceptions; and we know how far-flowing are the waters of the Nile and the Niger, how lofty and continuous the mighty mountains of Abyssinia. Many an umbrageous river, we doubt not, still rolls its crystal waters directly towards the all-absorbing sea, or fills up the glassy depth of unimagined lakes, whose beautiful shores are haunted by many unknown forms of existence,—

> Fair creatures, to whom Heaven
> A calm and sinless life, with love, hath given.

Our knowledge of African snakes, however, is still insufficient to admit of any accurate geographical sketch of their distribution being laid before our readers, for we have no data on which to assign limits to the majority even of the best-known species. Egypt and Abyssinia, Algiers, a part of Senegambia, the coast of Guinea, and the Cape,—these are the chief points from which any precise knowledge has been derived. Yet we may hazard the assertion, that Africa in general is much poorer in reptiles, particularly serpents, than either Asia or America. The number of genera is equally circumscribed; and the same observation applies to our present class as has been made in relation both to the higher animals and plants of Africa, to wit, that the species of certain genera are very numerous, and that several different kinds often inhabit the same places. Towards the southern extremity of the continent we meet with four species of the genus *Coronella*, as many of the genus *Naja*, and three *Vipers*. The other genera which

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[1] It is indeed alleged to have been met with, though sparingly, in the valley of the Po, and as far as the Florentine territory.

Ophidian Reptiles.

occur there have each only a single representative. These reptiles belong almost without exception to species peculiar to the African continent. *Lycodon Horstokii* and *Naja rhombeata* occur on the coast of Guinea, which produces likewise *Psammophis moniliger*,—but a local variety, resembling that which is found in Egypt. In Senegambia we find three species of tree-serpents, of the genus *Dendrophis*, which differ from those of the Cape, but of which one (*Den. picta*) is spread over a vast extent of the Asiatic world, as far south-eastwards as New Guinea. The intertropical countries of Africa produce *Python bivittatus*, characterized by an equally great extension, as it is found both in Java and the Chinese empire. *Viperus arietans* of the Cape is found as far north as Abyssinia, where it forms a variety of a paler hue. Northern Africa produces several serpents of species different from those of other parts of that continent. Such are *Tortrix eryx* and *Vipera echis*, which elsewhere inhabit as far south as Hindustan,—the *Cerastes*, a species of *Dipsas*, and several kinds of *Coluber*. Other species, such as *Naja haje* and *Psammophis moniliger*, differ more or less from their southern representatives. The Mediterranean countries of Africa nourish several kinds which occur in the south of Europe; and this analogy between the two continents is very striking when we compare, not the serpents alone, but the zoological productions in general, of Barbary, with those of Portugal and Spain. No serpents have been yet observed in the islands situate within the radius of Africa, and it appears certain that they do not exist in the Canary Islands.

The great island of Madagascar, of which the natural productions are as yet but slightly known, appears to be zoologically allied to Africa chiefly by the species of its western side; and although the eastern slopes of its great mountain chain exhibit features of an Asiatic character, its totality presents a very distinct and peculiar complexion. With the exception of *Tropidonotus schistosus*, all the known serpents belong to particular and elsewhere undiscovered species. For example, the *Lanhaga*, an anomalous and very remarkable species of *Dryophis*, *Herpetodryas Goudotii* and *Rhodogaster*, and *Dipsas Gaimardii*, are all peculiar to Madagascar. The Mauritius produces a very beautiful species, *Coluber miniatus*, and a small Boa (*B. Dussumieri*) of an extremely attenuated form. From the Seychelles Islands we know of no serpent but a species of the genus *Psammophis*.

With the exception of its two magnificent Indian peninsulas, Asia is not so productive as might be expected of the reptile race. The temperature of a vast portion of the loftier and central, and *a fortiori* of the northern districts, is subjected to a low temperature during many months of the year. We know that Northern Asia, Siberia more especially, produces several animals of the higher orders, identical with some which inhabit the more rigorous parts of Europe; but the alleged identity of the Siberian species of *Tropidonotus* and *Viperus* may possibly require confirmation. A curious Ophidian, peculiar to the southern countries of Siberia, is *Trigonocephalus halys*, intermediate organically between the vipers of Europe and those species of its own genus which have the head furnished with scaly plates. The deserts to the south of the Caspian Sea, which are prolonged on the one side into Hindustan, on the other by means of the Iran, into Arabia and Syria, thus connecting with the desert tracts of Africa, produce a few species common alike to corresponding portions of both continents. We are still in almost total ignorance of the snakes of the great plateaus and other portions of Central India.

The reptiles of Japan present this peculiarity, that while the Batrachian and Chelonian orders exhibit several species identical with those of Europe (*Rana esculenta* and *temporaria*, *Hyla arborea*, *Emys vulgaris*, &c.), the Saurian and Ophidian groups seem to consist of species altogether unknown in Europe. However, we know as yet but in part, for the Japanese species hitherto collected comprise, in addition to the genus *Hydrophis*, merely three species of *Coluber*, two of *Tropidonotus*, and a single *Trigonocephalus*.

The island of Ceylon, though not extremely remote from the coast of Coromandel, produces several serpents not known in continental India, such as *Tortrix maculata*, *Calamaria scytale*, *Lycodon carinatus*, and two species of *Trigonocephalus*,—*Trig. hypnale* and *nigromarginatus*. It is along the Ceylonese shores that we first perceive certain species of the genus *Hydrophis*, those singular snakes which dwell exclusively in the sea, and occur from the island in question over all the intertropical marine waters east of Malabar, and as far as Polynesia. The number of Ophidian species which inhabit the Gangetic Peninsula, without spreading into the great islands of the Indian Archipelago, is limited. Such, however, are *Tortrix eryx*, *Coronella Russelii* and *octolineata*, several species of *Coluber* and *Lycodon*, *Dipsas trigonata*, several kinds of *Tropidonotus*, *Elaps trimaculatus*, and some vipers. The great islands themselves, with their smaller dependencies, are regarded by M. Schlegel as presenting a most interesting field for the study of zoological geography, and the observation of those local races, constituted by the diversities observable in apparently identical species placed in different localities. These islands are of the first rank as to size, situate within the tropics, covered by an abundant vegetation, and inhabited by innumerable tribes of living creatures of every class and kind. They are separated from each other by seas of no great breadth, yet sufficient to present, as matters are now constituted, an insurmountable barrier to the migration of the majority of species. Now when we find the same creatures inhabiting many different and distant islands having no communication with each other, we may reasonably infer that each insulated tract of land has borne its own inhabitants since the relations of our earth's surface became as they now exist, and that the individuals of each species form in every island a family group, which will exhibit, when compared with the corresponding species in other islands, certain modifications produced by the disparities of their position. Experience has proved the accuracy of this assumption. It has not unfrequently happened, that the same species has been discovered to inhabit Sumatra, Java, Borneo, Timor, the Celebes, the Philippine Islands, and continental Asia, and in each locality has been observed to present some constant though extremely slight distinction. Now it would never do to regard these as so many distinct species. They are only local or climatic varieties, the origin of which may be obscure or incomprehensible (as are many things besides), but which we doubt not would show their identity, by each recognising the individuals of their kind, and by breeding together, could they be transported from one to another of their sea-girt isles. Innumerable examples of these climatic differences might be adduced, were we to extend our observations throughout the vast range of the animal kingdom; but here a few examples from the reptile races must suffice. The *Najas* from the isles of Sunda constantly differ in several characters from those of Bengal and the Philippine Islands. *Tortrix rufa* from the Celebes is distinguishable from individuals of the same species from Bengal and Java, by the uniform tint of the back, and by two small spots upon the occiput. *Calamar oligodon* of Java exhibits in Sumatra a difference in the dorsal tinting, and forms in Ceylon and the Philippine Islands a third local variety of great beauty. Analogous differences exist between the individuals of *Coronella baliodeira* of Java and Sumatra. *Lycodon hebe* of Java is smaller in size, and not so pale in colour, as that same species in Bengal, while those from Timor are still more diminutive, and of darker hue. The beautiful *Coluber melanurus* inhabits Java, Sumatra, and the Celebes; but the individuals from the last-named locality have the nape of the neck constantly adorned by an angular black mark. *Herpetodryas oxycephalus* is of a beautiful grass-green colour in Java; but this pure tint becomes embrowned in Borneo, and in Celebes appears almost black upon the dorsal region. *Dendrophis picta* inhabits almost all the intertropical countries of the Old World, from Senegal to New Guinea, but varies considerably at distant points of such a vast and surprising distribution. *Dryophis nasuta* of Bengal and the Mariannas has in Java the abdomen rayed with yellow. *Dryophis prasina*, common in the isles of Sunda, exhibits a local variety in the Celebes; and *Tropidonotus quincunciatus*, a species widely spread through India, has in Java the spots confluent, so that the dorsal portion seems rayed with black. *Trop. chrysargos* of Sumatra bears a different aspect from that species in the Celebes, while both vary from the individuals found in Java. *Homalopsis Schneideri*, which is spread from India to New Guinea, exhibits several varieties in different regions. The great *Python bivittatus* occurs in China, the isles of Sunda, both the Indian peninsulas, and Ceylon, and is, moreover, distributed across Africa as far as Senegambia. In this vast extent of territory it exhibits some considerable variations, which, when the extreme differences merely are regarded, and the intermediate links kept out of view, have caused it to be described, in its different aspects, as distinct species, all however referable, in Mr Schlegel's opinion, to one and the same. *Elaps furcatus* and *bivirgatus* exhibit a different distribution of colours in Sumatra from what they do in Java; but it may be stated as a general fact, that almost all the known serpents of the former island have been found also in the latter. Indeed a considerable number of these insular Ophidians occur likewise both in Hindustan and Bengal.

It is a singular circumstance, that the two most remarkable species of the genus *Trigonocephalus* (*Trig. puniceus* and *rhodostoma*) have hitherto been observed only in Java; while *Trig. viridis*, so common in India, Bengal, Sumatra, and Timor, does not occur in the first-named island. The genus *Bungarus*, on the other hand, which inhabits Ceylon, Hindustan, and Bengal, does not occur in any other of the great eastern islands, except Java. In the Celebes we find many peculiar forms of animal life, combined with others well known elsewhere. Among the serpents we find there a beautiful species of *Herpetodryas* (*Herp. dipsas*), and *Dipsas irregularis*, which also occurs in Amboyna. Several species are absolutely the same as those of Java and Sumatra, although a few form permanent local varieties, which exhibit some slight disparities of colour. Such are *Tortrix rufa*, *Coluber melanurus*, *Herpetodryas oxycephalus*, *Dryophis prasina*, *Dipsas dendrophilus*, and *Tropidonotus chrysargus*. . Of the Moluccas our knowledge is extremely slight, being confined chiefly to the island of Amboyna. We there find three or four serpents, likewise known as Javanese species; but it does not appear that the isles of Sunda produce *Lycodon modestus*, *Boa carinata*, *Dendrophis rhodopleuron*, or *Python amethystinus*. Timor is in some measure intermediate in its productions between Java and the Moluccas. Its *Python* is perhaps different from that of Amboyna, and it produces a singular *Homalopsis* (*H. leucobalia*). *Lycodon hebe* is there of a deeper tint than in Java; and *Coluber radiatus* is represented in Timor by *Col. subradiatus*,—a species analogous, but not the same. New Guinea and the adjacent islands produce several new species. We know little of the reptiles of the Philippines, though a few have been collected in the environs of Manilla, in the island of Luçon; and these clearly establish the curious fact, that the species of that island bear a strong analogy to those of Ceylon,—not a few being identical. The *Naja* of the Philippines belongs to the ordinary variety of *N. tripudians*, as it occurs in India, and which always differs in some measure from the same species from the isles of Sunda.

The vast insular continent of New Holland is as yet but slightly known, most of its ascertained productions having been sent only from a few limited localities; but the anomalous and extraordinary character of its productions may even now be fairly inferred. The snakes seem peculiar, and almost all belong to the venomous division. No water species have as yet been seen there. It has already been observed, that the innumerable islands of the great Pacific Ocean are believed to be unproductive of serpents. The Mariannas, however, form an exception to this general rule, and Dampier mentions green serpents as inhabitants of the Gallipagos.

A few brief notices of the serpents of the New World may terminate the geographical department of our subject. On comparing the species of the two great continents of America with each other, we observe some interesting parallels. The rattle-snake, *Crotalus horridus*, so common over a large extent of South America, is represented in the northern territories by *Crot. durissus*, as is *Coronella venustissima* by *Cor. coccinea*. This kind of comparison, however, applies but to a few species, for the majority of kinds produced by one of the continents differ from those of the other. Thus, the genera *Tortrix*, *Dipsas*, *Dendrophis*, *Boa*, have as yet been found only in South America, or as far north as the Antilles, while *Tropidonotus*, on the contrary, is not found in the southern continent, though frequent in the northern, from which it likewise extends to parts of the West Indies. A small number, however, of southern species are found also in North America, such as *Calamaria melanocephala*, *Lycodon clelia*, *Coronella cobella*, *Herpetodryas cursor*, *Dryophis Catesbyi*, *Elaps corallinus*, *Homalopsis carinicauda*; while in like manner *Heterodon platyrhinus*, and *Herpetodryas æstivus*, which may be regarded rather as northern species, have been ascertained to inhabit Brazil. The following species of North American reptiles also inhabit the Antilles; *Calamaria striatula*, *Coronella coccinea*, *Heterodon platyrhinus*, *Coluber constrictor*, *Herpetodryas æstivus* and *cursor*, *Tropidonotus bipunctatus*, *fasciatus*, and *saurita*. Those next named also occur in the Antilles, although their proper country is South America; *Calamaria melanocephala*, *Coronella reginæ*, *Lycodon clelia*, *Dendrophys liocercus*, *Dryophis Catesbyi* and *aurata*, *Dipsas annulata*, *Homalopsis angulata*, *Boa constrictor* and *cenchria*, and *Elaps corallinus*. The species peculiar to these West Indian islands are very few in number, the most characteristic being *Psammophis Antillensis*, *Trigonocephalus lanceolatus*, *Dendrophis Catesbyi*, and *Boa melanura*. On comparing the snakes of Guiana with those of Brazil, we find many species common to both countries, several, however, forming local varieties more or less distinct, as in the cases of *Herpetodryas lineatus* and *Olfersii*, *Coluber poëcilostoma*, &c. Certain species are peculiar to one or other of the countries above named,—for example, *Calamaria badia*, *Xenodon typhlus*, *Coluber corais*, *Herpetodryas Boddaertii*, *Dendrophis aurata*, *Dryophis Catesbyi* and *argentea*, *Homalopsis plicatilis*, *Elaps lemniscatus* and *Surinamensis*, &c. have never been seen except in Guiana; while *Calamaria Blumii*, *Coronella Merremii*, *Xenodon Scholtii* and *rhinostoma*, *Lycodon formosus*, *Herpetodryas serra*, *Homalopsis carinicauda* and *Martii*, are found only in Brazil. Other species, again, appear as it were to represent each other in these parts of South America, so that we may place in parallel, *Coronella venustissima*, *Dipsas Mikani*, *Wegeli*, *leucocephala*, and *Nattereri*, and *Trigonocephalus Jararaca*, of Brazil, with *Coronella venusta*, *Dipsas nebulata*, *Catesbyi*, *macrorhina*, *punctatissima*, and *Trigonocephalus atrox* of Guiana. The other parts of South America are too little known to admit of any detailed comparison; but it

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may be observed, that of the species discovered in Chili, several are entirely new, and distinct from such as exist on this side the Cordilleras.[1]

Notwithstanding the interest of the subject, we must now bring our general observations to a close, and proceed with a brief systematic sketch of the principal genera and species, referring the reader to M. Schlegel's work (and to those of the other Erpetologists here quoted) for more minute details. In conformity with the views of the author just named, we preserve the ancient subdivision of venomous and non-venomous kinds. The constant character of the former consists in being provided with a gland of a cellular structure, which secretes a very deleterious poison. Maxillary teeth, called fangs, of much greater length than the others, hollow interiorly, and furnished with openings at either extremity, for the entrance and exit of the poison, are the potent weapons with which these insidious reptiles inflict their fatal wounds. It is difficult, if not impossible, to assign to these serpents any certain character of external distinction, although there is something in their general aspect which points them out, even to the uninitiated, as dangerous neighbours. Their natural habits also offer this distinction, that the venomous kinds are almost always either terrestrial or marine, although *Trig. viridis* is slightly arboreal, and certain species of *Naja* occasionally occur in fresh water. But the colubriform venomous kinds so greatly resemble the innocent species, that professed naturalists have sometimes combined them with each other. Their most common characters consist in a thickish rounded muzzle, and a short, thick, conical tail. The marine serpents may be recognised by their flattened tails.

The constitution of the following families bears relation rather to the habits of life than the organic structure of the species they respectively contain.

FIRST PRIMARY DIVISION. NON-VENOMOUS SERPENTS.

Family I.—Burrowing Serpents.

Genus Tortrix. Body cylindrical, of nearly equal dimensions throughout; head small, obtuse, and covered by imperfectly developed plates; eyes small; nostrils narrow; gape not widely cleft; teeth short and conical; tail short. Plate CCCCXLIV. fig. 6.

The species of this genus (which in M. Schlegel's work includes also *Eryx* and *Xenopeltis* of other authors) inhabit the warmer countries of both the Old and New World, preferring dry and sandy districts, in which they form narrow excavations. *T. eryx* occurs over a vast extent of territory, from Egypt to Hindustan, and is met with in the southern parts of Europe. The ground colour of the dorsal region is a beautiful red with numerous confluent spots, and bands of blackish brown; the under parts are yellow, the whole covered by small scales. The muzzle is obliquely truncated at the end. Length about two and a half feet. Abdominal plates 195, caudal twenty. Six other species are known, of which *T. scytale* is American, and, of all undoubtedly Ophidian reptiles, makes the nearest approach to those ambiguous genera *Typhlops* and *Amphisbæna*.[2]

Family II.—Worm-like Serpents.

Genus Calamaria. Body small and cylindrical, terminated by a short conical tail. Head uniform with the body. Plates in the muzzle few in number.

The majority of the genus have the lower surface of a fine vermilion hue, a colour frequent among reptiles which inhabit low and moist abodes. They seldom exceed a foot in length, and are found in both the Americas, in Africa, Southern Asia, New Holland, and the Indian Archipelago. There are eighteen described species, of which one of the most curious is *Cal. lumbricoidea* of Boié.[3] Its body, though sometimes several feet long, does not exceed the thickness of a swan's quill. The colour is blackish-blue above, bluish below, with blackish spots, and a yellow ray along the sides. The scales are smooth, square, and disposed in thirteen rows. Abdominal plates from 190 to 217, caudal from sixteen to twenty-three.

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Family III.—Terrestrial Serpents.

Genus Coronella. Body somewhat pentagonal, thickening towards the centre. Head distinguishable from the neck, sometimes very broad at the base, depressed, the muzzle short, obtuse, and slightly truncated. Scales smooth, and disposed in from seventeen to nineteen longitudinal rows. Abdominal and caudal plates about 180 + 40.

The species of this genus are very alert in their movements, and defend themselves, when attacked, with great energy and perseverance. They are dispersed over almost all parts of the world (preferring plains and humid places), but have not as yet been observed in Japan or New Holland, and are rather rare in Asia. Specimens from South America are very frequent in collections. *Cor. lævis* is a well-known European species, which occurs in France, Germany, Switzerland, Italy, and, from Sparmann's description, appears to be among the number of the few Ophidians which inhabit Sweden.[4] It is of a shining bay colour, ornamented by irregular black marks, which form a peculiar design upon the head. The under surface is yellowish, marked with square black spots. There are twenty-one rows of scales, and the plates are 175 + 55. This species is viviparous, that is, the young are hatched within the body of the mother. When attacked, it attempts to escape with great celerity, and when foiled in that intention, it fights with energy, bites furiously, and will scarcely allow itself to be taken alive. It cannot be lifted by the end of the tail (at least with impunity), as many serpents may, as it possesses the power of bending its body upwards, and wounding the hand of its captor. However, its bite, though disagreeable, is in no way dangerous. It is an excellent swimmer, but does not enter the water willingly. It is very fond of mice. About thirteen other species are known to naturalists.

Genus Xenodon. General form heavy, head broad, muzzle short and truncated, body thick, abdomen flattened. Upper jaws provided posteriorly with a solid, elongated, compressed tooth. Scales smooth, and dispersed in rather oblique ranges, especially on the neck, which is capable of expansion. Plates of the head short and broad.

Of this genus the species are few in number, and of these the individuals are by no means abundant. They are of large size, sometimes measuring from three to four feet in length, and, being thick in proportion, present a somewhat formidable aspect. They are usually characterized by a grayish-blue tint, and occur chiefly in Java and intertropical America. None have been as yet found in Africa or New Holland, but *Xen. Michahelles* inhabits the south of France and Spain.[5] This species is distinguished by its short conical head, terminated by a prominent rostral plate. It has twenty-seven rows of scales, and 216 + 60 plates.

Genus Heterodon. Head not very distinguishable from the general form, which is slightly pentagonal, and almost of equal thickness throughout. Abdomen somewhat angular, and narrower than in Xenodon. Tail very short, and furnished beneath with divided plates. Rostral plate always prominent, sometimes prolonged into a small upturned trunk.

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[1] See *Physiognomie des Serpents* (distribution géographique), i. p. 195, et seq.

[2] *Museum Adolph. Fred.* pl. 6, fig. 2.

[3] *Erpétologie de Java*, pl. 22.

[4] *Neue Schwed. Abhandl.* xvi. 180, pl. 7, f. A, B.

[5] Figured by Wagler under the title of *Rhinechis Agassizii. Icones*, pl. 25.

All the species are natives of the New World. The prevailing colour is red, ringed or spotted by a deeper hue. Their manners are unknown, but it is presumed that they inhabit a dry and sandy soil. We shall here name only the harlequin snake of America (*Het. coccineus*), which inhabits Louisiana and the southern states.[1] The ground colour is a bright yellow, tending more or less to brown upon the back, which is adorned with above twenty broad round or oval spots, of a purplish-red colour, bordered with black. Its brilliant tints are effaced soon after death. "This beautiful snake," says M. Audubon, alluding, we believe, to our present species, "is rather rare in the United States, where I have observed it only in the south. It glides through the grass with ease, and ascends to the tops of bushes, and among the branches of fallen trees, to bask in the sun. Children are fond of catching it on account of its beauty. It feeds principally on insects, such as flies, and small Coleoptera."[2] This seems the species described by Herrera in his History of the West Indies, as inhabiting Mexico and the Floridas, where it is known by the name of *Madres de Hormigas*, on account of its frequenting the society of ants.

Genus Lycodon. Form usually thin, sometimes extremely slender. Anterior maxillary teeth longer than the others. Vertical and anterior frontal plates small and shortened, the occipitals rather long.

The species inhabit both the Old and New World. The prevailing tint is of an earthy hue, passing more or less into brownish or ochry-yellow, the majority of species being ornamented by a collar of a clearer colour. Several kinds are ringed with black, white, and red. The abdominal plates usually amount to 200, the caudal vary from fifty to a hundred. We know little of the habits of these reptiles, of which above a dozen species have been collected in different parts of the intertropical world.

Genus Coluber. This genus, as originally established by Linnæus, contained all the Ophidian reptiles with subdivided caudal plates. The venomous kinds were afterwards removed, and the genus itself partitioned into several groups; but even then the genus Coluber properly so called continued to contain a vast amount of species. MM. Boie and Schlegel restricted it still farther; and although it is difficult to apply the distinctive notes of these writers, the genus is natural in itself, when we seek to recognise it rather by the general bearing and physiognomy of the species, than by means of isolated characters.

It contains all those innocuous serpents of considerable size, which hold, as it were, by the form and proportion of their particular parts, a central position among the other Ophidians. Their bodies, less contracted than those of the fresh-water kinds, are yet by no means so slender as those of the arboreal species. Their head is not so lengthened as that of the latter, but is less broad than that of the aquatic sorts. The tail, modified in accordance with the nature of the species, varies in its form, as these resemble or recede from the conterminous groups in their mode of life. It is thus that certain species of the genus Coluber are closely connected with *Tropidonotus*, or even *Homalopsis*, while others are linked with *Herpetodryas*, *Psammophis*, *Coronella*, or *Xenodon*. The muzzle is usually broad, thick, rounded, rather short, the nostrils lateral, open, and oblong. The head is always laterally angular, from whence results the lateral position of the eyes, of which the pupil is orbicular in form. The body varies in proportional thickness in the different species, but is usually compressed, and slightly pentagonal. The abdomen is generally broad, convex, rarely angular, and is covered by numerous plates, more closely set together than in other serpents, and sometimes amounting to nearly 300. The tail is almost always cylindrical and pointed, generally of medium length, rarely slender and elongated, occasionally short and conic, its inferior portion furnished with divided plates.

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Almost all the countries of the earth, of which the nature of the soil and climate is not altogether opposed to the existence of the Ophidian order, are inhabited by the genus Coluber. Only a single species, however, has been found in Southern Africa, and not one has yet occurred in New Holland. Their habits are what may be termed terrestrial, that is, they rarely enter water of their own accord, although several climb among shrubs and bushes with some celerity in search of prey. Several kinds occur in Europe, and those from intertropical countries measure in some instances from seven to eight feet. They are rarely adorned with brilliant colours, brown being the prevailing hue. Of some the markings are uniform, while others are spotted or longitudinally rayed. Of the European species, one of the best known and most extensively distributed is *Col. Æsculapii*, which sometimes attains to the length of from four to five feet. The colour of the upper parts is olive-brown, beneath yellowish, or marbled with gray, with a paler collar. Abdominal plates 228, caudal seventy-nine.[3] We have notes on the history of this species from MM. Host and Lenz. It is described as being extremely active in its movements, climbing trees with facility, but avoiding contact with water. It is oviparous, and feeds on lizards, frogs, and small birds, but takes no nourishment in captivity. When attacked, it defends itself with great determination; but when captured, becomes tame in a few days. In the museum of Vienna, several specimens of this Æsculapian snake are preserved alive; and their manners are so gentle that children make playthings of them, and handle them for hours at pleasure.

The ancient Greeks adored the god of medicine in various places under diverse forms, but frequently in the guise of a serpent, as an emblem of sagacity, and an animal endowed with so many sanatory qualities, that several Hellenic peoples regarded the creature itself as the very Deity. It was especially so with the inhabitants of Epidaurus (a flourishing city of Peloponnesus), who in a sacred grove, the favourite abode of serpents, erected a magnificent temple in honour of these by us abhorred reptiles. The Roman people, when terrified by a great pestilence, which ravaged the capital (in their year 461), sent an embassy to Epidaurus in search of this imaginary god, whom they might have found in sufficient abundance near at hand. They entertained these slimy deities in the island formed by the Tiber, and where we may still see their figure sculptured in marble in the gardens of St Bartholomew.[4] Chandler tells us, in his Travels, that the environs of Epidaurus still abound in harmless serpents.

The only other species we shall here notice is *Coluber quator-radiatus*, remarkable as being the largest of the Ophidian reptiles of Europe. According to Metaxa (in his *Monograph* of the Serpents of the Environs of Rome), it sometimes attains the length of seven feet. It occurs in Italy, the south of France and Spain, Dalmatia, Hungary, &c. Its prevailing colour is an ochry-yellow passing into brown, and somewhat deeper on the under surface. Two lines of darker brown run along the flanks, and a blackish line passes from the eye to the corner of the mouth. This species, in spite of its great size and formidable aspect, is

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[1] Catesby's *Carolina*, pl. 60.

[2] *Ornithological Biography*, vol. i. p. 278; and *Birds of America*, pl. 52.

[3] Jacquin, *Collectan.* iv. 356, pl. 26 (Fem.), 27 (Mas).

[4] Metaxa, p. 37;—and Aldrovandus, *Serp.* pl. 240. The above is not the species called *Col. Æsculapii* by Linnæus, who misapplied the title to one of the coral snakes of America,—*Coronella venustissima* of modern authors.

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extremely gentle in its manners, and does not attempt to bite even when seized in its native haunts. It is very common in the fields near Tivoli, but is usually found on hillsides. There is a passage in Pliny[1] which relates that the Boas of Italy sometimes attain to so great a size that the entire body of an infant was found in the interior of one slain during the reign of the Emperor Claudius. The species just noticed is certainly the largest of all the Roman serpents, but its natural attributes in no way favour the reception of this preposterous story.[2] The largest species of the genus is *Coluber corais* of Surinam. There are twenty-seven different kinds described by M. Schlegel.

Genus HERPETODRYAS. This genus was established by the late M. Boié for the reception of certain species of Coluber (*Col. carinatus*, &c.), which combine the aspect and physiognomy of the preceding genus (to which they are closely allied) with the lengthened form and much of the habits of the arboreal serpents. Their colours are usually of a uniform greenish hue, sometimes passing into brown, or occasionally longitudinally rayed. The tail is generally long and slender, a character which, combined with the narrow and very angular abdomen, announces their arboreal disposition. Their manners are wild and distrustful, and they inhabit the warmer regions of both the Old and New World, with the exceptions, so far as yet known, of Africa and New Holland. We shall here name only *Herp. carinatus*, a Brazilian species, also common in Surinam. It is remarkable for having two central rows of dorsal scales, so that the total number of rows forms an *equal* number, a character unique in the Ophidian order. It varies greatly in its external markings.[3]

Genus PSAMMOPHIS. This little group may also be regarded as a dismemberment from Coluber, and brings us into still closer contact with the genuine tree-serpents. They offer an anomaly in their dentition, in as far as their posterior teeth, and those of the centre, are usually longer than the others, and furrowed. The head is elongated, the vertical plate very narrow. Some have the body thin and long drawn out, while others are more compact like Coluber. The species occur in India, Africa, and America; and *Psam. lacertina* is an European example well known in Dalmatia.[4] They all prefer sandy soils, and prey chiefly upon Saurian reptiles. Green and brown are the prevailing colours, although several are longitudinally rayed, or have the head adorned by linear figures.

Family IV.—Arboreal or Tree-Serpents.

The members of this family are characteristic of the great forests of the tropical countries of Asia and America. They are rare in Africa, still more so in New Holland, and Europe produces only a few anomalous species. Their form is in general extremely elongated, they pass the greater portion of their time in trees and bushes, and prey both on birds and lizards.

Genus DENDROPHIS. Body compressed; abdomen (and sometimes the tail) angular, and furnished with very broad plates; scales narrow and elongated. Tail very slender. Head lengthened. Eye large, the pupil orbicular. See Plate CCCCXLIII. fig. 5.

These reptiles inhabit both the western and eastern world, but are rare in New Holland, and unknown in Europe. They climb trees with great facility, and are extremely quick in their general movements. They are frequently adorned by lively colours. Nearly a dozen species are known to naturalists.

Genus DRYOPHIS. Muzzle slender and projecting. General form greatly elongated, the body compressed, the abdomen convex. Eye of moderate size.

The species of this genus are among the most remarkable of the innocuous serpents, their shape being so extraordinarily lengthened out, that many measure nearly five feet in length, and are yet no thicker than the little finger. Hence their Anglo-American name of coach-whip snakes, of one of which, first described by Catesby, it was absurdly believed by the Indians, "that it will by a jerk of its tail separate a man in two parts."[5] The tail, of extreme slenderness, always measures half the length of the whole body; and the muzzle is often drawn out in the form of a pointed proboscis. These reptiles inhabit the torrid zone, or the countries near the tropics, in Asia and the two Americas. Although unknown in the continent of Africa, a species (*D. langaha*) occurs in Madagascar. The genus admits of a geographical division,—those of the ancient continent being characterized by grooved maxillary teeth, and the pupil of the eye elongated horizontally, while such as inhabit America have the teeth less developed, and the pupil orbicular. We may briefly notice *Dryophis nasuta* (the *Passeriki* of Russel),[6] a remarkable species, of a beautiful grass-green colour above, the lower surface paler, and marbled with red. A white or yellow ray extends from behind the eye to the commissure of the lips, and another very distinct one passes along each side of the abdomen and tail. The muzzle is very sharp, and is terminated by a moveable fleshy appendage (See Plate CCCCXLIII. figs. 7 and 9.) This kind occurs over a great extent of India and the great eastern islands, and is frequent in the environs of Vizagapatam. It lives in trees, and its manners are described as being even ferocious. Its bite, however, is attended by no other bad consequences than the pain of the wound; but the common people deem it dangerous, as directing its attacks chiefly at the eyes of the passers by. There is an Indian whip-snake (probably not of this genus) common in the Concan, where it is described as concealing itself among the foliage of trees, from which it darts at cattle grazing below, generally also aiming at the eye. A bull which was thus wounded at Dazagon tore up the ground with extreme fury, and died in half an hour, foaming at the mouth. This habit of the reptile is truly singular,—for it seems to proceed neither from resentment nor from fear, nor yet from the impulse of appetite, but seems, "more than any other known fact in natural history, to partake of that frightful and mysterious principle of evil, which tempts our own species so often to tyrannize for mere wantonness of power."[7]

The species already named as a native of Madagascar, *Dryophis langaha*, Schlegel, partakes of those anomalous attributes which characterize so many animal products of that extraordinary island. It measures between two and three feet in length, and is of a beautiful reddish-brown colour above, the under surface being of a deep though lively yellow, spotted with brown, especially beneath the tail; but its most peculiar character is seen in the muzzle, which is prolonged into a fleshy appendage of half an inch in length, covered with small scales, and of variable form, being in some cases sharp-pointed, in others compressed and enlarged, or leaf-shaped. This curious reptile seems to have been first (we believe inaccurately) described by M. Bruguières,[8] and has since been banded about through various genera.[9] It is classed by M. Schlegel (we presume after due examination),[10] among the innocuous, that is, the non-venomous kinds,—although the natives of Madagascar veno-ous pents.

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[1] Lib. viii. c. 14.

[2] *Quadrupèdes Ovipares*, ii. 163, pl. 7, fig. 1.

[3] Wagler, *Serp. Braz.* pl. 7 and 12.

[4] Fleischman, *Nov. Gen.* pl. 2.

[5] *Carolina*, ii. plate 54.

[6] *Indian Serpents*, plate 12 and 13.

[7] *Quarterly Review*, xii. 183.

[8] *Journal de Physique*, xxiv. 132, plate 2.

[9] *Langaha Madagascariensis*, Lacép. *Quad. Ovip.* ii. 499:—*Langaya nasuta*, Shaw, *Gen. Zool.* iii. 571, plate 127:—*Amphisbæna langaha*, Schneid. *Hist. Amphib.* ii. 151.

[10] *Physiognomie des Serpents*, ii. 148.

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are said to hold it in great dread, from the belief of its being a highly poisonous species.[1]

Genus Dipsas. Head thick, broad, obtuse; the body vigorous, but much compressed. Pupil of the eye usually vertical. Plate CCCCXLIV. fig. 7.

This genus comprises all those tree-serpents which, resembling the Colubers (and so far differing from the two preceding genera) in the bulkier proportion of their parts, are distinguished by their compressed bodies and more slender tails. Both the size and colours differ greatly according to the species, some of which do not measure more than fourteen inches, while others extend to five or six feet. South America and the East Indies are their characteristic countries, although a somewhat anomalous species is found in Egypt and Dalmatia. The genuine Dipsas dwell habitually in trees, concealing themselves amid dense foliage, from whence they dart upon their unsuspecting prey. The largest species known to naturalists is *Dip. dendrophila*, a Javanese reptile, which sometimes measures seven feet in length. The ground-colour is a beautiful lustrous black, with steel-blue reflections, paler on the under surface; and the body is encircled by from forty-five to fifty transverse narrow bands of a fine golden yellow.[2] *Dip. fallax* is, we presume, the sole European species,—if the reptile so named really pertains to our present genus.[3] Its habits offer great disparity, at least M. Cantraine found it in Dalmatia in the month of December, creeping slowly among the ruins of an ancient castle. It had previously been found in the Levant by Olivier, and was more recently observed in the Morea by M. Bory St Vincent. Fleischman informs us that it lives under stones, stirs abroad only in the early morning and towards evening, avoids water, and feeds on insects, lizards, and mice. About twenty-five species of this genus are described by M. Schlegel.

Family V.—Fresh-water Serpents.

The members of this group are more or less allied to Coluber in their organization. They inhabit the water, or at least frequently enter into that element, and prefer the banks of rivers and the shores of lakes to situations more remote from moisture. It does not follow that all snakes endowed with analogous instincts and manners belong to this group, because the majority of the Boas, and almost all the Colubers, nearly correspond in their habits of life, and are yet very dissimilar in their structure. In this family there are combined those serpents which, having many mutual relations in their form and physiognomy, constitute a very natural assemblage, though by no means distantly separated from all other subdivisions. It is composed of two genera, of which the first exhibits, with few exceptions, nothing remarkable in its organization,—while the second is characterized by several singular features.

Genus Tropidonotus. Head broad, body rather bulky, abdomen broad and convex, tail short.

The majority of this genus inhabit Asia, especially the Indian Archipelago. Southern Africa produces only a single species; Europe two, which occur on both sides of the Mediterranean basin. The same restricted number is found in Japan, and several are native to North America. None is known to inhabit either South America or New Holland. Certain species are widely distributed, while others are confined within narrow limits. They usually occur along the shady, wooded banks of lakes and rivers, where they prey on frogs and fishes. They swim with great dexterity, and are capable of continuing for a length of time beneath the surface. Although they can both creep and climb with considerable swiftness, they usually prefer to escape from threatened danger by plunging into water. Many species never remove from the close vicinity of that element; others inhabit plains subject to inundation; and a few are found to dwell in moist umbrageous forests, even on the sides and towards the summits of high mountains. Certain species are gregarious; while some are solitary, dwelling in the deserted holes of small quadrupeds. Such as inhabit temperate climates fall into a lethargic state in winter. The whole are oviparous; but the eggs of many, even when newly laid, contain young in a state of considerable advancement.

The first species we shall notice is *Tropidonotus natrix* (*Coluber natrix*, Linn., *Natrix torquata*, Ray), the best-known and most generally-diffused of European serpents, and one of the few which inhabit the cold and cloudy clime of Britain. We have exhibited its osteology on Plate CCCCXLIV. fig. 2. It is subject to great variation of colour, but the prevailing tint is a pale ashy-blue tinged with green, and relieved by a series of black spots or bands. The under surface is dusky blue, with mottlings of yellowish white. The collar is white or yellow, bordered posteriorly by deep black; and the plates of the head are extremely regular in their form. The length ranges from two and a half to four, or occasionally five feet. The female is always the larger. This reptile has been studied and described by a host of European writers. It is not characterized by any wildness or ferocity, is easily tamed, and rarely bites even when seized. "Il m'est cependant arrivé," says M. Schlegel, "qu'étant encore très-jeune, et m'étant approché du bord d'un bois, où une société nombreuse de ces serpens s'était établie pour faire leur ponte, un Tropidonote d'une taille énorme m'attaqua avec fureur, tandis que plusieurs autres s'échappaient dans les trous dont la terre était percée."[4] The ringed snake, as our present species is generally named, prefers to take possession of the subterranean dwelling of a mouse or mole to commencing an excavation for itself. Being fond of warmth and shelter, it often approaches human habitations, and readily lays its eggs in dunghills. Yet it is often met with in the remotest wilds, or in thick umbrageous forests, and sometimes at a height of several thousand feet above the level of the sea. But on the whole it prefers the vicinity of tranquil waters, where it dives frequently in search of fishes, as well as of frogs and other batrachian reptiles. Although it possesses the power of remaining under water for nearly half an hour, it is not organized for a continued abode in that element; and when frequently forced from shore, its swimming powers become exhausted, and it is "found drowned." It is extremely voracious, and will swallow a great number of frogs at a meal. It hybernates, in cold and temperate countries, from the month of October or November, seeking profounder excavations, where frost can scarcely enter. It leaves its retreat in March or April, according to the region it inhabits, and casts its skin once a month till the end of August. In that month also it lays its eggs, to the number of two dozen or more. As the species pairs in April, it follows that these eggs take five months to be developed in the oviducts, though they are hatched in about three weeks after deposition. Their form is oval, and they measure about an inch and three lines in length. The young, when first visible, measure from six to eight inches. This species abounds over all France and Germany. It does not inhabit the maritime parts of Holland, but is common in Guelderland and the province of Drenthe. It is well known in Italy, Sicily, and Sardinia, as well as in Denmark, Sweden, and Norway, and extends over a great portion of temperate

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[1] *Gen. Zool.* iii. 572.

[2] Wagler, *Icones*, i. pl. 8.

[3] It is the *Tarbophis fallax* of Fleischman's *Dissertatio*, pl. 1.

[4] *Physiog.* ii. 304.

Asia, as far as Lake Baikal. It is a common species in England, where it occurs in woods and hedges, as well as in marshes. Mr Jenyns informs us, that it is particularly abundant in the fens of Cambridgeshire, where it sometimes attains a great size.[1] We shall merely add, that it is eaten in several continental countries. *Col. viperinus*, another European species, pertains to this genus; as do also a considerable amount of exotic kinds, which we cannot here so much as name.

Genus Homalopsis. Body bulky, head very thick, muzzle short and rounded; eyes and nostrils small, and opening upwards; form usually cylindrical, sometimes slightly compressed; abdomen broad and convex; tail short, conical, robust.

This genus inhabits the great fresh waters of the intertropical countries both of Asia and America, although it seems less extended than the preceding, being seldom seen beyond the tropics. A Bengal species occurs also in Java, and a few are found identically the same in both the Americas. The majority attain a considerable size; but though as thick as a man's arm, they rarely exceed the length of four feet. Their heavy inelegant forms, small insidious eyes, and large gaping mouths, confer upon them a peculiar and repelling physiognomy; yet they are quite innocuous, in spite of the malignity of their aspect, a proof that we should never judge from appearance. These are the most truly aquatic of all the fresh-water serpents, passing almost their entire lives submerged, and feeding chiefly on fish. They are endowed with great muscular strength and strong powers of locomotion in their favourite element. Their colours are usually dark and lugubrious,—a schistose gray, brown, olive, or a blackish hue prevailing over the upper surface; while a yellower tint, with large square spots, is frequent on the abdominal region. We are acquainted with few details regarding their habits of life; and the species are rare in collections, probably in consequence of their fish-like activity in the water rendering their capture difficult. They are distributed over a variety of genera by different naturalists; and M. Schlegel describes fourteen species, among which are included *Hom. herpeton* (*Erpeton tentaculatus*, Lac.[2]), a serpent remarkable for two fleshy appendages covered with scales, which extend from the termination of the muzzle. (See Plate CCCCXLIII. fig. 4.) The abdominal plates are scarcely broader than the other scales, and each is surmounted by a couple of ridges. Its native country is unknown.

Family VI.—Boas.

This family, according to M. Schlegel's views, comprehends the greater number of those species which modern naturalists have comprised under the genera *Boa*, *Python*, and *Acrochordus*. It is one of the most natural of the entire order, and has been too often erroneously separated, merely on the consideration of a few unimportant characters. We here find species, some of them the largest of the Ophidian race, distinguished by a prehensile tail, and a body possessing the power of twisting itself around other bodies with great force and facility. The surface is encompassed by numerous small scales, which advance upon the head and encroach on the abdomen, so that the former part never exhibits the regularly-formed plates of the Colubers, while those of the latter are unusually narrow. The vertical position of the nostrils and small-sized eyes announce a combination of aquatic with terrestrial habits of life. The first genus, that of *Boa* properly so called, is characterized by simple plates beneath the tail; the second, *Python*, peculiar to the ancient world, exhibits the subcaudal plates divided, a supernumerary bone on the upper margin of the orbits, and intermaxillary teeth; the third, *Acrochordus*, is destitute of anal hooks, and has the surface entirely covered over by small granular unimbricated scales. All these generic groups have many characters in common, both in habits and organization, and we shall here point out a few of their generalities.

The term *Boa*, according to Pliny,[3] is derived from *Bos*, because the young of these reptiles are wont to nourish themselves on cow's milk.[4] We are farther informed by that credulous author, of the great Boa slain in the Vatican, within the abdomen of which was found an entire infant. Linnæus applied the name to all serpents provided with simple sub-caudal plates. It is obvious that his genus, founded on a character of such slight importance, while it excludes the Pythons, necessarily brings together several heterogeneous groups. The defect in the modern arrangement of these reptiles arises chiefly from the practice of viewing a single and often subordinate character, and ruling, as it were, the forms of nature in simple accordance with its absence or existence. We thus find the Pythons almost always separated from the Boas, and placed in the genus Coluber, while the Acrochordi, estranged from both, comprise two distinct genera, sometimes placed among venomous serpents, sometimes classed with the innocuous kinds. " Nos temps," says M. Schlegel, " fertiles en invasions de toute sorte, ont vu démembrer la famille des Boas en autant de divisions génériques que l'on en compte d'espèces, qui elles-mêmes sont multipliées sans le moindre fondement de verité. Il n'est pas rare de voir la même espèce distribuée en deux ou trois genres différens, et ces genres placés au hazard parmi d'autres Couleuvres ou parmi les vipères." The opportunities enjoyed by the author just named, of studying the various species, has led him to the belief that these are much less numerous than generally supposed. He thinks that the majority of such as exist in nature are now in some measure known, and that they do not amount to more than fifteen, including *Acrochordus*. Various anomalies exist among the species when compared among each other. Some are spread over a vast tract of territory, while others are confined within narrow limits. They are all, however, inhabitants of countries either situate beneath the equator or near the tropics. They occur in both the Old and New World, but none is found in Europe, North America, or Japan. The South American species are frequent in collections; those of the (so-called) more ancient countries of the earth are rather rare. Some are oviparous, others produce their young alive. The Boas usually attain, in truth, to an enormous size, although their actual dimensions have been greatly exaggerated. Thus at the very name of *Boa constrictor* the imagination is filled " with folds voluminous and vast," although the species really so called scarcely ever exceeds ten or twelve feet in length. The largest Ophidian reptiles in the world are *Boa murina* and *Python Schneideri* and *bivittatus*; but it may be greatly doubted whether the first named, which is the most gigantic of all, ever exceeds twenty-five feet in these degenerate days, and we have no sufficient

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[1] *British Vertebrate Animals*, p. 296. Figured in Bell's *British Reptiles*.

[2] *Annales des Mus.*, ii. 280, pl. 50; Guérin, *Iconog. Reptiles*, pl. 20, fig. 3.

[3] *Hist. Nat.* 8–14.

[4] " Quant aux véritable serpens, il n'en est pas qui mâchent réellement, de même qu'il est evident qu'aucun ne peut sucer ou opérer le vide dans la bouche, et que, par consequent, c'est un préjugé de croire que plusieurs de ces animaux, comme les Boas et les Couleuvres, puissent téter les vaches; outre l'absence des lévres charnues, le defaut de voile du palais et de l'épiglotte, qui rendraient la succion impossible, il est evident que les crochets acérés et recourbés en arrière, qui garnissent leurs mâchoires et leur palais, s'accrocheraient comme des hameçons aux tétines des mammifères et qu'ils ne pourraient s'en detacher." (*Erp. Gén.* i. 135.)

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reason for supposing that it was ever any larger in former times.[1] The recitals of our travellers have been too often drawn, not from their own observation (by no means accurate at the best), but merely from the popular belief of ignorant and superstitious natives. The Pythons of the Old World seldom exceed from eighteen to twenty feet in length; and we can easily believe that one even of that extent being met by a benighted traveller in some lonesome forest glade, or murky meadow, might be afterwards described as something super-serpentine. Who in early life (how few at any period) ever caught a trout of two pounds or a pike of ten, without at least supposing that the one weighed four, the other fifteen? Yet who fears the innocuous finny race, and how greatly must doubt and dismay increase the seeming dimensions of a huge lugubrious reptile, weaving its way through some "wild wood, dingle or bushy dell," and dimly seen in sombre twilight hours, by snatches of only four or five yards at a time? The same exaggeration prevails regarding both the size of their natural prey, and its mode of capture. The lamented Boié, who made numerous observations on the Pythons of Asiatic countries, states that they particularly attack only the smaller kinds of quadrupeds, although individuals of unusual size sometimes swallow a young pig, or that species of deer called muntjac. But the larger mammiferous animals, and the human race more especially, need entertain no reasonable expectation of attack; and Prince Neuwied confirms this statement of the lamented naturalist of Kiel, so far as concerns the great species of the New World, which prey chiefly on birds and reptiles.

Boas are said to be by no means difficult to tame. M. Dieperink of Paramaribo informed M. Schlegel that he was in the practice of keeping by him several different kinds of live Boas, all of which lived in perfect harmony, both among themselves and with other domestic animals. Professor Reindwardt, however, was witness at Java to a spectacle which proved that these great serpents are not always as merciful as they are strong. A native of the island having brought to the Baron Van Der Capelle a huge Python, and being desirous to make it leave a pannier in which it was contained, the monster rose upon him suddenly, and inflicted a severe wound, at once laying open the fore-arm throughout its entire extent. It may be as well, then, upon the whole, not to allow the serpents of this family to sleep at large in the bed-chambers of any other family where there are small children.

The members of our present group seize their prey suddenly by ambuscade, usually lying in wait for it in the vicinity of water. They fix upon it with their teeth, and then, if of tolerable size or strength, entwine their folds around it, pressing out the breath of life, or even bruising the body, and breaking the bones in pieces. To aid this act of butchery, some of the species are said to keep their tails twisted around a tree, to which they drag their reluctant victim,—making use at the same time of the hard and gnarled trunk to give a still stronger stringency to their dreadful coils, while the faint-hearted prey

Clamores simul horrendos ad sidera tollit.

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When the animal attacked is of smaller size, it is merely *mouthed*, always head foremost, covered with saliva to hasten putrefaction and aid deglutition, and afterwards swallowed at leisure. These gigantic reptiles are endowed with great muscular force, which, however, they rarely exercise in a state of captivity. They seem extremely lethargic when imported into Europe; many of them, if not gentle in their manners, at least cannot be induced to bite by any provocation; their movements are very slow, they rarely eat, and the majority indeed die after a few months' confinement, without having tasted food.

The following curious, and we doubt not accurate, account of the swallowing powers of one of the great Asiatic serpents, has been recorded by Mr Macleod. He calls the species *Boa constrictor*, which, as it was captured in Bornea, it could scarcely be. It belonged, we presume, to the genus Python, and measured sixteen feet in length by about eighteen inches in circumference. We shall make no apology for the size of the ensuing extract, as it so clearly illustrates the peculiar manners and the mode of deglutition of these Boa-like serpents.

"The live stock for his use during the passage, consisting of six goats of the ordinary size, were sent with him on board, five being considered as a fair allowance for as many months. At an early period of the voyage we had an exhibition of his talent in the way of eating, which was publicly performed on the quarter-deck, upon which he was brought. The sliding door (of his cage) being opened, one of the goats was thrust in, and the door of the cage shut. The poor goat, as if instantly aware of all the horrors of its perilous situation, immediately began to utter the most piercing and distressing cries, butting instinctively at the same time with its head towards the serpent, in self-defence. The snake, which at first appeared scarcely to notice the poor animal, soon began to stir a little, and turning his head in the direction of the goat, he at length fixed a deadly and malignant eye on the trembling victim, whose agony and terror seemed to increase; for, previous to the snake seizing his prey, it shook in every limb, but still continuing its unavailing show of attack, by butting at the serpent, which now became sufficiently animated to prepare for the banquet. The first operation was that of darting out his forked tongue, and at the same time rearing a little his head; then suddenly seizing the goat by the fore leg with his mouth, and throwing it down, it was encircled in an instant in his horrid folds. So quick, indeed, and so instantaneous was the act, that it was impossible for the eye to follow the rapid convolution of his elongated body. It was not a regular *screw-like* turn that was formed, but resembling rather a knot, one part of the body overlaying the other, as if to add weight to the muscular pressure, the more effectually to crush his object. During this time he continued to grasp with his fangs, though it appeared an unnecessary precaution, that part of the animal which he had first seized. The poor goat, in the mean time, continued its feeble and *half-stifled* cries for some minutes, but they soon became more and more faint, and at last it expired. The snake, however, retained it for a considerable time in his grasp after it was apparently motionless. He

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[1] Unable as we are either to confirm or contradict, from personal experience, the reported observations of travellers regarding the supposed dimensions of these huge reptiles, we are under the necessity of stating the different opinions which prevail upon the subject, however irreconcileable these may sometimes seem with each other. The following quotation rather favours the idea of their great size and unexampled voracity. "In the Dutch colonies of the East Indies, André Cleyer purchased of the hunters of the country an enormous serpent, in the body of which he found a deer of middle age, altogether entire, with its skin and limbs. In another individual of the same species, also examined by the traveller, a wild he-goat was found, with its horns; and a third had evidently swallowed a porcupine with its quills. He adds, that a pregnant woman also became the prey of a reptile of the same genus in the island of Amboyna; and that this kind is sometimes kept for the purpose of attacking the buffaloes in the kingdom of Aracan, on the frontiers of Bengal. We need hardly be astonished at this, when Prince Maurice of Nassau-Siegen, one of the governors of Brazil, in the seventeenth century, assures us that he himself was an eye-witness of stags, and other equally voluminous mammifera, and even of a Dutch woman" (usually a considerable mammifer), "being devoured in this manner, in that region of South America where he commanded." Griffith's *Animal Kingdom*, ix. 295.

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then slowly and cautiously unfolded himself, till the goat fell dead from his monstrous embrace, when he began to prepare himself for swallowing it. Placing his mouth in front of the dead animal, he commenced by lubricating with his saliva that part of the goat; and then taking its muzzle into his mouth, which had, and indeed always has, the appearance of a raw, lacerated wound, he sucked it in as far as the horns would allow. These protuberances opposed some little difficulty, not so much from their extent, as from their points; however, they also in a very short time disappeared, that is to say, externally; but their progress was still to be traced very distinctly on the outside, threatening every moment to protrude through the skin. The victim had now descended as far as the shoulders; and it was an astonishing sight to observe the extraordinary action of the snake's muscles when stretched to such an unnatural extent,—an extent which must have utterly destroyed all muscular power in any animal that was not, like himself, endowed with very peculiar faculties of expansion and action at the same time. When his head and neck had no other appearance than that of a serpent's skin, stuffed almost to bursting, still the workings of the muscles were evident, and his power of suction, as it is erroneously called, unabated; it was, in fact, the effect of a contractile muscular power, assisted by two rows of strong, hooked teeth. With all this, he must be so formed as to be able to suspend, for a time, his respiration; for it is impossible to conceive that the process of breathing could be carried on while the mouth and throat were so completely stuffed and expanded by the body of the goat, and the lungs themselves (admitting the trachea to be ever so hard) compressed, as they must have been, by its passage downwards.

"The whole operation of completely gorging the goat occupied about two hours and twenty minutes; at the end of which time the tumefaction was confined to the middle part of the body, or stomach, the superior parts, which had been so much distended, having resumed their natural dimensions. He then coiled himself up again, and lay quietly in his usual torpid state for about three weeks or a month, when, his last meal appearing to be completely digested and dissolved, he was presented with another goat, which he killed and devoured with equal facility."[1]

As the vessel, which was sailing from Batavia to England, approached the Cape of Good Hope, this gigantic reptile began to droop, as was at first supposed, from the increasing cold. It refused to kill some fowls which were presented, and died before reaching St Helena. On dissection, the coats of the stomach were found to be "excoriated and pierced by worms!" Nothing of either goat remained except a single horn. During a prior captivity of some months at Whidah, in the kingdom of Dahomey, Mr Macleod had enjoyed opportunities of observing snakes "double the size of the one just described." These killed their prey in the same manner; but from their superior bulk were capable of swallowing much larger animals than either goats or sheep. Governor Abson, who had resided for nearly forty years at Fort William, a settlement of the African Company, used to describe some desperate struggles which had taken place between these great serpents and various wild beasts, as well as smaller cattle. A negro herdsman was once seized by the thigh, but the monster, in attempting to entwine itself around him, got entangled by a tree, and the man being armed with a knife, had presence of mind to inflict several severe gashes on the neck and throat, which enabled him to disengage himself from the dreadful coils which were closing fast around him. But he remained lame for life, in consequence of the wound and heavy pressure inflicted by the jaws.

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The natural colours, which are various in this family, disappear speedily after death. Some are brown upon a yellowish ground, others exhibit a uniformly greenish hue, red prevails among certain species, while a few are nearly black. Almost all are more or less spotted; and it has been observed that, unlike the smaller tribes of serpents, these markings continue equally, or rather more distinct, as the individual increases in years. The body of the Boas is thickest at the middle, tapers towards either end, and is always considerably compressed. The abdomen is broad, and slightly convex or keeled. The tail is shaped like the body, but is more slender, not very conical, and usually terminates in a blunted point. It is always prehensile, that is, possesses the power of rolling inwards upon itself, or forming convolutions around other bodies. The scales in general are rather small, and as they encroach considerably on the under surface, it follows that the abdominal plates are narrower than usual. There are sometimes from sixty to seventy ranges of scales, and about two hundred and fifty abdominal plates. The number of these, however, is greater in the Boas of the ancient world than among the American species, which moreover differ in several other respects; while the genus *Acrochordus* is distinguished from all its congeners by the small granular scales which clothe the entire surface, and of which a double series prevails along the median line of the abdomen, forming a kind of projecting ridge or keel.

The head of the Boas is always distinguishable from the trunk, being thick, rather lengthened, conical, depressed, and terminated by a muzzle for the most part elongated, and truncated at the point. The eyes are placed at some distance from the nostrils, and are lateral in the terrestrial species, of which the head is flattened above, and more or less angular on the sides; but the more aquatic kinds have the eyes rather vertical. These organs are always small in our present family, and, excepting *Acrochordus*, have the pupil horizontally elongated. The nostrils are broad, closely approached to the end of the muzzle, and in some are placed upon its summit. They open upwards in the genus just named, and assume a tubular form. All the species are provided with palatine teeth, nearly as much developed as the maxillary ones; but there are no intermaxillary teeth except among the Pythons. The glands of the head are less developed in this family than among the majority of Ophidian reptiles.

Genus BOA. No intermaxillary teeth. Space between the orbits formed solely by the frontals properly so called. Subcaudal plates simple.[2] See Plate CCCCXLIII. figs. 8–11.

This restricted genus includes the largest of Ophidian reptiles, and although composed chiefly of South American snakes, it also contains three Asiatic species, which, though of much smaller size, cannot be regarded otherwise than as a geographical division.

Boa constrictor, Linn., is a middle-sized species, which rarely exceeds the length of ten or twelve feet.[3] It is of a reddish tint, elegantly marked by irregular reticulations of

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[1] Macleod's *Voyage of the Alceste*, p. 290.

[2] This is the prevailing character of these parts, although we find in this, as in many other cases, a difficulty in seizing upon single determinate features of constant application. Thus we sometimes meet with several divided plates in the sub-caudal region of these so-called Boas.

[3] The true *B. constrictor* is often confounded with the more gigantic *B. murina*, and its dimensions have in consequence been greatly exaggerated. We doubt if any existing species ever attains to the alleged size of the so-called *B. constrictor*. Mr Swainson, however, who has travelled in South America, and is himself a zealous student of the facts of zoology, both as recorded in books and as existing in nature, states that the young individuals frequent in our menageries are mere pignies in comparison to the

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brownish black, and other hues, and is subject to a great variety of aspect, so far as colour is concerned. It is, however, well characterized by the small smooth scales which cover both head and body, and of which there are sixty-seven rows. The head is heart-shaped, and the tail short. Abdominal plates 243, caudal fifty-eight. This species is native to the intertropical countries of South America, and not only have its size and voracity been greatly exaggerated, but many traits have been applied to it which truly belong only to the Pythons of the ancient continent. Thus the very name of *Devin*, bestowed upon it by Lacépède, is borrowed from what Bosman relates of the worship accorded by the negroes to certain African reptiles. It is met with in Surinam and Brazil, in woody districts, being sometimes seen suspended from the branch of a tree, sometimes concealed in the hollows of rocks, or beneath an ancient trunk. It is feared by no one, is often killed with a short walking-stick, and is commonly known by the name of *Jiboya*. It feeds on small and middle-sized mammalia, such as mice, rats, agoutis, pacas, and capybaras, as well as on various reptiles. A hunter, however, assured the Prince of Neuwied, that his dog on one occasion would have fallen a victim to a Boa of this species, had he not contrived to shoot it during the combat. The true constrictor does not enter the water. The Brazilians take it by means of gins, and employ its skin for making boots and saddle-cloths. They also use its fat. All engraved representations of this species, having been made from ill-prepared museum specimens, are worse than indifferent.[1]

The rat-eating Boa, *B. murina*, Linn. (*B. Anaconda*, Daud.[2] *B. aquatica*, Neuw.[3]), is the largest Ophidian reptile of America, and probably the most gigantic of known species. It is distinguished in Brazil by the title of *Cucuriuba*, and passes a great portion of its time in the water, either swimming about in various directions, or floating lazily with the current. It dives with great dexterity, can remain for a length of time beneath the surface, and is said to prey on fish as well as quadrupeds. It is tenacious of life, and is killed by the natives either with bow or musket in the water, or with sticks when met with on shore, where its movements are somewhat sluggish. Both its skin and fat are used for various purposes, and its flesh is eaten by the Botocudes. M. Fermin measured one which had attained the length of twenty-three and a half feet; and the Prince of Neuwied was assured by the natives that it is often much longer, although he himself never saw one above twenty feet. This species exhibits less varied markings than the preceding. The general hue of the upper parts is sooty brown, with two rows of orbicular blackish spots along the back. The under surface and sides are of an ochry yellow, the latter marked with a double row of irregular eye-shaped spots, which confound themselves with numerous squarer spots upon the belly. The nostrils are vertical, the eyes also directed upwards. The head is of an elongated form, with a rounded muzzle. Abdominal plates 250, caudal sixty-six.

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The other species of this genus are *B. cenchria*, *canina* (Plate CCCCXLIII. figs. 8–11), *hortulana*, from South America; *B. Dussumieri*, from a small island near the Mauritius; *B. carinata*, from the Moluccas and New Guinea; *B. conica*, from Bengal; and *B. melanura*, from the island of Cuba.

Genus PYTHON. Several intermaxillary teeth. Upper portion of the orbit formed by a particular bone incased among the three frontals, and named super-orbital by Cuvier. Sub-caudal plates usually divided. Lips hollowed out in front. Plates of the head larger and more regular than in Boa. See Plate CCCCXLIII. figs. 1*b*, 1*c*, and 3, and Plate CCCCXLIV. fig. 5.

This genus was established by M. Daudin for the reception of the great serpents of the ancient world. Brown, black, and yellow, are their prevailing colours. Certain of the species equal (some say exceed) the Boas of America in size, for example the *Ular-sawa* (*Python bivittatus*, Khul,—*Col. Javanicus*, Shaw). This species is of a yellowish tint, relieved by a pattern of broad alternate brown spots. The top of the head is margined by two rays of the ground colour. The flanks are variously adorned by black and white, and the under surface is marked by deep square spots. There are sixty-three ranges of smooth small scales, 270 abdominal and seventy caudal plates. This great reptile is spread, according to M. Schlegel, over a vast extent of territory, being known to occur from the western coast of Africa, over the whole of intertropical Asia, as far east as China and the island of Java. It is said to attain the length of twenty-five feet, and individuals of twenty feet in length have been seen and described by trustworthy naturalists. A fine specimen lived for some time in Holland, and was observed to be slow in its movements, mild in its temper, and never inclined to bite even when provoked. It was kept in a large box enveloped in woollen cloths, where it lay in continued tranquillity, and suffered itself to be drawn out for frequent exhibition without manifesting any signs of anger or impatience. We suspect that the senses of this, and of other large tropical snakes, are so far benumbed by the change of climate in Europe as to produce stupefaction rather than tameness. The specimen in question was presented with food every eight days, which, however, it often refused for several successive times. It was most easily excited to eat by the sight of a live rabbit, into the head of which it would fix its teeth, and then, placing it within a fold of its body, deprived it almost instantly of life. After the commission of this murder, it was in no hurry to swallow its victim, but sometimes licked it for a while, occasionally taking two or three hours to effect the final deglutition. This is supposed to be the *Pedda-poda* of Dr Russel, called rock-snake by the Anglo-Indians.[4]

We do not happen to know to what extent this or any

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adults, "which have been *often found* to exceed *forty feet* in length" (*Cabinet Cyclopædia*, vol. cxvi. p. 143). Yet he does not state this as a result of observation, or as connected with his own knowledge as well as belief. A single specimen of such gigantic reptile would be the wonder of Europe, and would make a fortune for its owner. A Dutch friend of Mr Waterton's killed a Boa (he does not say of what species) twenty-two feet long, with a pair of stag's horns in its mouth. It had swallowed the stag, but could not swallow the horns (at which we are not much surprised), and so had to wait in patience with that uncomfortable mouthful till its stomach had digested the body, "and then the horns would drop out." It was in this expectant plight that the Dutchman found it, as he was going in his canoe up the river, and sent a ball through its head (*Wanderings in South America*, third edit. p. 209). The large serpent *bagged* by Mr Waterton, after "a sharp fray in the den, the rotten sticks flying on all sides, and each party struggling for superiority," measured rather more than fourteen feet in length. It was of the kind called *Coulacanara*, a rare species, and so much thicker in proportion to its length than any other snake of the forest, that an individual of the extent just stated "is as thick as a common Boa of twenty-four." Its jaws are so extensile, that Mr Waterton, after skinning his specimen, could easily get his head into its mouth.

[1] See Scheuchzer, *Biblia Sacra*, pl. 746, fig. 1:—Lacép. *Quad. Ovip.* ii. pl. 16, fig. 1:—Daudin, *Reptiles*, v. pl. 92, fig. 1. There are various figures of our *B. constrictor* in Seba's *Thesaurus*, and from these Laurenti seems to have composed such species as *Constrictor formosissimus*, *Rex serpentum*, *diviniloquus*, and several others.

[2] *Reptiles*, v. 161, pl. 63.

[3] *Abbild.* livrais ii. pl. 6, and *Beitr.* p. 226.

[4] Numerous nominal species have arisen from the superficial observance of different varieties of this Python. See Russel's *Serpents*, pl. 20, 23, 24, and 29; and Daudin's *Reptiles*, v. pl. 64, fig. 1, and pl. 59, fig. 4.

other species of Python may have attained in ancient times, but it is probably from some misconceived view of our present species that the marvellous traditions regarding almost immeasurable serpents have been derived. Who has not read of that enormous reptile which spread dismay even through a Roman army? It is thus related by Valerius Maximus, from one of the lost books of Livy, by whom it is said to have been recorded at greater length. "And since we are on the subject of uncommon phenomena, we may here mention the serpent so eloquently and accurately (!) recorded by Livy, who says, that near the river Bagrada in Africa, a snake was seen of so enormous a magnitude as to prevent the army of Attilius Regulus from the use of the river; and after snatching up several soldiers with its enormous mouth, and devouring them, and killing several more by striking and squeezing them by the spine of its tail, was at length destroyed by assailing it with all the force of military engines and showers of stones, after it had withstood the attack of their spears and darts; that it was regarded by the whole army as a more formidable enemy than even Carthage itself; and that the whole adjacent region, being tainted with the pestilential effluvia proceeding from its remains, and the waters with its blood, the Roman army was obliged to move its station: he also adds, that the skin of the monster, measuring 120 feet in length, was sent to Rome as a trophy." The learned Frienshemius, having had the advantage of living a thousand years or two after the historian of the Punic war, has given a still more circumstantial account of this bloody broil in his *Supplementa Liviana.* He there informs us, that "it caused so much trouble to Regulus, that he found it necessary to contest the possession of the river with it, by employing the whole force of his army; during which a considerable number of soldiers were lost, while the serpent could neither be vanquished nor wounded, the strong armour of its scales easily repelling the force of all the weapons that were directed against it; upon which recourse was had to battering engines, with which the animal was attacked in the manner of a fortified tower, and was thus at length overpowered. Several discharges were made against it without success, till its *back being broken by an immense stone*" (we admire detailed accounts of ancient actions), "the formidable monster began to lose its powers, and was yet with difficulty destroyed, after having diffused such a horror among the army, that they confessed they would rather attack Carthage itself than such another monster." Probably such another was not then at hand, and we believe has never been seen since; but the anecdote itself holds out great encouragement to modern travellers. It is, we doubt not, to *Python bivittatus* that Bosman and other writers refer, when they mention the religious veneration with which some great African serpents are regarded by the natives. But we must conclude our imperfect notice of this genus by stating, that of the remaining species, *P. Schneideri* (Plate CCCCXLIII. fig. 3, and Plate CCCCXLIV. fig. 5) is found in Malacca, Java, Sumatra, and Amboyna; *P. amethystinus*, in Saparua, a small island opposite Amboyna (a nearly identical kind being found in Timor, Samao, and New Ireland); and *P. Peronii* in New Holland.

Genus ACROCHORDUS. Head rounded, eyes extremely small, rather vertical, pupil orbicular, nostrils tubular, nearly terminal, opening forwards or upwards. Tail strongly prehensile, and, in common with the trunk, compressed. Anal hooks wanting. Whole body covered by small scales, and the abdomen furnished with a kind of keel beset with scales. Teeth as in the Boas proper.

The anomalous reptiles of our present genus may be said to combine the characters of the Boas and sea-serpents. Their dentition resembles that of the former, while the position of the eyes and nostrils, the compact closure of the mouth, compressed form of the body, the existence of the abdominal crest, and absence of anal hooks, assimilate them to the latter. They are, however, easily distinguished by being destitute of poison-fangs. Want of attention to the latter character, and some confused and contradictory data furnished by foreign naturalists, have caused several errors in the arrangement of the species, which are very few in number. They inhabit the intertropical countries of Asia, are extremely aquatic in their propensities, and are externally distinguished by a somewhat sombre colouring,—brown and a yellowish hue being the prevailing tints. The Javanese species, *Acrochordus Javanicus*, is of a deep earthen-brown colour, irregularly marbled. Its form is thick, the head short and obtuse, the tail slender in proportion to the other parts. It attains a total length of eight feet, with the thickness of a man's arm, and was first described by Hornstedt, from a specimen taken in a large pepper-ground near Sangasan in Java.[1] *Ac. fasciatus* is also of a brown colour, but with paler bands upon the sides, the general form much more slender, and the dimensions considerably less.[2] It is more extended in its distribution than the preceding, being found in Pondicherry, New Guinea, Sumatra, Java, and Timor. It forms (it is said erroneously) the genus *Chersydrus* of Baron Cuvier,—the great French naturalist having been informed by M. Leschenhault that the snake in question was extremely poisonous, and dwelt in the beds of the rivers of Java. The accuracy of the former assertion has been since disproved. No other species are distinctly known.

SECOND PRIMARY DIVISION.—VENOMOUS SERPENTS.

Family I.—Colubriform Venomous Serpents.

The poisonous species here assembled, although provided with envenomed fangs, so nearly resemble the Colubers in their general external forms as to be easily mistaken for them by an inexperienced eye. They also partake in some points of the features of the sea-serpents, but are distinguished by wanting the flattened tail; while from the concluding family of venomous serpents *properly so called*, they are kept apart by the bulkier proportions, thick triangular heads, vertical pupils, and carinated scales, which characterize the species last alluded to. At the same time it must be admitted, that those rigorous and distinct demarcations which so many lovers of nature desire to establish, but which so few can find, occur as seldom here as in other departments of zoology,—several species in each family showing a strong tendency of transition towards another.

The reptiles of our present family have a more slenderly elongated form than those of other poisonous groups. Their trunk is in general a good deal drawn out, sometimes cylindrical, or slightly compressed. Their tail, like that of all poisonous species, is rather short, conical, and rounded at the extremity. Their head, almost always of nearly equal dimensions with the neck, is small, short, and obtuse at the extremity. The eyes are rather small, sometimes vertical, the pupil always orbicular. The nostrils, always lateral and rather open, are pierced in a large plate on each side of the muzzle. The scales are not numerous, of medium size, and always smooth,—except in *Naja hæmachates*, in which they seem surmounted by a keel. The abdomen is constantly convex, and furnished with plates of greater or less extent, according to the species. But what particularly characterizes this family is, that all the genera of which it is composed have the crown of the head covered by nine plates,

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[1] *Act. Stockh.* 1787; and *Journ. de Physique*, 1788.

[2] Shaw, *Gen. Zool.* iii. pl. 130.

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modelled after the type of those of Coluber. The poison apparatus is much less developed than among other venomous kinds; but the fangs, though short, are strong. The species inhabit the warmer countries of both the New and Old World, but do not occur in Europe. They form three generic groups, as after mentioned.

Genus Elaps. Body slender and cylindrical, of nearly equal size throughout, and usually encompassed by fifteen rows of broad, smooth scales. Head elongated, and not strongly distinguishable from the trunk.

This genus was established by Schneider,[1] and now contains all those slender-bodied venomous kinds, which by their elongated forms remind us of *Tortrix and Calamaria.* They attain to no great size, seldom reaching three or four feet in length, and scarcely exceeding a finger's thickness in diameter. Their colours are often bright and beautiful, a combination of red and black being frequent among them. They prefer countries covered by an abundant vegetation, concealing themselves amid the herbs of the meadows, or the loftier luxuriance of the forest; and with this circumstance we may connect the fact, that only a single species is found in Africa, all the others occurring in tropical America, New Holland, the Indian Archipelago, and Bengal,—the latter country however producing likewise only a solitary instance in *Elaps trimaculatus.* Their agility is by no means great, and they prey chiefly on other reptiles,—birds being probably too active, quadrupeds too large, and fish too aquatic, for creatures of slowish movement, small size, and terrestrial habits. We cannot here detail the species, of which eleven are described by M. Schlegel, but must rest satisfied by referring, as examples, to a few figures, such as,—*E. corallinus* (*Nova Acta*, x. pl. 4), *E. Surinamensis* (*Seba*, ii. pl. 86, fig. 2), *E. collaris* (*Erpétol. de Java*, pl. 45), *E. trimaculatus* (Russel, *Ind. Serp.* i. pl. 8).

Genus Bungarus. Form more robust than that of Elaps. Head broad, depressed, rounded terminally, and towards the sides. Abdomen convex. Tail robust. Dorsal line furnished with a row of hexagonal scales, larger than the rest. Sub-caudal plates simple.

To this genus belong the *Bungarum pamma* of Russel (*Ind. Serp.* i. pl. 3), *B. annularis*, Daudin, and the *Geedi Paragoodoo* of the former author, *B. semifasciatus* of Khul and Schlegel. Both species inhabit India, as well as Java and Ceylon. The natives of India, who are said generally to exaggerate the noxious character of their serpents, assert that the bite of the latter produces immediate death, although Dr Russel's experiments go to prove that it is seldom fatal to chickens in less than half an hour, or to dogs in a shorter period than an hour and a half. A *Geedi Paragoodoo* was made to bite a large dog on the thigh, near the groin, where it held fast for more than twenty seconds, but the fangs scarcely penetrated farther than the skin. The dog howled much when first wounded, but on being set at liberty walked about for a time without manifesting any peculiar symptoms. In ten minutes, however, he drew up the wounded leg, continuing to stand on the other three; in a quarter of an hour he crouched, and howled again, and the thigh became paralytic, though the poor creature was still able to raise himself; in twenty-five minutes both thighs were paralytic; and in the course of the second hour he became greatly disordered, grew apparently torpid, lay panting on one side, and died in about two hours, without convulsions. Another dog of smaller size expired in one hour and ten minutes, after being strongly convulsed for some minutes prior to its death.

Genus Naja. General form robust. Body not cylindrical, but thickening in the middle, and tapering towards either end. Tail lengthened and conical. Abdomen broad and convex. Head well distinguished from the trunk. Eyes large and lateral. Neck more or less capable of inflation.

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This genus contains the famous hooded or spectacle-snakes, called *cobras de capello* by the Portuguese, the majority having the power of raising the anterior ribs, so as to produce a peculiar disk-like inflation of the neck or upper portion of the body. The species are peculiar to the ancient world,—if New Holland, which produces two, and was unknown to the ancients, may be classed therein. M. Schlegel describes eleven different kinds, many of which, however, are arranged in separate genera by other writers, but which that author regards as forming an uninterrupted series, closely connected with each other, and of which the foremost exhibit the announced generic characteristics in great strength and precision, while the others gradually depart from the type, and form a passage to the vipers.

The hooded snake, commonly so called (*Coluber naja* of the older writers,—*Naja tripudians* of the recent systematists), is one of the most noted as well as noxious of the Indian reptiles. Its general length is from three to four feet, and the diameter of its body about an inch and a quarter. The inflated portion is marked above by a large conspicuous patch, closely resembling the figure of an old-fashioned pair of spectacles. The usual colour of the upper parts is pale ferruginous brown, the under being of a bluish white occasionally tinged with yellow. The terminal portion tapers gradually, and ends in a rather slender sharp-pointed extremity. In India this dreaded species is more universally known than any other. It is frequently exhibited as a public show, and being carried about in a covered basket, is made to assume a kind of dancing motion (a modification, we presume, of some natural and instinctive movement) for the amusement of the public. Raising itself up on its lower extremity, and moving its head and body alternately from side to side, the insidious creature seems pleased by keeping time with the measured melody of "flutes and soft recorders." We presume that a love of music is natural to certain serpents; and that this fact was observed of old in Palestine, is probable from the expression of the inspired Psalmist, who compares the ungodly to the deaf adder, which "stoppeth her ears, and refuseth to hear the voice of the charmer." Chateaubriand relates that he was an eyewitness, on the banks of the Genesee, to the fact of a native appeasing the wrath of a rattle-snake (which he even caused to follow him), merely by the music of his flute. The dancing snakes of India are usually, though not universally, deprived of their poison-fangs. "When the music ceases," says Mr Forbes, "the snakes appear motionless; but if not immediately covered up in the basket, the spectators are liable to fatal accidents. Among my drawings is that of a *cobra de capello*, which danced for an hour on the table while I painted it; during which I frequently handled it to observe the beauty of the spots, and especially the spectacles on the hood, not doubting but that its venomous fangs had been previously extracted. But the next morning my upper servant, who was a zealous Mussulman, came to me in great haste, and desired I would instantly retire and praise the Almighty for my good fortune. Not understanding his meaning, I told him that I had already performed my devotions, and had not so many stated prayers as the followers of his prophet. Mohammed then informed me, that while purchasing some fruit in the bazaar, he observed the man who had been with me the preceding evening, entertaining the country people with his dancing snakes; they, according to their usual custom, sat on the ground around him; when, either from the music stopping too suddenly, or from some other cause irritating the vicious reptile which I had often handled, it darted at the throat of a young woman, and inflicted a wound of which she died in half an hour."[2] A similar fate had

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[1] *Hist. Amphib.* ii. p. 289.

[2] *Oriental Memoirs*, i. p. 44.

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nearly befallen an artist employed by Professor Reinwardt to paint the portrait of a living Naja. It had in some way disengaged its bands, and seemed to have prepared itself to attack the unsuspecting painter the moment he entered his apartment. He there found it supported on its tail, its body raised, its neck dilated, its head advanced,—and then giving utterance to some hissing sounds, it threw a quantity of saliva upon the very man who was about to hand it down to posterity, but who fortunately effected an instantaneous retreat before it came to closer quarters. We doubt not the painter loved the picturesque, although that was not the time to gaze with admiration on the fierce intruder:—

> Not with intended wave,
> Prone on the ground (as since), but on his rear,
> Circular base of rising folds, that tower'd
> Fold above fold, a surging maze! his head
> Crested aloft, and carbuncle his eyes.

Dr Russel informs us that he never knew the bite of a hooded snake prove mortal to a dog in much less than half an hour, although it kills chickens in less than half a minute. Now the rattle-snake has been known to kill a dog in less than two minutes. Yet the use of the lunar caustic, which in the hands of the Abbé Fontana proved so efficacious when applied as remedial to the bite of the viper, was found of little or no avail in India as a counteraction to the venom of the *cobra de capello*.[1] We shall conclude our notices of this species by observing, that the Ceylonese jugglers, according to Dr Davy, use it without extracting the fangs, the only means which they employ to avoid its vengeance being courage and agility. It is in fact held in veneration by the natives of that island, who carefully avoid it, offer it no injury, and put it out of doors unhurt when it happens to enter their dwellings.[2] The root of *Ophiorhyza mungos* is believed in India to be a specific against the bite of the *cobra de capello*.

Another noted species is the *Naja haje* (*Coluber haje*, Linn.), which plays the same part in the history and superstitions of the African tribes as the preceding does in those of the Asiatic nations. The ancient Egyptians named it *Ouro*, a term which signifies king, and which the Greeks adopted into their language in the word *Ouraios*. It is frequently represented in various Egyptian antiquities, whether as drawn in colours, sculptured on the covers of sarcophagi, or cast in bronze. One of the great creative spirits of the world, called Cneph, Cnouphis, or Ammon, in the cosmogony of Egypt, was represented in their symbolical writings under the form of a serpent winding itself around a globe, or placed in the centre of a disk.

The jugglers of modern Egypt, especially of Cairo, use this Naja in their pretended sorceries. These people affect to be descendants of the ancient Psylli, and boast of inheriting from their ancestors the power of subduing and commanding the most poisonous reptiles. The principal feat which they execute consists in making the naja counterfeit death, or they change it into a rod. This they seem to effect by pressing the neck of the creature between their fingers, so as to produce a kind of catalepsy, which renders it stiff and motionless. This is rather a singular fact when considered in connection with the scriptural narrative, where the rods of the magicians, when thrown down, are converted into serpents.[3] According to M. Geoffroy, the species is still sufficiently common in Egypt, occurring both in fields and ditches. " Les cultivateurs sont donc exposés à le rencontrer fréquemment; mais quoiqu'ils n'ignorent pas le danger de sa morsure, sa présence ne les empêche nullement de vaquer à leur travaux ordinaires; connaissant bien les habitudes du redoutable reptile, ils savent qu'ils n'auraient à craindre d'être attaqués par lui, que s'ils venaient à commetre l'imprudence de s'en approcher. En effet, tant qu'ils se tiennent à quelque distance, l'haje se contente de les suivre du regard, en élevant sa tête et en prenant l'attitude dans laquelle les fig. 4 et 5 le represent."[4] The African Naja attains to about the same size as the Asiatic, and greatly resembles it in general aspect; but its neck is less capable of inflation, and its muzzle more conical. It is usually of a yellowish-brown colour above, varied with numerous black and white spots; the under surface whitish, although some individuals exhibit broad black spots or bands on the abdomen. The Cape Naja is regarded by M. Schlegel merely as a climatic variety of that now mentioned.

The Australian species (*Naja porphyrica*) was first described by Dr Shaw.[5] It belongs to the genus *Oplocephalus* of Baron Cuvier, and we place it here on the authority of M. Schlegel. According to M. Lesson, it is greatly dreaded at Port Jackson, and several convicts are said to have died of its bite in a quarter of an hour. It is common in the sandy brushwood of the shores of Botany Bay. Its movements are full of force and vigour, its agility remarkable, and it defends itself when attacked with great hardihood.[6] Another New Holland species is *Naja curta*, described by MM. Quoy and Gaimard, and said to bear resemblance to a viper. It is probably the only Colubriform venomous reptile which exhibits a somewhat vertically elongated pupil.

Family II.—Sea-Serpents.

Our present family is placed here, on the supposition that all the species which it contains are poisonous. Several naturalists, proceeding on certain data given by Dr Russel, have maintained the contrary opinion; but long-continued researches on the part of M. Schlegel have led to the conclusion that there is really no exception to the rule. Great confusion prevails in the synonymy of the species, chiefly owing to the absence of good figures and accurate comparative descriptions,—even Dr Russel's plates, which are the most numerous, being insufficient to lead to a rigorous determination of the species. The specimens themselves are obtained with great difficulty, and are consequently rare in our collections.

We have not sufficiently precise information on which to settle the geographical boundaries of the marine family of serpents. That species occur in the Persian and Arabian Gulfs is by no means improbable; but the fact is inferred rather from some passages in ancient writers than from modern observation; and we know that the authors of antiquity, at least in some instances, mistook certain eel-formed fishes for actual snakes. Schneider indeed[7] (whose competence as a *scholar* no naturalist would dare to doubt) has quoted several classical writers to demonstrate a remote knowledge of sea-serpents; but that knowledge seems too superficially and vaguely expressed to be altogether trusted, or even understood. Ælian comes closer to the point when he says, that " the seas of India produce hydras with flattened tails."[8]

Modern naturalists are believed to be in error who assert their occurrence in the Atlantic Ocean, no proper proof having been yet adduced of any of these species inhabiting the " American Ferry," as we see that world of waters now named, since the steaming days of the British Queen and

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[1] *Edinburgh Cabinet Library*, vol. viii.

[2] *Ceylon*, p. 83, *et seq.*

[3] " Then Pharaoh also called the wise men and the sorcerers: now the magicians of Egypt, they also did in like manner with their enchantments; for they cast down every man his rod, and they became serpents; but Aaron's rod swallowed up their rods." (*Exodus*, vii. 11, 12.)

[4] *Descrip. de l'Egypte*, Atlas, Reptiles, pl. 7.

[5] *Zoology of New Holland*, pl. 10.

[6] *Voyage de la Coquille*, Zoologie, ii. p. 55.

[7] *Hist. Amphib.* i. p. 255.

[8] Æl. l. 16, chap. 8.

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pents.

Great Western. M. Schlegel characterizes the statement as an "assertion que je puis contredire avec certitude." Believing that there are more things in heaven and earth than are "dream't of in our philosophy," and desiring to bear in mind the sentiment of the inspired apostle, that "if any man think that he knoweth any thing, he knoweth nothing yet as he ought to know," we shall content ourselves by stating that sea-serpents have not yet been observed in the Atlantic Ocean. M. Schlegel's researches have led him to believe that they are confined "aux mers intertropicales, ou voisines des tropiques, comprises entre le 90me et les 230me degrés de longit. or. du méridien de Ferro."[1] We shall here state the chief of the actual localities. Several species were received by Dr Russel from among the numerous islands called Sunderabunds, which form the delta of the Ganges. The same author likewise obtained many from different points along the coast of Coromandel. Sir Stamford Raffles mentions three species which frequent the coasts of Sumatra.[2] The Dutch voyagers have observed only a single species on the coast of Java, but they have met with several among the Moluccas, near Timor, Banda, and the shores of New Guinea. Dr Strauss transmitted two species from the Celebes. M. Von Siebold observed them to abound in the China Sea, and met with many in the course of his passage from Java to Japan, from the region of the equator as far north as the 27th degree. Eschholtz has incidentally observed,[3] that the fishermen of the Philippine Islands capture *Acrochordus fasciatus* in the Bay of Manilla, and that this reptile cannot move upon the land. Now it so happens that the Acrochordi correctly so called never inhabit the sea; and it may therefore be inferred that the observer last named had in view, not an *Acrochordus*, but a sea-snake or *Hydrophis*. It is long since Dampier told us of those which he saw along the western shores of New Holland;[4] as did afterwards Sir Joseph Banks along the eastern coast, from the 20th to the 10th degree of north latitude. Forster, as Schneider has recorded, found *Hyd. pelamys* abundant near Otaheite.

The habits of these reptiles are indicated here and there by different writers. Dr Russel describes their aquatic movements as active and elegant, but they have scarcely any locomotive power on land, and speedily die when either brought ashore or placed in fresh water. He found in the abdomen of a female Hydrophis nine perfectly formed young, each of which was enclosed in an egg or envelope, from which (the matured condition) it may be inferred that they are viviparous. It would also seem that their manners are milder than those of the generality of poisonous species. Dr Russel, at least, assures us in regard to *Hyd. gracilis*, that no provocation would induce it to bite any object presented to it. Neither could M. Lesson succeed in his disinterested attempts to make *Hyd. pelamys* wound any poultry, though he kindly put them together alive into a copper bathing tub.[5] The observations received from M. Von Siebold by M. Schlegel confirm the belief of other naturalists, that these reptiles, though assuredly dangerous from their poisonous qualities, are not of a highly ferocious nature. The former traveller fell in with vast numbers while sailing from Batavia to Japan, all of the small species, elsewhere so frequent and widely spread, known to naturalists by the specific name of *pelamys*. Their movements were by no means rapid, although they glided through the water with grace and activity, raising their heads from time to time above the waves, for the purpose probably of respiration. Their motion is produced and directed by an action of the tail, accompanied by a lateral and undulating movement of the other parts of the body. They were easily enough entrapped in wooden buckets, and glided through the sailors' hands without attempting to bite them,—the said sailors having probably been previously informed that they were eels. "Le Professeur Reinwardt," says Schlegel, "confirme ce que M. von Siebold rapporte relativement au caractère doux et tranquille de ces animaux."[6] We cannot, however, help thinking that this alleged sweetness of temper and tranquillity are in some measure inconsistent with the cases of the native woman and Lascar already reported in our introductory observations. The comparatively slow movements also do not accord with what we are elsewhere informed by M. Lesson. "Le 27 Juillet," says that naturalist, "par une journée brûlante, nous fûmes pris de calme sur les côtes de la Nouvelle Guinée. De nombreux serpens marins passèrent le long de la corvette, et un embarcation que le capitaine fit mettre à la mer nous permit de les chasser. Nous atteignimes après de longues pursuites une Pelamide, dont l'agilité était extrême, et les mouvemens de natation des plus rapides."[7]

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Serpents.

We owe some interesting observations on the manners of these marine serpents to M. Peron,[8] although it may be doubted whether that voyager did not occasionally take his notes from too great a distance, especially in reference to size and colour. No other credible author has ever described any of these species as attaining to so great a length as twelve feet; the usual dimensions, we may here observe, varying from two and a half to five feet. However, M. Peron describes those he saw as gliding lightly in great numbers on the surface of the sea, and waging destructive war against a shoal of small herrings, which fled precipitately towards deeper water. The haunts of these snakes are by no means confined to the shallow shores, or even the vicinity of continents or islands, for they are often met with many hundred miles from land. On opening their stomach, our navigator found it filled with small fish, and various marine crustacea; but the reptiles themselves became the frequent prey of sharks, in the interior of which their half-digested remains were often found. It naturally became a subject of surprise, that creatures so light and active should so often fall victims to an enemy of such weight and sluggishness; but after more lengthened observation, a peculiarity in the habits of the former was thought sufficient to account for their capture. These serpents were often seen as if asleep, and floating on the waves, and so profound was their repose, that a large vessel, "with all its bravery on," might pass close by without their being disturbed by its surging prow, its huge furrow, or the loud voices of the garrulous sailors (Frenchmen, of course). M. Peron supposes that it is in this state of lethargy that the lazy sharks swallow them at their leisure. As to the cause of the torpor itself, he naturally enough suggests that it may arise, as among the terrestrial races, from repletion, and the indolence indulged in by all serpents during the digestive process. "Ces reptiles," he adds, "nagent et plongent avec une égale facilité: souvent à l'instant même où nous croyons pouvoir les saisir avec nos filets, ils disparaissaient à nos yeux; et, s'enfonçant à de grandes profondeurs sous les flots, ils restaient une demi-heure et plus sans remonter à leur surface, ou ne paraissaient qu'à de trés-grandes distances du point où nous les avions vus plonger."[9]

The general ground-colour of the majority of these reptiles is yellowish, varying towards green, blue, or white, and often relieved by blackish rings, or broad lozenge-shaped spots, disposed transversely along the dorsal region. The colours seem less subject to variation than among the other Ophidians, and there is no external difference between the sexes. All the species are included by M. Schlegel in the following genus.

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[1] *Physiog. des Serpents*, ii. p. 491.
[2] *Phil. Trans.* xiii. part ii. p. 334.
[3] In Kotzebue's *Neue Reise*, *Anh.* p. 32.
[4] *Voyages*, iv. p. 107 and 113.
[5] *Coquille*, ii. p. 58.
[6] *Physiog.* ii. p. 493.
[7] *Loc. cit.*
[8] *Voyage*, p. 105 and 129.
[9] *Loc. cit.*

Genus Hydrophis. Head small, uniform with the trunk. Nostrils vertical, of an orbicular form, and capable of being closed by a valve. Eye small, pupil orbicular. Fangs but slightly developed, and always followed by several other teeth, solid though slender. Body tapering towards both extremities. Scales lozenge-shaped or hexagonal, not imbricated, covered by a thin epidermis, and surmounted by a tubercle, of which there are two on the median range of the abdomen. The abdominal scales scarcely larger than the others. Tail broad, flattened laterally, and performing the functions of an oar or rudder. Lungs often prolonged into a reservoir of air as far as the commencement of the caudal region.

Of this genus there are seven species, the particular characters of which we cannot here detail, although their general attributes may be made out from the preceding observations. See Plate CCCCXLIV. fig. 4.

The most common kind is *Hyd. pelamys* of Oken[1] (*Anguis platura*, Linn.), of a comparatively thickish form, the head much elongated, the median line of the abdomen indicated by a suture formed by two rows of scales. It is of a blackish brown above, beneath yellow; the tail, and sometimes the entire body, varied by these colours. It is the most extensively distributed of the genus, being found wherever any sea-snakes occur. It seems to be the black backed hydrus of Shaw (*Hydrus bicolor*, Schneid.); and in India rejoices in the euphonious name of *Nalla Wahlagillee Pam.*[2] Of general occurrence in the Asiatic seas, it is also common round the coasts of Otaheite, where it is relished as an article of food, and known under the title of *Etoonatoree.*

Family III.—Poisonous Serpents properly so called.

The species of this family are the most venomous of all, and may, for the most part, be recognised by something especially repulsive and forbidding in their aspect. Their form is rather thick and heavy, their tail short, their head extremely broad, depressed, and somewhat heart-shaped; rarely protected by plates, but usually covered by scales resembling those of the dorsal region; the eyes are small, deeply seated in the sides of the head, and shaded by projecting superciliary plates, the pupil vertical; the upper lip is inflated, and falls over the lengthened fangs; the body is usually beset by scales of a lanceolated form, surmounted by a ridge, except in one or two species of Trigonocephalus, in which they are smooth.

Their habits and modes of life likewise present some disparities when compared with those of the preceding groups. Being of a lethargic nature and slow of movement, they seldom wander about in search of prey, but keep themselves coiled up till it approaches closely, and then springing upon it by a sudden straightening of the body, they inflict a fatal wound, which needs no repetition. There seems reason to believe that this mode of attack is peculiar to the present family, the other poisonous kinds pursuing their prey, and *holding on* when they have seized it, while the poisonous serpents properly so called are satisfied by sinking their envenomed fangs into the flesh of their victim. Their gape is very wide, their hooks long and sharp, their poison abundant and in a state of high concentration, and the wound is inflicted suddenly, with great force. The result is left to nature, and is in consequence both sure and speedy.

We have said that the poison-fangs are more developed than among the other Ophidians. They alone occupy the maxillaries, being never followed by any small solid teeth, though these occur along the palate and at the extremity of the lower jaw. The nostrils are in some spacious, in others narrow, and vary also in their position. They are followed in certain species by a deep pit or hollow, scooped in the sides of the muzzle, and connected with a broad cavity in the upper maxillaries. This character (of which, however, we know not the function) seems analogous in some measure to the *larmiers* of ruminating quadrupeds, and has been employed for the distribution of these serpents into several groups. Such as are distinguished by this nasal pit inhabit the forests of tropical countries, and consist of two genera, *Trigonocephalus* and *Crotalus*, of which the former (native both to Asia and America) is chiefly found in moist and sombre woods, or places covered by an abundant vegetation; while the latter (peculiar to the western world) prefers a somewhat drier and more barren soil. Such as possess no nasal excavation are comprized in the genus *Viperus*. They affect a more open, sandy soil, and occur exclusively in the ancient continents and New Holland. We shall briefly survey these different groups, in the order now named.

Genus Trigonocephalus. Head, as in other members of the family, heart-shaped or triangular, extremely broad behind, and consequently very distinguishable from the neck. Tail terminated by a conical corneous plate.

The poison apparatus of these reptiles is developed in the highest degree; and as the species sometimes attain a length of five or six feet, they may be regarded as among the most redoubtable of venomous serpents. They all frequent wooded or shady situations, or moist meadows in the immediate vicinity of forest-land. The abdomen is always broad, rather convex, and furnished with plates, which vary, according to the species, from 140 to about 270. The tail is always short, conical, and usually somewhat slender. The sub-caudal plates vary from forty to seventy; and of these some are simple, others divided into two. The body is often marked by large irregular or lozenge-shaped spots upon a brownish or yellowish ground. Some, however, are reddish, others of a greenish hue, and there is frequently a line of deeper hue behind the eye. The species are rare in collections. None occur in Europe or Africa. America and the intertropical countries of Asia produce a large majority. The genus is divisible into two sections, according as the head is covered with scales or with plates.

One of the most noted species of the first section is *Trig. lanceolatus*, a native of the West Indies.[3] The general colour is greenish yellow, paler beneath, and variously marked with specks, spots, and bands of brown. A broad brown line, bordered with white, proceeds from the eye towards the mouth. We have a good account of the habits and history of this reptile from Colonel Moreau de Jonnès.[4] He tells us of one killed by an officer which measured above seven feet and a half in length; and still greater (but perhaps less accurate) measurements are given by Dutertre[5] and Labat.[6] In the bodies of such females as were examined, he found some fifty or sixty young ones, which, when the period of their birth arrives, issue forth completely formed, and much inclined to bite. In the adult state they prey chiefly on rats, which, though not indigenous to these islands, are now in all probability as 10,000 to one compared with the native quadrupeds. The snakes in question omous ents.

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[1] *Naturgesch.* vol. iii. part ii. p. 279.

[2] *Indian Serpents*, i. 47, pl. 41.

[3] *Quad. Ovip.* ii. p. 121, pl. 5, fig. 1. Also described by Dr Shaw, under the title of *Coluber megæra. Gen. Zool.* iii. 406.

[4] *Monographie du Trigonocéphale des Antilles.*

[5] *Hist. Gén. des Antilles habitées par les François.*

[6] *Nouveau Voyage aux Antilles, contenant l'Hist. Nat.*

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have also multiplied prodigiously in St Lucia and Martinique, where from sixty to eighty may be killed during the cutting of a single field of sugar-cane. According to M. Moreau de Jonnès, they people the marshes, the cultivated grounds, the forests, the banks of rivers, and even the summits of the mountains. The observer just named encountered one on the very edge of the crater of that naked mountain which overhangs the town of St Pierre, in Martinique, at an elevation of more than 5000 feet; and he feared it the more from the excessive lassitude under which he himself at that time laboured. His alarm was not without cause, for only a few days before, a fisherman at the foot of the mountain had been attacked by a similar reptile, which issued from its concealment among the basalts of the shore, and no efforts could save his life. These dreaded serpents are sometimes found in holes made by rats or land-crabs. They also enter hen-roosts and poultry-yards, and sometimes creep into dwelling-houses, chiefly, however, the huts of the negroes. But the sugar-plantations are their favourite places of resort. "Je n'ai jamais trouvé," says our author, "de serpent stationnaire, qu'il ne fût dans une *position offensive.* L'action par laquelle le reptile prend cette position, s'exprimer aux Antilles par le verbe *lover.* Elle consiste à contourner en spirale toute la longueur de son corps, qui forme quatre cercles egaux en diamètre, superposés les uns au dessus des autres, et sous le dernier duquels la queue est placée comme point central d'appui, de resort et de pivot. La tête, qui termine le cercle supérior, est retirée en arrière. Quand l'animal s'élance sur une proie, il fait effort sur la queue, et déroule subitement les quatre cercles qui semblent se débander." This species preys on birds as well as quadrupeds, and the former manifest their hatred by vain and clamorous cries whenever they behold their "arch destroyer." It avoids the brilliant equatorial light, and usually dwells in shaded places, seeking what it may devour chiefly towards sunset, or during cloudy weather.[1] The distribution of this species is rather remarkable. It does not extend throughout the whole of the Antilles, nor is it found even in the majority of those islands. "By a chance equally singular, fortunate, and inexplicable, it is confined to the islands of Martinique, St Lucia, and Beconia alone; and there is no proof, as has been pretended, that it is common in the American continent. Nevertheless, a tradition exists among the Indigenes, that it was introduced into Martinique by the Arronages, a horde which inhabited near the mouth of the Orinoco, and which, impelled by sentiments of hatred and vengeance against the Carribs of that island, made them this fatal present, and let loose in their forests this serpent, which was brought over in calabashes. But according to another popular opinion in the same country, the Trigonocephalus is aboriginal of Martinique, and cannot live elsewhere, not even in Guadaloupe. Some, however, think differently, and explain the phenomenon by the existence of the dog-headed serpent, which is believed to be a Boa, and which, common in Dominica and St Vincent, has delivered these islands from the Trigonocephalus."[2]

Of the second section of this genus, comprising such as have the head covered by plates instead of scales, we may here name *Trig. rhodostoma*, which is of a thicker and more vigorous form than the other species. The body tapers towards either end, the tail is short and acuminated, the abdomen broad, and the back prolonged into a well-marked keel. The colour is reddish brown, paler on the back, the sides adorned by broad, deep, triangular spots, the abdomen white. The summit of the head is black, surrounded by a broad streak of pale red, which descends the sides of the neck to combine with the beautiful rose-colour which tinges the lateral parts of the head, and from which it is separated by a black band proceeding from behind the eye. The iris is of a golden yellow. "L'expression sauvage de sa physiognomie," says M. Schlegel, "est, pour ainsi dire, adoucie par la nature et la conformation des plaques écailleuses qui semblables à celles de la plupart des couleuvres, ont la surface unie et luisante."[3] This species inhabits the western parts of Java, where it conceals itself in tangled vegetation, and makes its way at times into fields and gardens. It preys chiefly on frogs, and is itself attacked by a species of civet cat which occurs in Java. It is greatly dreaded by the natives on account of its deadly poison; and during M. Khul's residence at Buitenzorg, two labourers bitten by it died in five minutes. Although a viviparous reptile, the fœtus is enclosed in a coriaceous envelope, as large as a pigeon's egg. The species is figured by Russel.[4]

The only other example of the genus we need here notice is *Trig. cenchris*, which inhabits the southern provinces of the United States. Its occipital plates are of small dimensions, and are sometimes even wanting. The ground colour is grayish brown, marked by broad transverse bands of a more coppery hue. The abdomen is yellowish, marked by dark irregular spots. The point of the tail is usually black, and all the parts are minutely speckled by that colour. It is a sluggish, slow-moving reptile, very poisonous, but not given to bite, except in self-defence, when it maintains its position courageously. It has been described by different authors under a great variety of names, and by some under more than one at a time.[5] It is the *Mokassin* snake of the Anglo-Americans, thus called on account of the resemblance of its colour to the piece of dress so named by the native tribes. It is figured by M. Daudin.[6]

Genus CROTALUS. This dreaded genus contains the rattle-snakes, and is distinguished from the preceding by a more robust form, a thicker head, and a tail either armed

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[1] *Monographie*, p. 37.

[2] Griffith's *Animal Kingdom*, ix. 350.

[3] *Phys. des Serpens*, ii. 547.

[4] *Indian Serpents*, ii. pl. 21.

[5] It is both the *brown* and the *black viper* of Catesby's *Carolina*, pl. 44 and 45; it is once figured, and at least twice described, by Dr Shaw, as *Col. Cacodæmon* and *Tisiphone*, *Gen. Zool.* iii. pp. 377 and 406; it is the *Pelias Niger* of Merrem, *Tentamen*, p. 149; and had been previously described by Linnæus as a Boa (*B. Contortrix*, xii. ed. p. 373). M. Schlegel, indeed, supposes that it is also the *Coluber Constrictor* of the great Swedish naturalist. The Boa just named is believed to be identical with the *hog-nosed snake* of Catesby (*Car.* ii. pl. 56), and may be identical with the preceding nominal species, none of which seem to exceed the size of our common viper; but *Col. Constrictor* of America is usually described as of different habits and much larger dimensions. It is the black *snake* of Catesby (*Car.* ii. pl. 48). "This," observes that author, "is a large and very long snake, some being six feet in length. They are all over of a shining black, never changing their colour, and are very nimble and beneficial in killing rats, which they pursue with wonderful agility to the roofs and all parts of houses and barns, where rats are able to run, for which service they are preserved by most of the inhabitants. They are bold and furious, leaping at and biting those that attack them, though no harm ensues, *their bite not being venomous.* It is said in Carolina that they will attack and swallow rattle-snakes. It is certain most or all snakes will devour one another, not only of their own, but of other kinds, which I have often seen; one, after a long struggle, swallowing another but little less than itself. They are the most numerous of all snakes." "Many ridiculous frights," says Mr Pennant, "have happened from this *innocent* reptile. As every one in America is full of the dread of the rattle-snake, they are apt to fly at the sight of any of the serpent kind. This pursues, soon overtakes, and twisting round the legs of the fugitive, soon brings him to the ground; but he happily receives no hurt, but what may result from the fright. All the mischief this species does is to the housewives, for it will skim their milk-pans of the cream, and rob their hen-roosts of all the eggs." (*Arctic Zoology*, Appendix, p. 92.)

[6] *Reptiles*, v. 358, pl. 70, figs. 3 and 4, and 60, fig. 25.

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by a peculiar organ called the rattle, or prolonged into a sharpened point. There are four species, all peculiar to America. These are often confounded, even by systematic writers; and it is by no means easy to apply the general attributes assigned by travellers to the proper species, which no doubt differ from each other.

It seems ascertained, however, that the bite of all these reptiles is extremely dangerous, the slightest prick of their envenomed fangs, in any part of the body well supplied with blood-vessels, being sufficient to kill almost any animal. Laurenti says, that a person bitten by a Crotalus experiences a swelling of the entire body, the tongue becomes prodigiously inflamed, an unextinguishable thirst takes place, the edges of the wound become gangrened, and the unfortunate victim dies in frightful agony in five or six minutes. Different experiments made in Carolina by Captain Hall, are related in the Philosophical Transactions. A rattle-snake, four feet long, was fastened to a stake, and being made to bite three dogs, the first died in less than a quarter of a minute; the second, in convulsions, in about two hours; the third in about three hours. Four days after this, another dog was bitten by the same snake, and died in half a minute; and then a second received the murderous fangs, and died in four minutes. A common black snake, about three feet long, and very vigorous, was next procured. The reptiles bit each other,—the black snake dying in eight minutes, the rattle-snake not seeming in any way affected by its wound. Proceeding upon the supposition that "none but itself could be its parallel," it was then made to inflict a bite on its own body, and this suicidal deceit was followed by the hoped-for consequence,—it died in less than twelve minutes. The story is probably well known to all, though not credited by so many, of a disagreeable kind of an heirloom which once existed in an American family. A man had been bitten through his boots by a rattle-snake, and died. The boots afterwards descended into the successive possession of two other persons, and killed them both,—an envenomed fang having remained sticking in the leather. As usual, we have contradictory accounts of the effects of corresponding causes. We know that an Englishman who was unfortunately bitten by a rattle-snake at Rouen, in 1827, expired in eight hours; yet in the April of that same year, at a meeting of the Academy of Sciences in Paris, Professor Bosc declared that he had *seen* more than thirty persons who had been bitten by rattle-snakes, not one of whom had died. According to Kalm, even the largest animals, such as horses and oxen, die almost instantly. Dogs longer resist this fatal action. Most animals exhibit an instinctive horror on nearing one of these death-dealing creatures. "I have often," says M. Bosc, "amused myself by trying to force my horse and dog to approach one of these animals. But they would sooner have allowed themselves to be knocked down upon the spot than have come near them." Yet Mr Audubon informs us that the mocking-bird of America, so strong and overpowering is the instinct of parental love, does not hesitate to attack the rattle-snake when it approaches too near its nest,—that it will strike it on the head, pick out its eyes, and eventually put it to death.

The so-called *rattle* of these reptiles consists of a series of hollow, vertically flattened, scaly pieces, of which the posterior portion of one fits into the anterior portion of that which follows. They are thus mechanically and somewhat loosely connected together, without being actually joined, so that when shaken they make a rattling or rustling noise, resembling that produced by rumpled parchment. When young there is at first but a single horny portion at the end of the tail, and attached to the last caudal vertebra. Another is formed on the renewal of the skin, pushing its predecessor onwards, so that the first joint, which is closed at the end, continues to be the terminal one. M. Bosc is of opinion that an additional joint is formed every year, and that if the parts in question were not so often broken off accidentally, we might thus determine the age of each individual. They are, however, extremely fragile; and M. Palisot de Beauvois informs us, that he frequently found these rattles lying detached, in the course of his travels in the United States.[1] Their amount sometimes exceeds thirty, but usually ranges from one to thirteen. Some say that the noise may be heard at the distance of a hundred feet, while Bosc and others allege that it is scarcely audible beyond some twelve or fifteen paces. We shall now briefly notice the different species, the names of which, as already hinted, have been frequently transposed by naturalists.

Crotalus horridus inhabits South America, and is known to the Portuguese by the name of *Carcavela.* Its muzzle is covered by three or four pairs of plates. The scales, which are lozenge-shaped, and surmounted by a cutting keel, are disposed in twenty-nine ranges. Abdominal plates 145, sub-caudal twenty-five. The colour of the upper parts is yellowish brown, relieved upon the back by a range of broad, lozenge-shaped spots. This species measures from four to six feet in length, and, dwelling in a sultry clime, continues in a state of activity throughout the year. Some singular peculiarities in its manners are narrated by naturalists. For example, M. Palisot de Beauvois states, that during one of his journeys he observed a rattle-snake lying on the path, and approached it as quietly as possible. When he was about to strike it, it sprung its rattle, opened its mouth very widely, and received into its throat five young ones, each as thick as a goose's quill. After ten minutes' time, believing itself to be out of danger, it opened its mouth, and allowed the exit of the young, which, however, re-entered on a fresh alarm. This curious fact has been testified (if not confirmed) by another French gentleman, M. Guillemart.

Crotalus durissus (Plate CCCCXLIII. figs. 6 and 10) is a more northern species than the preceding, and to it we may refer the numerous observations which have been made by travellers and tourists on the rattle-snakes of North America. It seems to inhabit from the southern side of the Great Lakes as far as Mexico and California, extending westwards to the foot of the Rocky Mountains, but not occurring to the north of the river St Lawrence. It has only one or two pair of plates upon the muzzle, and the keel upon the scales is less developed; the eyes are smaller, the tints deeper, the spots frequently assume the form of bands, and the tail is black. Abdominal plates 170, sub-caudal twenty-two. As this species dwells in districts subjected during winter to the influence of rigorous cold, it creeps in autumn into covered places, or, hiding itself beneath masses of sphagnum, falls into a state of lethargic repose. An individual killed by M. Bosc, and which did not measure more than four feet in length, was found to have a hare in its interior. Its usual food consists of rats, squirrels, and other small Rodentia. This serpent, commonly called the striped rattle-snake, is said to traverse rivers, and even lakes, by inflating its body like a bladder. "The largest rattle-snake," says Catesby, alluding to one or other of these species, "which I ever saw, was about eight feet in length, and weighing between eight and nine pounds. This monster was sliding into the house of Colonel Blake of Carolina, and had certainly taken up his abode there undisturbed, had not the domestic animals alarmed the family with their repeated outcries; the hogs, dogs, and poultry united in their hatred to him, showing the greatest consternation, by erecting their omous pents.

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[1] Latreille, *Reptiles*, vi. 73.

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bristles and feathers, and expressing their wrath and indignation, surrounded him, but carefully kept their distance, while he, regardless of their threats, glided slowly along." "It is not uncommon," he adds, "to have them come into houses; a very extraordinary instance of which occurred to myself in the same gentleman's house, in the month of February 1723. The servant, in making the bed in a ground room (but few minutes after I left it), on turning down the sheets, discovered a rattle-snake coiled between the sheets in the middle of the bed." According to M. Audubon, the skin of this species is used in making shoes.[1] Mr Say informs us that it inhabits bare and sterile regions, and is often found in the subterranean dwelling of a marmot, *Arctomys Ludoviciana*.[2] M. Becker of Darmstadt placed two rabbits in a cage with this species, one of them being white, the other reddish brown. The fierce reptile, which was lying in a spiral form in the centre, sounded its rattle, and raised and extended its head from time to time, but made no attempt to seize its prey, although repeatedly provoked by its keeper so to do. A black rabbit was then introduced, which it bit instantaneously, and the victim was dead in eight minutes.[3]

Crotalus miliaris is a small species of North America, recognisable by its head clothed with nine well-developed plates. The eyes are large, the general colour a reddish brown, with three ranges of deeper spots. There are twenty-three rows of scales, and the lower plates are, abdominal 131, sub-caudal twenty-six. This snake was observed by Catesby in Carolina, and is described by Mr Say (under the title of *Crot. tergeminus*) as an inhabitant of those lonely sterile plains which stretch between the Mississippi and the Rocky Mountains. It is regarded as more dangerous than the preceding; its small size and peculiar colour prevent its attracting notice, and its rattle is too feeble to be heard at any distance. People are thus apt to tread or even to sit down upon it unawares, and the consequences are as easily imagined as described. It lives on frogs and insects, is by no means timid, but is easily killed by the slightest blow. It was figured long ago both by Seba[4] and Catesby.[5]

Lastly, *Crotalus mutus* differs from the other species in having the tail terminated by a hardened point instead of rattle. Its head is clothed with scales. The back is keeled, and the scales are surmounted by a tubercular ridge. Abdominal plates 227, sub-caudal forty-nine. This great serpent inhabits Cayenne, Essequibo, Surinam, and other parts of South America. It sometimes measures above ten feet in length, and may be regarded as the most gigantic of all poisonous reptiles. In its mode of life it somewhat resembles *Trigonocephalus* (and is in fact described as a species of that genus by Baron Cuvier[6]). But it is essentially a rattle-snake, though destitute of the particular part from which these species derive their general name. It seems the same as that described under the title of *Curucucu* by Marcgrav.[7] Its poison has been experimented on by Dr Hering.[8]

Genus Vipera. Nasal pit wanting. Head usually covered by ridged lanceolated scales. General form thickish, tapering towards each extremity. Tail short and conical.

The species of this genus, greatly restricted since the time of Linnæus, still exhibit a considerable diversity of character when compared among each other. They inhabit either open sandy plains, or desert heaths, where the vegetation is not umbrageous. Hence their abundance in Africa, and their comparative scarcity in other countries. None occurs in America, a few are found in the drier districts of Asia, three inhabit Europe, and one (of a somewhat anomalous nature) is native to New Holland.

The common viper of Great Britain, and of most parts of the Continent (*Vipera berus*, Daudin—*Coluber berus*, Linn.),[9] is the most poisonous of European reptiles. It rarely exceeds two feet in length. The upper portion of the head is protected by a few plate-like scales, somewhat larger than the others. The usual colour is pale ashy brown above, with a space between the eyes, and a patch on each side of the occiput, deep brown or black. A zigzag band of black (composed in some of confluent spots) extends along the back from the nape to the tail; and there is also a parallel row of small black spots on each side. The abdomen and sub-caudal region are steel-blue, sometimes marbled by a yellowish tint, sometimes uniform, or nearly black. The abdominal plates are about a hundred and forty-five,—the sub-caudal about thirty-five. This species is widely spread over the central and northern parts of Europe, but some uncertainty prevails regarding the so-called common viper of Italy and other southern regions. M. Gistl describes the viper of the environs of Munich as having an upturned snout,[10] which is a character of the aspic; and although Metaxa enumerates *Vipera berus* and its varieties as occurring in the Roman territories,[11] others are of opinion that all its alleged localities are doubtful beyond the Alps.[12] It seems, however, to be found in the temperate parts of Siberia, in Russia, Hungary, all Germany, parts of France, Holland, Denmark, Sweden, and, we believe, Norway. Though common in Great Britain, and many of the western isles of Scotland, it is not indigenous in Ireland. Its vertical as well as horizontal range is considerable, for although it affects the low wide heaths of Groninguen, Overyssel, and Friesland, it also occurs on the summit of the Inselberg in Thuringia, at an elevation of nearly three thousand feet above the level of the sea. The viper preys chiefly on mice and insects. A specimen, on the tail of which we inadvertently tramped while crossing a moor in Glenmuick, and which our friend Dr Greville struck down with his umbrella, was found on dissection to have a large field-mouse in its abdomen.

The bite of this reptile is seldom fatal to animals of moderate size. We have several times seen sporting dogs bitten by vipers on the Scotch moors; and although the cheek might swell, and a heaviness of spirits, and disinclination to distant ranging, usually ensued for a few hours, no perceptible effect could be traced on the following day. A sparrow, however, or even a pigeon, dies in a few minutes after being bitten. Sheep usually escape without any serious consequences. Fontana ascertained, that the hundredth part of a grain of poison was sufficient to kill a sparrow, and that a pigeon required six times that amount. From these data he made a calculation, that it would take nearly three grains to kill a man, and as a viper does not carry above two grains of poison in its vesicles, and does not entirely exhaust that quantity, even after many bites, it was concluded that a human being might receive the bite of five or six vipers without dying in consequence. Now this may be all accurately reasoned in its way, but as physiology is by no means a science of calculation, we would not advise any one to try the experiment. Several facts have been recently adduced to prove, that the bite of this reptile is frequently dangerous, and occasionally fatal. Dr Paulet, in his obser-

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[1] *Edinburgh New Phil. Journ.* iii. 21.

[2] *Expedition to the Rocky Mountains*, p. 234 and 236.

[3] *Isis*, 1828, p. 1132.

[4] *Thesaurus*, ii. pl. 95.

[5] *Carolina*, pl. 42.

[6] *Trig. rhombifer, Règne Animal*, ii. 90.

[7] *Hist. Rerum Nat. Brasiliæ*, lib. vi.

[8] *Neuw. Beitrag.* p. 465.

[9] *Vip. berus* of Cuvier, and of some other French naturalists, seems to be identical with the aspic, *vipera aspis*,—a species common in France and Switzerland.

[10] *Isis* for 1829, p. 1071.

[11] *Monograph of the Serpents of the Environs of Rome*, p. 42.

[12] *Physiog. des Serpens*, ii. 597.

Venomous Serpents.

vations on the viper of Fontainebleau, states, that an infant of seven years and a half, which was bitten beneath the internal malleolus of the right foot, died at the end of seventeen hours,—while another infant, of only two years, which was bitten in the cheek, took two days to die. Dr Hervez de Chegoni mentions the case of a woman, aged sixty-five years, in good health, and of a sound constitution, who having been bitten in the thigh only once by a single viper, expired under the most deplorable symptoms in thirty-seven hours.

The aspic, *Vipera aspis*, is a species nearly allied to the preceding, of which it is by some regarded as a variety, and of which it seems to assume the place in the south-western countries of Europe, extending as far as the island of Sicily.[1] Its form is more slender, its head larger, its top covered by irregularly formed scales, and the muzzle is slightly turned up. The aspic is the species which served the experiments of Redi, Charas, and Fontana. It inhabits the dry and rocky countries of Italy, has been observed in Switzerland, and is common in France from the 49th degree of north latitude, spreading into Savoy, the Pyrenees, and the Mediterranean shores. It is the viper of Fontainebleau, and is also found in the forest of Montmorency; but in Burgundy, and the more northern parts of France, it is replaced by our common viper.

New Holland produces a rare and remarkable species, which some class as generically distinct, under the title of *Acanthophis*. It is of a thickened form, with a slender hard-pointed tail, the upper part of the head protected by nine plates. The eye is surrounded by plates, of which the superciliary are elevated, and inclined towards the top of the head. It is the *Vipera acanthophis* of M. Schlegel,—*Acanthophis cerastinus*, Lacépède.[2] See Plate CCCCXLIV. fig. 8.

A still more remarkable and anomalous species is the famous *Vipera cerastes* of Africa, figured and described by Bruce the traveller,[3] and also in the great French work on Egypt.[4] Its head is very broad, and heart-shaped; its muzzle broad, obtuse, and rounded; its nostrils rather narrow, vertical and terminal; and its scales surmounted by a tubercular ridge. One of the superciliary scales on each side is converted into a projecting horn-like process, curved forwards; and the ancient name *cerastes* is no doubt derived from this peculiar character,—the Greek word κέρας signifying horn.

Cornua prætendens immania fronte cerastes,
Dum torquet spinam sibilat ecce vagus.

It seldom much exceeds a foot in length, and inhabits the sandy deserts of the north of Africa. Its description by Bruce has been so often quoted, that we shall rest satisfied by the reference already given to the writings of that impugned author.

We here close our sketch of this insidious order. But there still remains the singular genus *Cæcilia*, with which Baron Cuvier concludes his classification of Ophidian reptiles, although other naturalists, both prior to and since the publication of his latest system,[5] have arranged it in the Batrachian order, or have even raised it, with the other constituents of that order, to the rank of a distinct and separate class, called AMPHIBIA.[6] As we have already discussed that so-called class in the article REPTILIA of the present work (see *Encyc. Brit.* vol. xix. p. 150), we shall here subjoin the characters of the anomalous reptiles just referred to, as given by the great French anatomist. They form, under the name of NAKED SERPENTS (*Serpens nues*), the third and concluding family of his Ophidian order.

Genus CÆCILIA. Eyes extremely small, almost concealed beneath the skin, sometimes wanting. Skin smooth, viscous, furrowed by annular folds, apparently naked, but exhibiting in its thickness certain slender scales, regularly disposed on many transverse ridges between the wrinkles of the skin. Head depressed, anus nearly terminal, tail consequently short or almost wanting. Ribs too short to surround the trunk. Vertebræ articulated by facets like hollowed cones filled with gelatinous cartilage, as in fishes and some Batrachia; the cranium united to the first vertebra by two tubercles, also as in Batrachian reptiles. The orbits, covered by the maxillary bones, are only pierced by a very small hole; and the bones of the temples cover the temporal fossæ, in such a way that the head exhibits superiorly nothing but a continuous bony buckler. (See Plate CCCCXLIII. fig. 1*d.*) The hyoid bone, composed of three pair of arches, is so constructed as almost to lead to the belief that in early age there were gills. The maxillary and palatine teeth are ranged on two concentric lines, as in the genus Proteus, but are frequently sharp and curved backwards, as in true serpents. The nostrils open at the back part of the palate, and the lower jaw has no moveable pedicle, the tympanic bone being encased with the other bones in the buckler of the cranium. The auricle of the heart is not sufficiently divided to be described as double; but the second lung is rudimentary, as among the genuine Ophidians. The liver is divided into many transverse foliations.

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[1] Although the title of *Aspic* has been applied to this species, it is not the reptile so named in ancient days, which was not a European species, but more probably the *Naja haje* of Africa.

[2] *Ann. du Mus.* iv. 100.

[3] *Travels*, v. pl. 41.

[4] *Atlas*, pl. 6, fig. 3, vol. xxv. 83.

[5] *Règne Animal*, 2d ed. 1829.

[6] The separation above alluded to, although first precisely expressed by the word *class*, in the writings of M. de Blainville, and subsequently followed in our own country by Messrs Gray, Bell, &c. had been practically effected by several other authors at an earlier period. M. Duméril seems to have been the first to indicate the propriety of placing the genus *Cæcilia* with the Batrachians, and apart from the Ophidian order (*Mémoires de Zoologie et d'Anatomie comparée*, 1807,—"Sur la division des Reptiles Batraciens en familles naturelles"). In like manner, the *Reptilia nuda* of Oppel (as distinguished from his *Reptilia Testudinata*,—Turtles and Tortoises,—and his *Reptilia Squammata*,—Crocodiles, Lizards, and Serpents) is composed of three primary divisions: 1st, APODA (genus *Cæcilia*); 2d, CAUDATA (gen. *Siren*, *Proteus*, *Triton*, *Salamandra*); 3d, ECAUDATA (Frogs, Toads, &c.). His work, *Die Ordnungen, Familien, und Gattungen, der Reptilien, als Prodrom einer Naturgeschichte dorselben*, was published at Munich in 1811. Merrem, whose unfinished publication (*Beitræge zur Naturgeschichte der Amphibien*) appeared at different periods from 1790 to 1821, published the first edition of his *Tentamen Systematis Amphibiorum* in 1800, and a revisal of the same work in 1820. He first partitions his reptiles into two great classes,—PHILODOTA, containing all such as have the body protected by a corneous or coriaceous covering, and BATRACHIA, including the species of which the covering is soft, smooth, and mucous. He then proceeds to subdivide the latter into three great groups,—APODA, SALIENTIA, and GRADENTIA,—which he makes constituently the same as Oppel's APODA, ECAUDATA, and CAUDATA. Then follows M. de Blainville, with his *class* AMPHIBIENS, ou NUDIPELLIFERES (as distinct from other reptiles), consisting of the Batrachians commonly so called, and the genus *Cæcilia*,—the latter forming the Order PSEUDOPHYDIENS. See *Nouv. Bulletin des Sciences de la Soc. Phil.* for July 1816, and the first volume of *Principes d'Anatomie Comparée*, 1822. Mr Gray also views the Batrachian reptiles as a distinct class or great primary division of the Animal Kingdom, adding thereto the genus *Cæcilia*. *Synopsis Reptilium*, and Griffith's *Animal Kingdom*, vol. ix. Appendix, p. 99, 1831. Finally, Mr Bell has likewise arranged our Batrachian reptiles, and the genus in question, in a separate class AMPHIBIA, which he divides into the five following orders, 1st, AMPHIPNEURTA,—*Sirens* and *Protei*; 2d, ANOURA,—*Frogs* and *Toads*; 3d, URODELA,—*Salamanders*; 4th, ABRANCHIA,—gen. *Menopoma* and *Amphiuma*; 5th, APODA,—genus *Cæcilia*. *Encyclopædia of Anatomy and Physiology*, part i. p. 91. It will be perceived that this system differs chiefly from those now enounced, in the placing of two very peculiar American genera,—*Menopoma* and *Amphiuma*, characterized by the absence of gills,—in a separate order, termed ABRANCHIA, from the presumed peculiarity just alluded to. The last-named arrangement is adopted by Mr Swainson, in *Cabinet Cyclopædia*, vol. cxvi. pp. 83 and 339.

We know nothing of the natural history or habits of the animals of this genus. They are said to dwell in marshy ground, several feet below the surface. They probably prey on worms and insects, although vegetable matters, mould, and sand, have been found in their intestines.

In certain species the muzzle is obtuse, the skin loose, the folds conspicuous, and there are two small hairs near the nostrils. To this section belongs *Cæc. annulata* of Spix, a Brazilian species, of subterranean habits. It is of a blackish hue, with upwards of eighty annular folds, and circularly marked with white. The teeth are conical. Others have the folds more numerous, or rather in the form of serrated transverse striæ. Such is *Cæc. glutinosa*, Linn., from Ceylon, a blackish-coloured reptile, marked by a longitudinal band of white on either side, and characterized by 350 folds, which unite beneath in an acute angle. We have figured a nearly allied species from America, *Cæc. bivittata* of the French naturalists (see Plate CCCCXLIV. fig. 3). Finally, a few have the folds almost effaced, the body long and slender, and the muzzle projecting. *Cæc. lumbricoides*, Daudin,[1] is entirely blind, of a blackish colour, two feet long, and not thicker than a quill. Baron Cuvier possessed the skeleton of a Cæcilia more than six feet long.[2] There were 225 vertebræ, but the external characters were unknown. (T.)

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SERPENT, a powerful bass musical instrument of the wind kind, invented by a French priest at Auxerre in 1590. See the article MUSIC.

SERPENT, in *Mythology*, was a common symbol of the sun, and he is represented biting his tail, and with his body formed into a circle, in order to indicate the ordinary course of this luminary. The serpent was also the symbol of Medicine, and of the gods which presided over it, as of Apollo and Æsculapius; and this animal was the object of very ancient and general worship, under various appellations and characters. In most of the ancient rites we find some allusion to the serpent, under the several titles of Ob, Ops, Python, and the like. This idolatry is alluded to by Moses. The woman at Endor who had a familiar spirit is called Oub, or Ob, which is interpreted Pythonissa. The place where she resided, says Bryant, seems to have been named from the worship there instituted; for Endor is compounded of *En-ador*, and signifies *fons Pythonis*, "the fountain of light," the oracle of the god Ador, which oracle was probably founded by the Canaanites, and had never been totally suppressed. His pillar was also called *Abbadir* or *Abadir*, compounded of *ab* and *adir*, and meaning the serpent deity Addir, the same as Adorus.

In the orgies of Bacchus, the persons who partook of the ceremony used to carry serpents in their hands, and with horrid screams call upon Eva, being, according to the writer just mentioned, the same as epha or opha, which the Greeks rendered *ophis*, and by it denoted a serpent. These ceremonies and this symbolical worship began among the Magi, who were the sons of Chus; and by them they were propagated in various parts. Wherever the Ammonians founded any places of worship, and introduced their rites, there was generally some story of a serpent. There was a legend about a serpent at Colchis, at Thebes, at Delphi, and at other places. The Greeks called Apollo himself Python, which is the same as Opis, Oupis, and Oub.

In Egypt there was a serpent named Thermuthis, which was looked upon as sacred; and the natives are said to have made use of it as a royal tiara, with which they ornamented the statues of Isis. The kings of Egypt wore high bonnets, terminating in a round ball, and surrounded with figures of asps; and the priests had likewise the representation of serpents upon their bonnets.

Abadon, or Abaddon, mentioned in the Revelations (xx. 2), is supposed by Bryant to have been the name of the Ophite god, with whose worship the world had been so long infected. This worship began among the people of Chaldæa, who built the city of Ophis upon the Tigris, and were greatly addicted to divination and to the worship of the serpent. From Chaldæa the worship passed into Egypt, where the serpent deity was called Canoph, Can-eph, and C-neph. It had also the name of Ob or Oub, and was the same as the Basiliscus or royal serpent, the same as the Thermuthis, and made use of by way of ornament to the statues of their gods. The chief deity of Egypt is said to have been Vulcan, who was styled Opas. He was the same as Osiris, the Sun; and there were pillars sacred to him, with curious hieroglyphical inscriptions bearing the same name, whence, among the Greeks, who copied from the Egyptians, every thing gradually tapering to a point was styled obelos, or obeliscus.

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[1] *Reptiles*, viii. 92, 2.

[2] *Règne Animal*, ii. 101, note.

As the worship of the serpent began among the sons of Chus, Bryant conjectures, that from thence they were denominated Æthiopians and Aithiopians, from Ath-ope or Ath-opes, the god whom they worshipped, and not from their complexion. The Æthiopes brought these rites into Greece, and called the island where they first established them, *Ellopia, Solis Serpentis insula*, the same with *Eubœa*, or *Oubaia*, "the serpent island." The same learned writer discovers traces of the serpent-worship among the Hyperboreans, at Rhodes, in Phrygia, and upon the Hellespont; in the island Cyprus, in Crete, among the Athenians; in the name of Cecrops, among the natives of Thebes in Bœotia, among the Lacedæmonians, in Italy, in Syria; and in the names of many places, as well as of the people, where the Ophites settled. One of the most early heresies introduced into the Christian church was that of the Ophitæ. (Bryant's Analysis of Ancient Mythology, vol. i. p. 43 and 473.)

SERPENTARIUS, in *Astronomy*, a constellation of the northern hemisphere, called also Ophiuchus, and anciently Æsculapius. The stars in the constellation Serpentarius are, in Ptolemy's catalogue twenty-nine, in Tycho's fifteen, in Hevelius's forty, and in the British catalogue seventy-four.

SERPENTINE, in general, denotes any thing that resembles a serpent. Hence the worm or pipe of a still, twisted in a spiral manner, is termed a *serpentine worm.*

Serpentine *Verses* are such as begin and end with the same word; as,

Ambo florentes ætatibus, Arcades ambo.

Serpentine, in the *Manège.* A horse is said to have a serpentine tongue, if it is always frisking and moving, and sometimes passing over the bit, instead of keeping in the void space called the liberty of the tongue.

SERPOOR, a town of Hindustan, province of Berar, in the nizam's territories, 104 miles south from Nagpoor. Long. 80. 2. E. Lat. 19. 41. N.

SERPUCHOW, a city of European Russia, in the province of Moscow, the capital of a circle of the same name. It stands at the junction of the rivers Nara and Serpeika, which soon after fall into the Oka. It is a place of some trade in corn, tallow, hemp, flax, and wool, which are sent both to Moscow and to St Petersburg. It contains sixteen churches, 780 houses, and 5740 inhabitants. Long. 37. 2. E. Lat. 55. 51. N.

SERRA, a town of Italy, in the Neapolitan province of Calabria Ulteriore I., containing 4830 inhabitants.

Serra di Falco, a town of the Island of Sicily, in the province of Mazzara, situated in a moderately healthy plain, sixty-four miles from Palermo. It contains 3800 inhabitants.

SERRAMANNU, a town of the island of Sardinia, in the diocese of Cagliari. It is situated upon the unhealthy plain of Ippis, and contains 1820 inhabitants.

SERRANUS, Joannes, or *John de Serres*, a learned French Protestant, was born about the middle of the sixteenth century. He acquired the Greek and Latin languages at Lausanne, and devoted himself to the study of the philosophy of Aristotle and of Plato. On his return to France he studied divinity, and in 1574 he began to distinguish himself by his writings, but was obliged to forsake his country after the dreadful massacre of St Bartholomew. He became minister of Nismes in 1582, but was never regarded as a very zealous Calvinist; he has even been suspected, though without reason, of having actually abjured the Protestant religion. He was one of the four clergymen whom Henry IV. consulted about the Catholic religion, and who returned for answer, "that Catholics might be saved." He wrote afterwards a treatise in order to reconcile the two communions, entitled "De Fide Catholica, sive de Principiis Religionis Christianæ, communi omnium Christianorum consensu, semper et ubique ratis." This work was disliked by the Catholics, and received with such indignation by the Calvinists of Geneva, that many writers have affirmed that they poisoned the author. It is certain at least that he died at Geneva in 1598, at the age of fifty. His principal works are, 1. A Latin translation of Plato, published by Henry Stephens; 2. A treatise on the Immortality of the Soul; 3. De Statu Religionis et Republicæ in Francia; 4. Mémoire de la Troisième Guerre Civile et derniers Troubles de France sous Charles IX. &c.; 5. Inventaire Général de l'Histoire de France, illustré par le Conférence de l'Eglise et de l'Empire; 6. Recueil des Choses Memorables avenues en France sous Henri II., François II., Charles IX., Henri III. These three historical treatises have been justly accused of partiality and passion; faults which it is next to impossible for a contemporary writer to avoid, especially if he bore any part in the transactions which he describes. His style is exceedingly incorrect and inelegant; his mistakes and mistatements of facts also are very numerous.

SERRATED, in general, something indented or notched in the manner of a saw; a term much used in the description of the leaves of plants.

SERRA-VALLE, a town of Italy, in the kingdom of Sardinia, in the province of Turin. It is situated on the river Scrivia, has an old castle, four churches, and four monasteries, and a college formerly occupied by the Jesuits. It contains 5420 inhabitants.

SERRAVALLE, a city of the delegation of Treviso, in the Austrian kingdom of Lombardy. It stands on the river Maschio, between two mountains; is the seat of a bishop, has a cathedral and several churches and monasteries, and 5630 inhabitants employed in the silk and woollen manufactories, and some trade in corn, wine, and oil.

SERRIS, a town of Hindustan, in the province of Bahar, eighty miles south-west by south from Patna. Long. 84. 18. E. Lat. 24. 50. N.

SERT, a town of Kurdistan, in Asiatic Turkey, the ancient capital of Tigranes, which was plundered by the Romans under Lucullus, but retained its consequence till after the Saracen invasion. It is now only a large village, containing about 3000 inhabitants, partly Mahommedans and partly Armenian Christians, for whose accommodation there are three small mosques, a college, and an Armenian church. It is situated in a small plain, surrounded by mountains, and is washed by the river Kabour. The chief is a powerful feudal lord. It is seventy-five miles south-east of Diarbekir.

SERVANDONI, John Nicholas, a celebrated architect, was born at Florence in 1695. He rendered himself famous by his exquisite taste in architecture, and by his genius for decorations, fetes, and building. He was employed and rewarded by most of the princes in Europe. In Portugal he was honoured with the order of Christ. In France he was architect and painter to the king, and member of the different academies established for the advancement of these arts. He received the same titles from the kings of Britain, Spain, Poland, and from the Duke of Wirtemberg. Notwithstanding these advantages, his want of economy was so great, that he left nothing behind him. He died at Paris in 1766. Paris is indebted to him for many of its ornaments. He made decorations for the theatres of London and Dresden. The French king's theatre, called *La Salle des Machines*, was under his management for some time. He was permitted to exhibit certain shows, consisting of simple decorations. Some of these were astonishingly sublime; his Descent of Æneas into Hell in particular, and his Enchanted Forest, are well known. He built and embellished a theatre at Chambor for Marshal Saxe, and furnished the plan and the model of the theatre-royal at Dresden. His genius for fetes was remarkable; and he had the management of a great number in Paris, and even in London. He conducted one at Lisbon, given on account of a victory gained by the Duke of Cumberland. He was employed frequently by the king of Portugal, to whom he presented several elegant plans and models. The Prince of Wales, too, the father of George III. engaged him in his service; but the death of that prince prevented the execution of the designs which had been projected. He presided at the magnificent fete given at Vienna on account of the marriage of the Archduke Joseph and the Infanta of Parma. But it would be endless to attempt an enumeration of all his performances and exhibitions.

SERVANT, a term of relation, signifying a person who owes and pays obedience for a certain time to another in quality of a master.

The first sort of servants acknowledged by the laws of England are menial servants, so called from being *intra mœnia*, or domestics. The contract between them and their masters arises upon the hiring.

Another species of servants are called apprentices, from *apprendre*, to learn; and are usually bound for a term of years, by deed indented, or indentures, to serve their masters, and be maintained and instructed by them.

A third species of servants are labourers, who are only hired by the day or the week, and do not live *intra mœnia*, as part of the family.

There is yet a fourth species of servants, if they may be so called, being rather in a superior or ministerial capacity, such as stewards, factors, and bailiffs; whom, however, the law considers as servants *pro tempore*, with regard to such of their acts as affect their master's or employer's property.

SERVETISTS, a name given to the modern Antitrinitarians, from their being supposed to be the followers of Michael Servetus, who, in the year 1553, was burned at Geneva, together with his books.

SERVETUS, MICHAEL, a learned Spanish physician, was born at Villanueva in Aragon, in 1509. He was sent to the university of Toulouse to study the civil law. The Reformation, which had awakened the most polished nations of Europe, directed the attention of thinking men to the errors of the Romish church, and to the study of the Scriptures. Among the rest Servetus applied to this study. From the love of novelty, or the love of truth, he carried his inquiries far beyond the other reformers, and not only renounced the false opinions of the Roman Catholics, but went so far as to question the doctrine of the Trinity. Accordingly, after spending two or three years at Toulouse, he determined to go into Germany to propagate his new opinions, where he could do it with most safety. At Basel he had some conferences with Œcolampadius. He went next to Strasburg to visit Bucer and Capito, two eminent reformers of that town. From Strasburg he went to Hagenau, where, in 1531, he printed a book entitled *De Trinitatis Erroribus*. The ensuing year he published other two treatises on the same subject. In an advertisement to this work he informs the reader that it was not his intention to retract any of his former sentiments, but only to state them in a more distinct and accurate manner. To these two publications he had the courage to put his name, not suspecting that, in an age when liberty of opinion was asserted, the exercise of that liberty would be attended with danger. After publishing these books he left Germany, probably finding his doctrines not so cordially received as he expected. He went first to Basel, and thence to Lyons, where he lived two or three years. He then removed to Paris, where he studied medicine under Sylvius, Fermelius, and other professors, and took the degrees of master of arts and doctor of medicine. His love of controversy involved him in a serious dispute with the physicians of Paris; and he wrote an Apology, which was suppressed by an edict of the parliament. The misunderstanding which this dispute produced with his colleagues, and the chagrin which so unfavourable a termination occasioned, made him leave Paris in disgust. He settled two or three years in Lyons, and engaged with the Frellons, eminent printers of that age, as a corrector of the press. At Lyons he met with Pierre Palmier, the archbishop of Vienne, with whom he had been acquainted at Paris. That prelate, who was a great encourager of learned men, pressed him to accompany him to Vienne, offering him at the same time an apartment in his palace. Servetus accepted the offer, and might have lived a tranquil and happy life at Vienne, if he could have confined his attention to medicine and literature. But the love of controversy, and an eagerness to establish his opinions, always possessed him. At this time Calvin was at the head of the reformed church of Geneva. With Servetus he had been acquainted at Paris, and had there opposed his opinions. For sixteen years Calvin kept up a correspondence with him, endeavouring to reclaim him from his errors. Servetus had read the works of Calvin, but did not think that they merited the high eulogies of the reformers, nor were they sufficient to convince him of his errors. He continued, however, to consult him; and for this purpose sent from Lyons to Geneva three questions, which respected the divinity of Jesus Christ, regeneration, and the necessity of baptism. To these Calvin returned a civil answer. Servetus treated the answer with contempt, and Calvin replied with warmth. From reasoning he had recourse to abusive language; and this produced a polemical hatred, the most implacable disposition in the world. Calvin having obtained some of Servetus's papers, by means, it is said, not very honourable, sent them to Vienne along with the private letters which he had received in the course of their correspondence. The consequence was, that Servetus was arrested; but having escaped from prison, he resolved to retire to Naples, where he hoped to practise medicine with the same reputation which he had so long enjoyed at Vienne. He imprudently took his route through Geneva, though he could not but know that Calvin was his mortal enemy. Calvin informed the magistrates of his arrival; Servetus was apprehended, and appointed to stand trial for heresy and blasphemy. It was a law at Geneva that every accuser should surrender himself a prisoner, that if the charge should be found false, the accuser should suffer the punishment in which he meant to involve the accused. Calvin not choosing to go to prison himself, sent one of his domestics to present the impeachment against Servetus. The articles brought against him were collected from his writings with great care, an employment which took up three days. One of these articles was, "that Servetus had denied that Judæa was a beautiful, rich, and fertile country; and affirmed, on the authority of travellers, that it was poor, barren, and disagreeable." He was also charged with "corrupting the Latin Bible which he was employed to correct at Lyons, by introducing impertinent, trifling, whimsical, and impious notes of his own through every page." But the main article, which was certainly fatal to him, was, "that in the person of Mr Calvin, minister of the word of God in the church of Geneva, he had defamed the doctrine that is preached, uttering all imaginable injurious and blasphemous words against it."

Calvin visited Servetus in prison, and had frequent conferences with him; but finding that, in opposition to all the arguments he could employ, the prisoner remained inflexible in his opinions, he left him to his fate. Before sentence was passed, the magistrates of Geneva consulted the ministers of Basel, of Berne, and Zurich, and, as another account informs us, the magistrates of the Protestant cantons of Switzerland. And to enable them to form a judgment of the criminality of Servetus, they transmitted the writings of Calvin, with his answers. The general opinion was, that Servetus ought to be condemned to death for blasphemy. He was accordingly sentenced to be burned alive on the 27th of October 1553. As he continued alive in the midst of the flames more than two hours, it is said, finding his torment thus protracted, he exclaimed, "Unhappy wretch that I am, will the flames be insufficient to terminate my misery? What, then, will the hundred pieces of gold, and the rich collar, which they took from me, not purchase wood enough to consume me more quickly?" Though the sentence of death was passed against Servetus by the magistrates of Geneva, with the approbation of a great number of the magistrates and ministers of Switzerland, yet it is the opinion of many historians that this dreadful sentence was pronounced at the instigation of Calvin. This act of severity for holding a speculative opinion, however erroneous and absurd, has left a stain on the character of the illustrious reformer, which will attend the name of Calvin as long as history shall preserve it from oblivion. The address which he used in apprehending Servetus, as well as his harshness towards him during his trial, proves that he was as much influenced by personal hatred as by a desire to support the interest of religion, though, no doubt, he believed he was performing a very praiseworthy action. In what practical school were the principles of toleration to be then studied? This intolerant spirit of Calvin and the magistrates of Geneva gave the Papists a favourable opportunity to accuse the Protestants of inconsistency in their principles, which they did not fail to embrace. "How could the magistrates," says the author of the *Dictionnaire des Heresies*, "who acknowledged no infallible interpretation of the Scriptures, condemn Servetus to death because he explained them differently from Calvin; since every man has the privilege to expound the Scripture according to his own judgment, without having recourse to the church? It is a great injustice to condemn a man because he will not submit to the judgment of an enthusiast, who may be wrong as well as himself."

Servetus was a man of great acuteness and learning, and well versed in the arts and sciences. In his own profession his genius exerted itself with success. In his tract entitled *Christianismi Restitutio*, published in 1553, he remarks, that the whole mass of blood passes through the lungs by the pulmonary artery and vein, in opposition to the opinion which was then universally entertained, that the blood passes through the partition which divides the two ventricles. This was an important step towards the discovery of the circulation of the blood.

His works consist of controversial writings concerning the Trinity; an edition of Pagninus's version of the Bible, with a preface and notes; an Apology to the Physicians of Paris; and a book entitled *Ratio Syruporum*. Mosheim has written in Latin an elaborate history of the heresy and misfortunes of Servetus, which was published at Helmstädt in 1728, 4to.

SERVIA, a province of Turkey in Europe, bounded on the north by the rivers Danube and Save, which separate it from Hungary; on the east it is bounded by Bulgaria; on the west by Bosnia; and on the south by Albania and Macedonia. It is about 190 miles in length from east to west, ninety-five in breadth from north to south, and it is divided into four sangiacates. Two of these were ceded to the Christians in 1718, who united them into one. This continued till 1739, when the Turks were victorious, and then they were abandoned to the Turks by the treaty of Belgrade. Belgrade is the capital town.

SERVICE, Choral, in the Romish church, &c. consists of a certain order of antiphonies and psalms sung to what is called *canto fermo* in Italian, *canto llano* in Spanish, and *plain chant* in French. This kind of chant, in its simplest form, consists of slow sounds of equal duration, and without any embellishment, sung in unisons and octaves. In other cases the *canto fermo* is accompanied by Parts in harmony, but always with due regard to a certain *antique* and very simple style of melody and of harmony, which is founded upon the peculiar *tonality* and *cadences* of the *canto fermo*, and without which it loses its characteristic effects. The *canto corale*, or choral chant, is often particularly named *canto Gregoriano*, or Gregorian chant, from the great pains taken by St Gregory, in the sixth century, to improve and to teach to his pupils the oriental church chants derived from the Greeks. St Ambrose before him had introduced the oriental choral chants into the western church of Italy. We believe that there is yet much curious matter for investigation regarding the probable origin of the melodies that constituted the older *canto fermo*, and the nature and character of oriental scales and melodies. See Music. With regard to the tunes introduced into the early reformed church in the time of Luther and Calvin, some curious particulars are to be found in Bayle's *Dictionaire Historique et Critique*, article Marot. The Puritans in England suppressed the church choral service, and permitted psalm-singing only. Charles II. revived the choral service in England. For minute accounts of the origin, progress, and revolutions of this species of music in various Christian churches, the reader may consult Gerbert, *De Cantu et Musica Sacra*, Padre Martini's *Storia*, Hawkins and Burney's Histories of Music. For technicalities, &c. consult, among other works, A. E. Choron's *Méthode de Plain-Chant*, &c. Paris, 1818; and his *Principes pour apprendre le Plain-Chant*, Paris, 1818.

SERVITES, a religious order in the church of Rome, founded about the year 1233, by seven Florentine merchants, who, with the approbation of the bishop of Florence, renounced the world, and lived together in a religious community on Mount Senar, two leagues from that city.

SERVITOR, in the university of Oxford, a student who attends on another for his maintenance and learning.

SERVIUS, Maurus Honoratus, a celebrated grammarian and critic of antiquity, who flourished about the time of Arcadius and Honorius. He is now chiefly known by his Commentaries on Virgil. There is also extant a piece of Servius upon the feet of verses and the quantity of syllables, called *Centimetrum*.

SERWEL, a small district in the province of Caubul, between the 34th and 35th degrees of north latitude. The country is but little known, it never having been explored by Europeans.

SESOSTRIS, Sesoosis, or Sesonchis, the fifteenth sovereign of the eighteenth dynasty of the Egyptians, is called Rameses by Eusebius, and is said to have reigned during the sixteenth century before the Christian era. At his birth his father is said to have collected all the children born at the same time with him, and to have subjected them to an education which he thought best fitted to render them able to assist his son in his future career. When they had reached the age of puberty, he sent them, under the command of his son, to subdue the inhabitants of Arabia, and afterwards to Libya. On his accession to the throne, he first devoted his attention to the internal affairs of his kingdom, and after having divided it into thirty-six nomi, and appointed governors, he commenced a military career, which only ended when he had subdued the greater part of the world. The Æthiopians, the Gangetic Indians, the Scythians, and the Thracians, with the whole of Asia Minor, acknowledged his sway; and, as memorials of his victories, he erected pillars in the various countries he subdued, some of which were seen by Herodotus. On his return to Egypt he narrowly escaped being burnt to death by the treachery of his brother, who was Danaus of Greece. He brought home a large body of captives, whom he employed in the erection of public works, and more particularly in constructing canals. He erected two statues representing himself and his wife before the temple of Hephæstos, which were forty-five feet high; and four representing his sons, which were thirty feet high. At his death he was succeeded by his son Pheros.

SESQUI, a Latin particle, signifying a whole and a half. When joined with *altera*, *terza*, *quarta*, &c. it is much used in the Italian music to express a kind of ratios, particularly several species of triples.

SESQUIALTER, in *Music*, the ratio of 3 : 2 in the numerical calculation of musical intervals. This, and many other old pedantic terms, such as *super-particular* and *superpartient*, &c., employed to express ratios very simple, and easily intelligible under other terms, had better be abandoned entirely in musical nomenclature, which has long been overloaded with such jargon.

Sesqui-alterate, in *Geometry* and *Arithmetic*, is a ratio between two lines, two numbers, or the like, where one of them contains the other once, with the addition of a half.

Thus 6 and 9 are in a sesqui-alterate ratio, since 9 contains 6 once, and 3, which is half of 6, over; and 20 and 30 are in the same, as 30 contains 20 and half 20, or 10.

Sesqui-duplicate *Ratio* is when of two terms the greater contains the less twice, and half the less remains; as 15 and 6, 50 and 20.

Sesqui-tertional *Proportion* is when any number or quantity contains another once and one third.

SESSION, in general, denotes each sitting or assembly of a council, or other body.

Session *of Parliament* is the season or space from its meeting to its prorogation.

Kirk-Session, the name of a petty ecclesiastical court in Scotland.

Sessions for weights and measures. In London, four justices, from among the mayor, recorder, and aldermen, may hold a session to inquire into the offences of selling by false weights and measures, contrary to the statutes; and to receive indictments and punish offenders.

Court of Session. See Scotland.

Court of Quarter-Sessions, an English court that must be held in every county once in every quarter of a year.

SESTERCE, Sestertius, a silver coin in use among the ancient Romans, called also simply *nummus*, and sometimes *nummus sestertius.* The sestertius was the fourth part of the denarius, and originally contained two asses and a half. It was at first denoted by LLS, the two Ls signifying two libræ, and the S half. But the librarii, afterwards converting the two Ls into an H, expressed the sestertius by HS. The word *sestertius* was first introduced by way of abbreviation for *semistertius*, which signifies two and a half of a third, or, literally, only half a third; for in expressing half a third, it was understood that there were two before.

Some authors make two kinds of sesterces, the less, called *sestertius*, in the masculine gender, and the great one, called *sestertium*, in the neuter; the former we have already described, the latter containing a thousand of the other. Others maintain that any such distinction of great and little sesterces was unknown to the Romans. *Sestertius*, say they, was an adjective, and signified, *as sestertius*, or two asses and a half; and when used in the plural, as in *quinquaginta sestertium*, or *sestertia*, it was only by way of abbreviation, and there was also understood *centena millia*, &c.

This matter has been accurately stated by Mr Raper, in the following manner. The substantive to which sestertius referred is either *as* or *pondus;* and *sestertius as* is two asses and a half; *sestertium pondus*, two pondera and a half, or two hundred and fifty denarii. When the denarius passed for ten asses, the sestertius of two asses and a half was the quarter of it; and the Romans continued to keep their accounts in these sesterces long after the denarius passed for sixteen asses, till, growing rich, they found it more convenient to reckon by quarters of the denarius, which they called *nummi*, and used the words *nummus* and *sestertius* indifferently, as synonymous terms, and sometimes both together, as *sestertius nummus.* In this case the word *sestertius*, having lost its original signification, was used as a substantive; for *sestertius nummus* was not two nummi and a half, but a single nummus of four asses. They called any sum under two thousand sesterces so many *sestertii* in the masculine gender; two thousand sesterces they called *duo* or *bina sestertia*, in the neuter, so many quarters making five hundred denarii, which was twice the sestertium; and they said *dena, vicena, &c. sestertia*, till the sum amounted to a thousand sestertia, which was a million of sesterces. But, to avoid ambiguity, they did not use the neuter *sestertium* in the singular number when the whole sum amounted to no more than a thousand sesterces, or one sestertium. They called a million of sesterces *decies nummûm*, or *decies sestertiûm*, for *decies centena millia nummorum*, or *sestertiorum*, in the masculine gender, omitting *centena millia* for the sake of brevity. They likewise called the same sum *decies sestertium*, in the neuter gender, for *decies centies sestertium*, omitting *centies* for the same reason; or simply *decies*, omitting *centena millia sestertiûm*, or *centies sestertium;* and with the numeral adverbs *decies, vicies, centies, millies*, and the like, either *centena millia* or *centies* was always understood. These were their most usual forms of expression, though for *bina, dena, vicena sestertia*, they frequently said *bina, dena, vicena millia nummûm.* If the consular denarius contained sixty troy grains of fine silver, it was worth something more than eightpence farthing and a half sterling; and the as, of sixteen to the denarius, a little more than a halfpenny. To reduce the ancient sesterces of two asses and a half, when the denarius passed for sixteen, to pounds sterling, multiply the given number by 5454, and cut off six figures on the right hand for decimals. To reduce *nummi sestertii*, or quarters of the denarius, to pounds sterling; if the given sum be consular money, multiply it by 8727, and cut off six figures on the right hand for decimals; but for imperial money diminish the said product by one eighth of itself. To be qualified for a Roman knight, an estate of 400,000 *sesterces* was required; and for a senator, one of 800,000.

SESTET, Italian *Sestetto*, a piece of vocal or instrumental music for six voices or six instruments.

SESTOS, a fortress of European Turkey, situated at the entrance of the Hellespont or Dardanelles, twenty-four miles south-west of Gallipoli. This place is famous for the loves of Hero and Leander, sung by the poet Musæus.

SET, or Sets, a term used by the farmers and gardeners to express the young plants of the white thorn and other shrubs, with which they used to raise their quick or quickset hedges. The white thorn is the best of all trees for this purpose; and, under proper regulations, its sets seldom fail to answer the farmer's utmost expectations.

SETCHEOU, a city of China, of the first rank, in the province of Koeitchoo. The inhabitants are extremely rude and ignorant. Long. 108. E. Lat. 27. 10. N.

SETCHING, a city of China, of the first rank, in the province of Quangsee, bordering on Yunan. Long. 105. 54. E. Lat. 24. 17. N.

SETCHUEN, a province of China, on the western frontier. It has on the north Chen-si, on the east and south Houquang and Yunan, and on the west Thibet. It is mountainous, but is fertilized by the great river Yang-tse-kiang. It produces the sugar-cane, silk, orange and lemon trees, and the best rhubarb in China; while in the mountains are found iron, tin, lead, loadstone, and lapis lazuli. It breeds a small but handsome race of horses. The population is estimated by Sir George Staunton at twenty-seven millions.

SETH, the third son of Adam, the father of Enoch, was born 3874 before Christ, and lived 912 years.

SETHIANS, in *Ecclesiastical History*, Christian heretics, who were so called because they paid divine worship to Seth, whom they looked upon as Jesus Christ the son of God, but who was made by a third divinity, and substituted in the room of the two families of Abel and Cain, which had been destroyed by the deluge. These heretics appeared in Egypt in the second century; and as they were addicted to all sorts of debauchery, they did not want followers, and continued in Egypt above two hundred years.

SETON, in *Surgery*, a few horse hairs, small threads, or large packthread, drawn through the skin, chiefly the neck, by means of a large needle or probe, with a view to restore or preserve health.

Experience shows that setons are useful in catarrhs, inflammations, and other disorders, and particularly those of the eyes; to which may be added, severe headachs, with stupor, drowsiness, epilepsies, and even apoplexy itself.

SETTEE, in sea-language, a vessel very common in the Mediterranean, with one deck and a long sharp prow. They carry some two masts, and some of them three, without top-masts. They have generally two masts, equipped with triangular sails, commonly called lateen sails. The least of them are of sixty tons burden. They serve to transport cannon and provisions for ships of war, and the like. These vessels are peculiar to the Mediterranean Sea, and are usually navigated by Italians, Greeks, or Mahommedans.

SETTING, in *Astronomy*, the withdrawing of a star or planet, or its sinking below the horizon. Astronomers and poets make three different kinds of setting of the stars, viz. the cosmical, acronycal, and heliacal.

Setting, in nautical language. To set the land or the sun by the compass, is to observe how the land bears on any point of the compass, or on what point of the compass the sun is; also, when two ships sail in sight of each other, to mark on what point the chased bears, is termed *setting the chase by the compass.*

SETTLE, a town of the parish of Giggleswick, in the wapentake of Staincliff and Ewcross, in the west riding of the county of York, 253 miles from London. Its situation is very romantic, on the river Ribble, among the hills that separate the counties of York and Lancaster. There is a large market-place, well attended on Thursdays. Near the town is the curious phenomenon of an ebbing and flowing well. In the neighbourhood are some curious Roman antiquities. The population amounted in 1821 to 1508, and in 1831 to 1627.

SETUVAL, or St Ubes, as it is called by the English and Dutch sailors that repair to it. This city is a seaport in the province of Estremadura, and the corregimento of its own name, in the kingdom of Portugal. The harbour is five leagues to the eastward of Cape Espichel. It has a shoal-bar, which extends outwards to the distance of half a league. On the western side of the entrance is a peaked height, 1350 feet above the level of the sea. The eastern side is low, with a very narrow passage, so that no written notices can be sufficient to guide the mariner; but the services of a pilot are indispensable, though when entered it is the best harbour in the whole kingdom.

The possession taken of this place by the fleet of the Emperor of Brazil, in the late war of succession in Portugal, led to the conquest of Lisbon, the capital, and then to the submission of the rest of the kingdom.

The chief article of export is salt, from the evaporation of the sea-water by the heat of the sun. There are more than 500 pits on the banks of the river Jabo, where this salt is formed by the hand of nature. The quantity annually collected amounts to about 200,000 tons, nearly one half of which is sent to Ireland, Sweden, Denmark, and Russia. It is stated that from 400 to 500 foreign vessels enter the port annually. Good wine, to the extent of 1800 pipes, is made in the neighbourhood, one half of which is exported. Oranges and lemons also afford articles for foreign trade.

The city contained, a few years ago, five churches, eleven monasteries, a hospital, a poor-house, about 3000 dwelling-houses, and 14,820 inhabitants.

SEVASTOPOL, known formerly by the Turkish name Achtiar, an important naval arsenal and city belonging to Russia, in the peninsula of the Crimea. It is situated at the south-west point, has an extensive and commodious port, and its depth renders it secure at all seasons and during all winds. By a decree of 1804, it was declared that Sevastopol was to be considered thereafter as a port exclusively for the use of the imperial navy; merchant-ships are therefore not admitted, unless forced in by stress of weather, or when requiring repairs from accidents. The fortifications do not surround the city, but it is defended by six strong batteries towards the sea, and has commonly a garrison of 4000 men.

The fleet, whose head-quarters is at this place, consisted in 1793 of eight ships of the line and twelve frigates and smaller vessels; in the year 1817 it had reached twelve ships of the line, carrying 918 guns, four frigates with 164 guns, seventeen brigs, and eighteen smaller vessels; in 1823 it consisted of fourteen ships of the line, ten frigates, and a number of small craft; and in 1838 it had been augmented to sixteen ships of the line, with a large number of frigates, gun-boats, &c.

The city has the appearance of an amphitheatre on the south side of the port: its white walls and gaudy domes, rising amid green trees, give it a peculiarly lively look. The streets are wide and regular, and intersect each other at right angles, but none of them have any pavement. The houses have of late been increasing in number, and are built in the modern style of Italian architecture. A public garden, with terraces rising one above the other, has been lately formed upon a rising elevation in the middle of the town, and has a very pleasing effect.

The place is well supplied with the necessaries, and even the luxuries, of life; but good water is not abundant, and fuel is scarce. The population, ten years ago, amounted to 22,000 persons; not more than one tenth were civil inhabitants. Since that period, with the increase of the marine, the numbers have probably been augmented. The lazaretto is situated in long. 33. 29. E. and lat. 44. 35. N.

SEVEN Islands, a cluster of very small isles, extending along the north coast of the island of Banca, from which they are separated by a navigable channel. Long. 105. 20. E. Lat. 1. 10. S.

SEVENOAKS, a town of the county of Kent, in the lathe of Sutton-at-Hone, and hundred of Codsheath, twenty-three and a half miles from London. It is pleasantly situated on the side and top of a hill. It has a good grammar-school. There is a good market on Saturdays. Adjoining to the town is the magnificent castle and park of Knowle, the ancient seat of the Dukes of Dorset, but now the property of the Earl of Plymouth. The population, including Riverhead and Weald, amounted in 1821 to 3942, and in 1831 to 4709.

SEVEN Stars, a common denomination given to the cluster of stars in the neck of the sign Taurus, the bull, and properly called the *Pleiades.* They are so called from their number, seven, which appear to the naked eye, though some eyes can discover only six of them; but by the aid of telescopes there appears to be a great multitude of them.

SEVENTH, in *Music*, an interval called by the Greeks heptachordon.

SEVERN, a river of England, which rises near Plinlimmon Hill, in Montgomeryshire, and before it enters Shropshire receives about thirty streams, and passes down to Laudring, where it receives the Morda, that flows from Oswestrey. When it arrives at Monford, it receives the river Mon, passing on to Shrewsbury, which it almost surrounds, and then to Bridgeworth; afterwards it runs through the skirts of Staffordshire, enters Worcestershire, and passes by Worcester; then it runs to Tewkesbury, where it joins the Avon, and from thence to Gloucester, keeping a north-westerly course, till it falls into the Bristol Channel. It begins to be navigable for boats at Welchpool, in Montgomeryshire, and takes in several other rivers in its course, besides those already mentioned, and is the second in England. By means of inland navigation, it has communication with the rivers Mersey, Dee, Ribble, Ouse, Trent, Derwent, Humber, Thames, and Avon; which navigation, including its windings, extends above five hundred miles in the counties of Lincoln, Nottingham, York, Lancaster, Westmoreland, Chester, Stafford, Warwick, Leicester, Oxford, and Worcester. A canal from Stroudwater, a branch of the Severn, to join the Thames, was projected and executed for the purpose of conveying a tunnel sixteen feet high and sixteen feet wide, under Sapperton Hill and Hayley Wood, for two miles and a quarter in length, through a very hard rock, which was lined and arched with brick. This stupendous undertaking was completed, and boats passed through it the 21st of May 1789. By this opening a communication is made between the river Severn at Framiload and the Thames near Lechlade, and is continued over the Thames near Inglesham, into deep water in the Thames below St John Bridge, and so to Oxford and London, for conveyance of coals and goods.

SEVERNDROOG, a small rocky island of Hindustan, on the coast of the Concan, joined to the continent by a reef of rocks, which forms a safe bay for vessels on the south side. This place was taken by the Mahrattas from the king of Bejapore; but his admiral revolting from their authority, it became the head-quarters of a gang of pirates. It was taken by the British in 1756. Long. 73. 13. E. Lat. 17. 47. N.

SEVERUS, CORNELIUS, an ancient Latin poet of the Augustan age, whose *Ætna*, together with a fragment *De Morte Ciceronis*, were published, with notes and a prose interpretation, by Le Clerc, Amsterdam, 1703, in 12mo. They were before inserted among the *Catalecta Virgilii*, published by Scaliger, whose notes, with others, Le Clerc has received among his own.

SEVERUS's *Wall*, in British topography, the fourth and last barrier erected by the Romans against the incursions of the North Britons.

We learn from several hints in the Roman historians, that the country between the walls of Hadrian and Antoninus continued to be a scene of perpetual war and contention between the Romans and Britons, from the beginning of the reign of Commodus to the arrival of the Emperor Septimius Severus in Britain, in the year 206. This last emperor having subdued the Mæatæ, and repulsed the Caledonians, determined to erect a stronger and more impenetrable barrier than any of the former, against their future incursions.

Though neither Dio nor Herodian make any mention of a wall built by Severus in Britain for the protection of the Roman province, yet we have abundant evidence from other writers of equal authority that he really built such a wall. "He fortified Britain," says Spartian, "with a wall drawn cross the island from sea to sea, which is the greatest glory of his reign. After the wall was finished, he retired to the next station (York), not only a conqueror, but the founder of an eternal peace." To the same purpose Aurelius Victor and Orosius, to say nothing of Eutropius and Cassiodorus: "Having repelled the enemy in Britain, he fortified the country, which was suited to that purpose, with a wall drawn cross the island from sea to sea." "Severus drew a great ditch, and built a strong wall, fortified with several turrets, from sea to sea, to protect that part of the island which he had recovered from the yet unconquered nations." As the residence of the Emperor Severus in Britain was not quite four years, it is probable that the two last of them were employed in building this wall; according to which account, it was begun in the year 209, and finished in the year 211.

Severus's Wall.

This wall of Severus was built nearly on the same track with Hadrian's rampart, at the distance only of a few paces north. The length of this wall, from Cousin's House, near the mouth of the river Tyne on the east, to Boulness on the Solway Frith on the west, has been found, from two actual mensurations, to be a little more than sixty-eight English miles, and a little less than seventy-four Roman miles. To the north of the wall was a broad and deep ditch, the original dimensions of which cannot now be ascertained, only it seems to have been larger than that of Hadrian. The wall itself, which stood on the south brink of the ditch, was built of freestone; and where the foundation was not good, it is built on piles of oak. The interstices between the two faces of this wall are filled with broad thin stones, placed not perpendicularly, but obliquely on their edges; and the running mortar or cement was then poured upon them, which, by its great strength and tenacity, bound the whole together, and made it firm as a rock. But though these materials are sufficiently known, it is not easy to guess where they were procured, for many parts of the wall are at a great distance from any quarry of freestone; and though stone of another kind was within reach, yet it does not appear to have been anywhere used. The height of this wall was twelve feet besides the parapet, and its breadth eight feet, according to Bede, who lived only at a small distance from the east end of it, and in whose time it was in many places almost quite entire. Such was the wall erected by the command and under the direction of the Emperor Severus in the north of England; and, considering the length, breadth, height, and solidity, it was certainly a work of great magnificence and prodigious labour. But the wall itself was but a part, and not the most extraordinary part, of this work. The great number and different kinds of fortresses which were built along the line of it for its defence, and the military ways with which it was attended, are still more worthy of our admiration, and come now to be described.

The fortresses which were erected along the line of Severus's wall for its defence were of three different kinds, and three different degrees of strength; and were called by three different Latin words, which may be translated *stations*, *castles*, and *turrets*. Of each of these in their order.

The *stationes*, stations, were so called from their stability, and the stated residence of garrisons. They were also called *castra*, which has been converted into *chestres*, a name which many of them still bear. These were by far the largest, strongest, and most magnificent of the fortresses which were built upon the wall, and were designed for the head-quarters of the cohorts of troops which were placed there in garrison, and whence detachments were sent into the adjoining castles and turrets. These stations, as appears from the vestiges of them which are still visible, were not all exactly of the same figure nor of the same dimensions; some of them being exactly squares, and others oblong, and some, again, a little larger than others. These variations were no doubt occasioned by the difference of situation, and other circumstances. The stations were fortified with deep ditches and strong walls, the wall itself coin-

Severus's Wall.

ciding with and forming the north wall of each station. Within the stations were lodgings for the officers and soldiers in garrison; the smallest of them being sufficient to contain a cohort, or six hundred men. Without the walls of each station was a town, inhabited by labourers, artificers, and others, both Romans and Britons, who chose to dwell under the protection of these fortresses. The number of the stations upon the wall was eighteen; and if they had been placed at equal distances, the interval between every two of them would have been four miles and a few paces. But the intervention of rivers, marshes, and mountains, the conveniency of situations for strength, prospect, and water, and many other circumstances to us unknown, determined them to place these stations at unequal distances. The situation which was always chosen by the Romans, both here and everywhere else in Britain where they could obtain it, was the gentle declivity of a hill, near a river, and facing the meridian sun. Such was the situation of the far greatest part of the stations on this wall. In general, we may observe, that the stations stood thickest near the two ends and in the middle, probably because the danger of invasion was greatest in these places. But the reader will form a clearer idea of the number of these stations, their Latin and English names, their situation and distance from one another, by inspecting the following table, than we can give with equal brevity in any other way. The first column contains the number of the station, reckoning from east to west; the second contains its Latin, and the third its English name; and the three last its distance from the next station to the west of it, in miles, furlongs, and chains.

No.	Latin Name.	English Name.	M.	F.	C.
1	Segedunum...	Cousin's House....	3	5	1½
2	Pons Ælii.....	Newcastle...........	2	0	9
3	Condercum...	Benwell Hill	6	6	5
4	Vindobala.....	Rutchester	7	0	3½
5	Hunnum......	Halton-chesters....	5	1	7
6	Cilurnum......	Walwick-chesters .	3	1	8
7	Procolitia......	Carrawbrugh	4	5	3½
8	Borcovicus ...	Housesteeds........	1	3	8
9	Vindolana.....	Little Chesters.....	3	6	4
10	Æsica..........	Great Chesters.....	2	1	6½
11	Magna..........	Carrvoran...........	2	6	0
12	Amboglana...	Burdoswald.........	6	2	8
13	Petriana.......	Cambeck............	2	6	6
14	Aballaba......	Watchcross.........	5	1	9
15	Congavata.....	Stanwix	3	3	4
16	Axelodunum..	Brugh	4	0	9
17	Gabrosentum.	Brumbrugh.........	3	4	1
18	Tunnocelum..	Boulness............	0	0	0
		Length of the wall	68	3	3

The *castella*, or castles, were the second kind of fortifications which were built along the line of this wall for its defence. These castles were neither so large nor so strong as the stations, but much more numerous, being no fewer than eighty-one. The shape and dimensions of the castles, as appears from the foundations of many of them which are still visible, were exact squares of sixty-six feet every way. They were fortified on every side with thick and lofty walls, but without any ditch, except on the north side, on which the wall itself, raised much above its usual height, with the ditch attending it, formed the fortification. The castles were situated in the intervals between the stations, at the distance of about seven furlongs from each other, though particular circumstances sometimes occasioned a little variation. In these castles guards were constantly kept, by a competent number of men detached from the nearest stations.

The *turres*, or turrets, were the third and last kind of fortifications on the wall. These were still much smaller than the castles, and formed only a square of about twelve feet, standing out of the wall, on its south side. Being so small, they are more entirely ruined than the stations and castles, which makes it difficult to discover their exact number. They stood in the intervals between the castles; and from the faint vestiges of a few of them, it is conjectured that there were four of them between every two castles, at the distance of about three hundred yards from one another. According to this conjecture, the number of the turrets amounted to three hundred and twenty-four. They were designed for watch-towers and places for sentinels, who, being within hearing of one another, could convey an alarm or piece of intelligence to all parts of the wall in a very little time.

Sever Wa

Such were the stations, castles, and turrets, on the wall of Severus; and a very considerable body of troops was constantly quartered in them for its defence. The usual complement allowed for this service was as follows:

1. Twelve cohorts of foot, consisting of 600 men each..	7,200
2. One cohort of mariners in the station at Boulness...	600
3. One detachment of Moors, probably equal to a cohort...	600
4. Four alæ or wings of horse, consisting, at the lowest computation, of 400 each..............................	1,600
	10,000

For the conveniency of marching these troops from one part of the wall to another, with the greater ease and expedition, on any service, it was attended with two military ways, paved with square stones, in the most solid and beautiful manner. One of these ways was smaller, and the other larger. The smaller military way run close along the south side of the wall, from turret to turret, and castle to castle, for the use of the soldiers in relieving their guards and sentinels, and such services. The larger way did not keep so near the wall, nor touch at the turrets or castles, but pursued the most direct course from one station to another, and was designed for the convenience of marching larger bodies of troops.

It is to be regretted that we cannot gratify the reader's curiosity, by informing him by what particular bodies of Roman troops the several parts of this great work were executed, as we were enabled to do from inscriptions with regard to the wall of Antoninus Pius. For though it is probable that there were stones with inscriptions of the same kind, mentioning the several bodies of troops, and the quantity of work performed by each of them, originally inserted in the face of this wall, yet none of them are now to be found. There have indeed been discovered, in or near the ruins of this wall, a great number of small square stones, with very short, and generally imperfect, inscriptions upon them, mentioning particular legions, cohorts, and centuries, but without directly asserting that they had built any part of the wall, or naming any number of paces. Of these inscriptions the reader may see no fewer than twenty-nine among the Northumberland and Cumberland inscriptions in Horsley's *Britannia Romana*. As the stones on which these inscriptions are cut are of the same shape and size with the other facing-stones of this wall, it is almost certain that they have been originally placed in the face of it. It is equally certain, from the uniformity of these inscriptions, that they were all intended to intimate some one thing, and nothing so probable as that the adjacent wall was built by the troops mentioned in them. This was perhaps so well understood, that it was not thought necessary to be expressed; and the distance of these inscriptions from one another showed the quantity of work performed. If this was really the case, we know in general that this great work was executed by the second and sixth legions, these being the only legions mentioned in these inscriptions.

Now, if this prodigious wall, with all its appendages of ditches, stations, castles, turrets, and military ways, was executed in the space of two years by two legions only, which, when most complete, required no less than 12,000 men, how greatly must we admire the skill, the industry, and excellent discipline of the Roman soldiers, who were not only the valiant guardians of the empire in times of war, but its most active and useful members in times of peace?

This wall of Severus, and its fortresses, proved an impenetrable barrier to the Roman territories for nearly two hundred years. But about the beginning of the fifth century, the Roman empire being assaulted on all sides, and the bulk of their forces withdrawn from Britain, the Mæatæ and Caledonians, now called Scots and Picts, became more daring; and some of them breaking through the wall, and others sailing round the ends of it, they carried their ravages into the very heart of provincial Britain. These invaders were indeed several times repulsed after this, by the Roman legions sent to the relief of the Britons. The last of these legions, under the command of Gallio of Ravenna, having, with the assistance of the Britons, thoroughly repaired the breaches of Severus's wall and its fortresses, and exhorted the Britons to make a brave defence, took their final farewell of Britain. It soon appeared that the strongest walls and ramparts are no security to an undisciplined and dastardly rabble, as the unhappy Britons then were. The Scots and Picts met with little resistance in breaking through the wall, while the towns and castles were tamely abandoned to their destructive rage. In many places they levelled it with the ground, that it might prove no obstruction to their future inroads. From this time no attempts were ever made to repair this noble work. Its beauty and grandeur procured it no respect in the dark and tasteless ages which succeeded. It became the common quarry, for more than a thousand years, out of which all the towns and villages around were built; and is now so entirely ruined, that the penetrating eyes of the most poring and patient antiquary can hardly trace its vanishing foundations.

SEVIGNE', Marie de Rabutin, Marquise de, a French lady, was born in 1626. When only a year old she lost her father, who was killed in the descent of the English on the isle of Rhé, where he commanded a company of volunteers. In 1644 she married the Marquis of Sevigné, who was slain in a duel by the Chevalier d'Albret, in 1651. She had by him a son and a daughter, to the education of whom she afterwards religiously devoted herself. Her daughter was married in 1669 to the Count de Grignan, who conducted her to Provence. Madame de Sevigné consoled herself by writing frequent letters to her daughter, but she fell at last the victim to her maternal tenderness. In one of her visits to Grignan, she fatigued herself so much during the sickness of her daughter, that she was seized with a fever, which carried her off on the 14th of January 1696. We have two portraits of Madame de Sevigné; the one by the Comte de Bussi, and the other by Madame de la Fayette. The first exhibits her defects, the second her excellencies. Bussi describes her as a lively gay coquette, a lover of flattery, fond of titles, honour, and distinction; M. de la Fayette, as a woman of wit and good sense, as possessed of a noble soul, formed for dispensing benefits, incapable of debasing herself by avarice, and blessed with a generous, obliging, and faithful heart. Both these portraits are in some measure just. That she was vain-glorious, appears evident from her own letters, which, on the other hand, exhibit undoubted proofs of her virtue and goodness of heart.

This illustrious lady was acquainted with all the wits of her age. It is said that she decided the famous dispute between Perrault and Boileau concerning the preference of the ancients to the moderns. She left behind her a most valuable collection of letters, the best edition of which is that of 1775, in eight volumes 12mo. "These letters," says Voltaire, "are filled with anecdotes, written with freedom, and in a natural and animated style; are an excellent criticism on studied letters of wit, and still more on those fictitious letters which aim at the epistolary style, by a recital of false sentiments and feigned adventures to an imaginary correspondent." It were to be wished that a proper selection had been made of these letters. It is difficult to read eight volumes of letters, which, though inimitably written, present frequent repetitions, and are often filled with trifles. What makes them in general perhaps so interesting is, that they are in part historical. They may be looked on as a relation of the manners, the tone, the genius, the fashions, the etiquette, which reigned in the court of Louis XIV. They also contain many curious anecdotes nowhere else to be found. But these excellencies would be still more striking, were they sometimes stripped of that multitude of domestic affairs and minute incidents which ought naturally to have died with the mother and the daughter. A volume entitled *Sevigniana* was published at Paris in 1756, which is nothing more than a collection of the fine sentiments, literary and historical anecdotes, and moral apophthegms scattered throughout these letters.

Seville.

SEVILLE, the largest, the richest, and most populous of the four kingdoms or provinces of Andalusia, in Spain. Its extent is 752 square miles, and its population amounts to 970,087 souls. It is bounded on the east by Granada and Cordova, on the north by Estremadura, on the west by Portugal, and on the south by the Mediterranean Sea.

The principal river of this province is the Guadalquivir, which, rising in the southern part of New Castille, passes through the whole of the province. This river is navigable for small ships up to the centre of the capital, and much higher for boats and small craft. Below Seville the Guadalquivir is divided into three branches, forming large islands between them, after passing which it unites and enters the ocean at St Lucar.

A great portion of this province is very mountainous. Next to the mountains of Ronda, the loftiest and most picturesque are the Trocha, to the westward of Algesiras, and those on which the city of Medina is situated, and a part of the Sierra Morena. Although these mountains are for the most part uninhabited and uncultivated, yet they afford excellent pasture for sheep during the winter season, when all is bare in the north of Spain. In the valleys is found the most extensive plains of the richest alluvial land, which, though frequently so burnt up by the heat of the summer sun as to display no traces of vegetation, yet, after two or three days of autumnal rain, produce the very richest pasture. As no hay is made in any part of Andalusia, the greatest distress is experienced by the farmers in keeping their cattle through the summer months, and at that period they feed mostly on broken straw, and become very lean; but after the autumnal rains the verdure is abundant, and the cattle become fat. Though the province of Seville does not grow corn sufficient for its own consumption, yet considerable quantities of wheat and barley are produced. The former grain is generally sown after a fallow, which may be made by about three ploughings in the summer months. Where they have manure, as is the case near the large towns, the increase is very great; and where they have not, the fallow alone will produce a very fair crop. The rotation of crops is little attended to. Clover and turnips are not cultivated. The harvest generally takes place in the latter end of June or beginning of July, when the weather is invariably fine. As soon as the wheat is cut, it is thrashed in the field where it is grown. This is done by piling the sheaves on a floor of round pebbles in the open air; and a number of unbroken mares, with a long rein held by a driver, are galloped in a circle over the sheaves. By this operation, from the dry state of the corn, it is easily separated, and the straw is broken into small fragments. They then wait till the wind rises, when the breeze performs the operation of separating the grain from the chaff and broken straw. The former is sent to the granary in a kind of rush paniers on the backs of asses, and the latter is made into a clumsy stack in the field, and kept there for food in the dry season. The barley sown in the spring is most rapid in its growth: sometimes in less than twelve weeks from the period of its being sown, it is cut, thrashed, and fit for the market. But grain is not the most important branch of rural economy in this province. Oil, the substitute for butter in warm climates, is the chief dependence of the Andalusian farmer, and the cultivation of it is more congenial to the indolent habits of the natives. The trees only require planting, and will then yield their produce for ages, with but little attention on the part of the proprietors. The oil, though an important article, and the chief source of the wealth of the province, is not made with much attention either to its cleanliness or its sweetness. The oils of Spain are inferior to those of France and Italy, though the olives from which they are made are decidedly superior. Wines are made to a considerable extent in this province, but not sufficient for its consumption.

Few articles of husbandry are of more universal attention than garlic, which grows in prodigious quantities, and forms in all the markets of Andalusia the most prominent object. The capsicum, or pimento, is also much in demand, and is used in almost every culinary preparation. Instead of hedges formed by thorn bushes, the enclosures are secured by the aloe plant, which makes excellent fences, and, by their sharp points, are a security against all cattle. Instead of orchards of apples and pears, nothing is seen but oranges, lemons, pomegranates, and other fruits of a southern climate.

One production, not alimentary, is of vast importance, and is sedulously cultivated, the Spanish broom or esparto, which is made into a variety of articles for domestic uses.

The breed of horses in Andalusia has at all times been very highly esteemed; they have in them a considerable mixture of the Arabian breed. As cows are not kept for the purposes of the dairy, they are rather neglected, and the breed is by no means good. The sheep are numerous; those of the merino kind are migratory, and belong rather to the whole kingdom of Spain than to this particular province. There are, however, large flocks on the mountains; but as their propagation is left in a great measure to nature, neither their flesh nor their wool is very good.

Some of the largest estates in the province belong to convents, cathedrals, or municipal corporations: they are frequently let to tenants, who pay rent in a portion of the produce. The richer inhabitants in all parts of the peninsula prefer mules to horses for drawing their carriages; and they are used by the corps of artillery in the military service, where they can be procured, in preference to horses.

Besides its agricultural riches, this province is stored with mineral wealth to a great degree. It is well known that the Romans drew from this district, then called Betica, a great portion of their silver; and it continued equally productive during the power of the Arabian race; but the discovery of America, an event contemporaneous with the final extinction of the Moorish government, rendered the industry applied to mining less productive, and in consequence it has greatly diminished. There are, however, mines of silver, copper, mercury, lead, and iron, still worked. The commerce and manufactures of this province are almost wholly confined to the cities of Cadiz and Seville. The inhabitants are estimated at 746,221. It possesses the laws and privileges of Castille. The captain-general resides at Puerto Maria, but there is a royal audienza at Seville.

Seville, a city of Spain, the capital of the province of the same name, and formerly the capital of the ancient kingdom of Aragon. Its origin is unknown; but, under the Roman government, it was a place of considerable note under the name Hispalis. It enjoys a most delightful climate, and is surrounded by a fruitful country. It contains about 100,000 inhabitants, exclusive of the suburb Triana, divided from it by the river. The population of the latter is about 15,000.

Seville abounds with ancient buildings, both Roman and Moorish, and with numerous modern structures of great extent and magnificence. The golden tower, on the banks of the river, is said to have been the work of Julius Cæsar. It is in perfect repair, and, before Cadiz rose to its present importance, the gold and silver transmitted from America was landed here, and deposited in this tower, on account of its strength and security. The aqueduct which supplies the city with spring-water is the work of the same people. It is still in perfect repair, and now, after the lapse of ages, serves the purpose for which it was originally constructed. In the vicinity of the city, at the ancient town of Italica, the birthplace of the Emperor Trajan, are the remains of an ancient amphitheatre, which, though partly in ruins, is sufficiently perfect to show its plan and extent; and from the rows of benches for spectators, which remain, it may be calculated that it would seat about ten thousand persons. Its dilapidated condition is the result of an earthquake, and has not been occasioned by the regular decay of time.

The chief building of the Moorish period that remains is the alcazar or palace: the date of its origin is not ascertained. A considerable part was added by Peter the Cruel, between the years 1353 and 1364. In the addition, the Arabian style of building is so closely imitated, that it is impossible to determine which part was built first. Though the exterior is mean, like all the Arabian buildings, yet the inside is beautifully filled up with noble staircases, marble halls, and courts with fountains of pure and cool water. Before the French entered Andalusia, the central junta occupied the palace after their dispersion. Joseph Bonaparte held his court in it.

Some of the houses of this city, belonging to individuals, have the most entire specimens of the exquisite stucco workmanship with which the rich Moors adorned the interior of their houses. In some of the most obscure streets of the city are found houses with the exterior appearance of a prison, with no windows towards the town, and only an entrance through massy doors studded or plated with iron; but the visiter, on entering, is surprised with the view of arcades surrounded with marble courts and sparkling fountains, and the whole adorned with that durable kind of stucco, in the composition of which the Moors so greatly excelled.

The buildings erected in Seville since the extirpation of the Moors are materially different in their style of architecture. One of these is the cathedral, with its tower, the Giralda, 360 feet in height. The length of this church is 398, and the breadth 290; but its choir and principal altar being in the centre, they take off very considerably from the effect of its dimensions. The different specimens of architecture which in successive periods have prevailed in Spain, may all be seen in this extraordinary church. The tower, and a part called the orange court, *Patio de las Narangas*, was built about the year 1000, by the Moors, and in their peculiar style; another part, built 200 years later, is in the Gothic taste, which was then introduced into Spain; whilst the part which completed it, and which was finished about the year 1520, is in a style denominated by Spanish artists *platareca*, or the imitation of the silver ornaments of a Catholic church. Though this last fashion is a most gross perversion of taste, yet the contrast with the Gothic is not unpleasing; and, viewed as a whole, the cathedral is perhaps one of the grandest of all the modern edifices in the Peninsula.

La Lonja, or the Exchange, for it was designed, though never used, for that purpose, was completed in 1598, and is a most extensive and chaste building, now used as a depository for state-papers, in which are collected all the original despatches from America at the period of its discovery, and the library of the son of Columbus. The college of the Jesuits, since converted into the inquisition, is a most beautiful pile of building, with a handsome church, a hall of judgment, and various cells for the reception of prisoners.

This city abounds in convents, monasteries, and other religious establishments, most of them richly endowed; and their chapels are the repositories of the finest specimens of the art of painting, at the period which produced better artists in Spain than in any other part of Europe. The works of the native artists Murillo, Velasquez, Zubaran, Spanioletti, Morales, Cano, and others, as well as of Titian, Rubens, Michel Angelo, and other foreigners, are preserved in the cathedral, and in several of the other churches, chapels, and convents.

There is a university, though the building is gloomy and tasteless, and the professors neither enlightened or learned; the number of pupils is very considerable, and most of them are destined for the ecclesiastical profession. It is said that two thirds of the houses in this city are either the property of the cathedral or other ecclesiastical bodies, who receive the rents of them in some cases weekly, and in others monthly.

In this city the edifices belonging to the government are numerous and extensive. The mint is one of them, in which the whole process of coining money is conducted. There is a foundery for cannon, a manufactory for muskets, swords, and other military accoutrements; but the largest establishment is the manufactory of tobacco, which, being a royal monopoly, can be sold only by the crown, either in the form of snuff, or in cigars or smaller particles for smoking.

The manufactures of this city are not great in proportion to the whole number of the population. But a large proportion of the inhabitants are ecclesiastics; and a much larger portion are paupers, who have no inducement to work, because they can obtain bare necessaries by going the rounds of different convents, where food is gratuitously bestowed on them, or by receiving from the episcopal palace a share of the alms which are daily dispensed. There are, however, fifteen hundred looms employed in making silk goods of various descriptions. Very little silk is raised in the vicinity of the city, it being principally drawn from Valencia and Murcia, where mulberry-trees abound. There are some manufactories of cloths, serges, hats, stockings, and other more minute articles. There is a very extensive establishment for currying leather, and every part of the process, from the first currying to the conversion into boots, shoes, saddles, bridles, gloves, and other articles, is carried on upon a large scale. The bark of the cork-trees is used for tanning, which, though not so strong as the common oak-bark, is yet in larger quantities found to be equally efficacious.

The foreign trade of Seville is but small, the harbour of Cadiz being more commodious for large vessels. The principal exports are, oil, goat and kid skins, quicksilver, liquorice, shumac, cork, and olives. The imports are almost wholly made through Cadiz.

The streets of Seville are in general so narrow as to forbid the passage of carriages through most of them; and some, in which frequently the best houses are to be found, are so close, that a person standing in the middle and extending both arms may touch the walls on the opposite sides. There is, however, what compensates for this, a fine public walk on the banks of the Guadalquivir, where all that is fashionable of the city may be seen enjoying the cool of the evening. This city was the birthplace of the Emperors Trajan, Adrian, and Theodosius; of Juan de la Cueva, of Diego Velasquez de Silva, and of Francis de Herrara. It is situated in long. 5. 18. W. and lat. 37. 24. N.

SEVRES, Deux, a department of France, formed out of the ancient province of the Lower Poitou. It extends from 1. 37. east, to 0. 8. west longitude, and from 46. 0. to 47. 12. north latitude. It is bounded on the north by the department of the Maine and Loire, on the east by that of Vienne, on the south by the Charente, on the south-west by the Lower Charente, and on the west by Vendée. It comprehends 2135⅕ square miles, or 607,350 hectares, equal to 1,366,538 English acres. In 1834, of this land, 369,297 hectares were under the plough, 18,896 were vineyards, 7280 gardens, 17,466 moors, heaths, pasture, &c., 29,806 woods, and the remainder the sites of towns, rivers, morasses, and uncultivated lands. It is divided into four arrondissements, thirty-one cantons, and 356 communes. Its population in 1836 amounted to 304,105. The surface is generally level, except that a chain of hills, the highest point of which does not exceed 450 feet, extends through the department from north-west to south-east. The chief rivers are the two streams from whence the department takes its name. The Sèvres-Nantaise receives the waters of the Louine and the Chambron, and passes into Vendée; and the Sèvres-Niortaise receives the streams Lamdon and Guerande, and becomes navigable at Niort, and then enters Vendée. There are a great number of smaller streams, most of which reach the sea by the Loire. The agriculture is in a backward state, the oxen are used for the plough, and much of the land is in fallow. The greater part of the cultivators are metayers, dividing the produce with the proprietors. The fertility is such that nearly one half the corn grown is supplied to other districts; and much hay and clover are furnished to the departments that are contiguous. The manufacturing industry is almost exclusively confined to providing necessaries for home consumption. The breed of horses is good, and many of them, as well as of a strong breed of asses, and some mules, are articles of commerce. The only mines are of iron, the ore of which is sent into Charente to be manufactured. There are quarries from which excellent millstones are obtained. The department elects two deputies to the legislative chamber. The capital is the city of Niort, with a population in 1836 of 18,197.

SEWAD, an extensive district in Afghanistan, situated about the thirty-fourth degree of north latitude, and partly bounded by the Indus. The country rises to a great elevation, consisting of snow-clad mountains, interspersed with fertile valleys producing all the finest fruits of Europe. It is about seventy miles in length by forty in breadth, and contains twenty-five valleys, each watered by a separate stream. It is principally inhabited by the tribe of the Yusufzies, who, taking advantage of the difficult passes and strong situations abounding in the country, have not only held themselves independent of the Mogul sovereigns, but have made inroads into their territories. They are a brave and independent people, ready to contribute their quota of troops to any plundering expedition, or in defence of the country.

SEWALIC Mountains. This chain of mountains, which reaches a considerable elevation, divides the province of Delhi from Serinagur, in Northern Hindustan. It is through these mountains that the Ganges enters on the plains of Hindustan, at a place called Hurdwar. The hills, which rise with a moderate though unequal slope from the plains, are skirted with deep forests, which abound with valuable timber, and afford shelter to elephants. These, however, seldom exceed seven feet in height, and hence are not considered so valuable as those caught nearer the sea.

SEWAN, a town of Hindustan, province of Bahar, sixty-six miles north-west from Patna. Long. 84. 25. E. Lat. 26. 11. N.

SEWEE, a district in the province of Beloochistan, situated about the thirty-first degree of north latitude, and bounded on the east by a mountainous ridge of hard black rock.

Sewer
||
Sex.

SEWER, in the household, an officer who arranged on the table the dishes of a king or nobleman.

SEWER is also a passage or gutter made to carry water into the sea or a river, and thereby to preserve the land from inundations and other annoyances.

Common SEWERS, in Rome, were executed at a great expense. It was proposed that they should be of sufficient dimensions to admit a waggon loaded with hay. When these common sewers came to be obstructed, or out of repair, under the republic, the censors contracted to pay a thousand talents, or about L.193,000, for clearing and repairing them. They were again in disrepair at the accession of Augustus Cæsar, and the reinstating of them is mentioned among the great works of Agrippa. He is said to have turned the course of seven rivers into these subterraneous passages, to have made them navigable, and to have actually passed in barges under the streets and buildings of Rome. These works are still supposed to remain; but as they exceed the power and resources of the present city to keep them in repair, they are quite concealed, except at one or two places. They were, in the midst of the Roman greatness, and still are, reckoned among the wonders of the world; and yet they are said to have been works of the elder Tarquin, a prince whose territory did not extend in any direction above sixteen miles; and, on this supposition, they must have been made to accommodate a city that was calculated chiefly for the reception of cattle, herdsmen, and banditti. Rude nations sometimes execute works of great magnificence, as fortresses and temples, for the purposes of war and superstition; but seldom palaces, and still more seldom works of mere convenience and cleanliness, in which, for the most part, they are long defective. It is not unreasonable, therefore, to question the authority of tradition in respect to this singular monument of antiquity, which so greatly exceeds what the best accommodated city of modern Europe could undertake for its own convenience. And as those works are still entire, and may continue so for thousands of years, it may be suspected that they were even prior to the settlement of Romulus, and may have been the remains of a more ancient city, on the ruins of which the followers of Romulus settled, as the Arabs now encamp on the ruins of Palmyra and Baalbeck. Livy owns, that the common sewers were not accommodated to the plan of Rome as it was laid out in his time; they were carried in directions across the streets, and passed under buildings of the greatest antiquity. This derangement, indeed, he imputes to the hasty rebuilding of the city after its destruction by the Gauls; but haste, it is probable, would have determined the people to build on their old foundations, or at least not to change them so much as to cross the direction of former streets.

SEWISTAN. See SEISTAN.

SEWURI, an oriental kind of guitar.

SEX, the property by which any animal is male or female. "The primary matter of which women are constituted appears to be more flexible, irritable, and elastic, than that of man. They are formed to maternal mildness and affection; all their organs are tender, yielding, easily wounded, sensible, and receptible."

"The female thinks not profoundly; profound thought is the power of the man. Women feel more. Sensibility is the power of woman. They often rule more effectually, more sovereignly, than man. They rule with tender looks, tears, and sighs, but not with passion and threats."

"Men embrace the whole, women remark individually, and take more delight in selecting the minutiæ which form the whole. Man hears the bursting thunder, views the destructive bolt, with serene aspect, and stands erect amidst the fearful majesty of the streaming clouds. Woman trembles at the lightning, and the voice of distant thunder, and shrinks into herself, or sinks into the arms of man. Man receives a ray of light single; woman delights to view it through a prism in all its dazzling colours."

In determining the comparative merit of the two sexes, it is no derogation from female excellency that it differs in kind from that which distinguishes the male part of our species; and if, in general, it shall be found that women fill up their appointed circle of action with greater regularity than men, the claim of preference cannot justly be decided in our favour. In the prudential and economical parts of life, it is undeniable that they rise far above us; and if true fortitude of mind is best discovered by a cheerful resignation to the measures of Providence, we shall find little reason to claim that exalted virtue as our peculiar privilege. But whatever real difference there may be between the moral or intellectual powers of the male and female mind, nature does not seem to have marked the distinction so strongly as our vanity is willing to imagine; and after all, perhaps, education will be found to occasion the chief distinction.

SEXAGENARY, something relating to the number sixty. Thus sexagenary or sexagesimal arithmetic is a method of computation proceeding by sixties, such as that used in the division of a degree into sixty minutes, of the minute into sixty seconds, and of the second into sixty thirds. Sexagenary tables are also tables of proportional parts, showing the product of two sexagenaries that are to be multiplied, or the quotient of the two that are to be divided.

SEXAGESIMA, the second Sunday before Lent, or the next to Shrove Sunday; so called as being about the sixtieth day before Easter.

SEXAGESIMALS, or *SEXAGESIMAL Fractions*, fractions whose denominators proceed in a sexagecuple ratio; that is, a prime, or the first minute $= \frac{1}{60}$; a second $= \frac{1}{3600}$; a third $= \frac{1}{216000}$. Anciently there were no other than sexagesimals used in astronomy; and they are still retained in many cases, though decimal arithmetic has come into use now in astronomical calculations. In these fractions, which some call *astronomical fractions*, the denominator, being always 60, or a multiple of that number, is usually omitted, and the numerator only written down. Thus 4°, $59'$, $32''$, $50'''$, $16''''$, is to be read, 4 degrees, 59 minutes, 32 seconds, 50 thirds, and 16 fourths.

SEXTANS, SEXTANT, a sixth part of certain things. The Romans having divided their *as* into twelve ounces or uncia, the sixth part of that, or two ounces, was the sextans.

Sextans was also a measure which contained two ounces of liquor, or two cyathi.

SEXTANS, in *Astronomy*, a constellation of the southern hemisphere, made by Hevelius out of unformed stars. In Hevelius's catalogue it contains eleven, but in the British forty-one stars.

SEXTANT, in *Mathematics*, denotes the sixth part of a circle, or an arch comprehending sixty degrees.

The word sextant is more particularly used for an astronomical instrument made like a quadrant, excepting that its limb only comprehends sixty degrees. The use and application of the sextant is the same with that of the quadrant.

SEXTILE, SEXTILIS, the position or aspect of two planets when at sixty degrees distance, or at the distance of two signs from one another. It is marked thus (*).

SEXTIUS, QUINTUS, a Pythagorean philosopher, who flourished in the time of Augustus. He seemed formed to rise in the republic; but he shrunk from civil honours, and declined accepting the rank of senator when it was offered him by Julius Cæsar, that he might have time to apply to philosophy. It appears that he wished to establish a school at Rome, and that his tenets, though chiefly drawn from the doctrines of Pythagoras, in some particulars resembled those of the Stoics.

He soon found himself involved in many difficulties. His laws were tinctured with great severity, and in an early period of this establishment he found his mind so harassed, and the harshness of the doctrines which he wished to establish so repulsive, that he had nearly resolved to put a period to his existence.

Of the school of Sextius were Fabianus, Sotion, Flavianus, Crassitius, and Celsus. Of his works only a few fragments remain; and whether any of them formed a part of the work which Seneca admired so much, cannot now be determined. Some of his maxims are valuable. He recommended an examination of the actions of the day to his scholars when they retired to rest; and he taught, that the road to heaven was by frugality, temperance, and fortitude. He used to recommend holding a looking-glass before persons disordered with passion. He enjoined his scholars to abstain from animal food.

SEXTON, a church-officer, thus called by corruption of the Latin, *sacrista*, or Saxon, *segerstone*, which denotes the same thing. His office is to take care of the vessels, vestments, and other things belonging to the church; and to attend the minister, church-warden, and others at church. He is usually chosen by the parson only. Sextons, as well as parish-clerks, are regarded by the common law as persons who have a freehold in their offices; and, therefore, though they may be punished, yet they cannot be deprived by ecclesiastical censures.

The office of sexton in the pope's chapel is appropriated to the order of the hermits of St Augustin. He is generally a bishop, though sometimes the pope only gives a bishopric *in partibus* to him on whom he confers the post. He takes the title of *Prefect of the Pope's Sacristy*, and has the keeping of the vessels of gold and silver, the relics, and so forth. When the pope says mass, the sexton always tastes the bread and wine first. If it be in private he says mass, his holiness, of two wafers, gives him one to eat; and if in public, the cardinal, who assists the pope in quality of deacon, of three wafers, gives him one to eat. When the pope is desperately sick, he administers to him the sacrament of extreme unction, and enters the conclave in quality of first conclavist.

The office of sexton in Sweden is sometimes singular. During M. Outhier's stay at Stockholm in 1736, he visited the church of St Clara, and during divine service he observed a sexton going about with a long rod, waking those persons who had fallen asleep.

SEXTUPLE, in *Music*, denotes a mixed sort of triple, which is beaten in double time.

SEXTUS Empiricus, a famous Pyrrhonian philosopher, who lived in the second century, under the reign of Antoninus. He was a physician of the sect of the Empirics, and is said to have been one of the preceptors of Antoninus the Philosopher. There are still extant his Pyrrhonian Institutions, and a large work against the mathematicians. The best edition of Sextus Empiricus is that of Fabricius in Greek and Latin, printed at Leipsic in 1718, folio.

SEXUALISTÆ, among botanical writers, those who have established the classes of plants upon the differences of the sexes and parts of fructification in plants, according to the modern method.

SEYNE, La, a city of France, in the department of the Var, and the arrondissement of Toulon. It is a port on a small bay or roadstead, about three miles from Toulon. It is well built, has good quays, and an establishment for building vessels. It contains 5230 inhabitants, many of whom are occupied in fishing for sardinias and tunnies.

SEYSUMAH, a town of the Mahratta territories, in Hindustan, province of Malwah, situated on the east side of the Chumbul. It is twenty miles south-west from Kotah. Long. 75. 37. E. Lat. 24. 55. N.

SEZAWUL, a Hindu word, used in Bengal to express an officer employed at a monthly salary to collect the revenue.

SHACK, in ancient customs, a liberty of winter-pasturage. In the counties of Norfolk and Suffolk, the lord of the manor has shack, that is, a liberty of feeding his sheep at pleasure in his tenants' lands during the six winter months. In Norfolk, shack also extends to the common for hogs, in all men's grounds, from the end of harvest till seed-time. Hence to go *a-shack* is to feed at large.

SHACKLES, aboard a ship, are those oblong iron rings, bigger at one end than at the other, with which the ports are shut fast, by thrusting the wooden bar of the port through them. There is also a sort of shackles to lift up the hatches with, of a like figure, but smaller. They are fastened at the corners of the hatches.

SHADOW, in *Optics*, a privation or diminution of light, by the interposition of an opaque body; or a plane where the light is either altogether obstructed, or greatly weakened, by the interposition of some opaque body between it and the luminary.

Shadow, in *Perspective*. The appearance of an opaque body, and a luminous one whose rays diverge, being given; to find the just appearance of the shadow, according to the laws of perspective. The method is this. From the luminous body, which is here considered as a point, let fall a perpendicular to the perspective plane or table, that is, find the appearance of a point upon which a perpendicular, drawn from the middle of the luminary, falls on the perspective plane; and from the several angles, or raised points of the body, let fall perpendiculars to the plane. These points, on which the perpendiculars fall, connect by right lines with the point upon which the perpendicular let fall from the luminary falls, and continue the lines to the side opposite to the luminary. Lastly, through the raised points draw lines through the centre of the luminary, intersecting the former; the points of intersection are the terms or bounds of the shadow.

SHADOWRAH, a town of Hindustan, in the Mahratta territories, province of Malwah, forty miles north by west from Seronge. Long. 77. 47. E. Lat. 24. 20. N.

SHADWEL, Thomas, descended of an ancient family in Staffordshire, was born in 1640, and educated at Caius College, Cambridge. He was then placed in the Middle Temple to study the laws; and having spent some time there, he travelled abroad. Upon his return home, he became acquainted with the most celebrated persons of wit in that age. He applied himself chiefly to dramatic writing, in which he had great success, and upon the Revolution was made poet laureat and historiographer to King William and Queen Mary, in the room of Mr Dryden. These employments he enjoyed till his death, which happened in 1692. Besides his dramatic writings, he composed several other pieces of poetry, the chief of which are his congratulatory poem on the Prince of Orange's coming to England, another on Queen Mary, and his translation of Juvenal's tenth satire. Mr Dryden treats him with great contempt, in his satire called *Macflecno*. The best judges of that age, however, gave their testimony in favour of his comedies, which have in them fine strokes of humour; the characters are often original, strongly marked, and well sustained. An edition of his works, with some account of his life and writings prefixed, was published in 1720, in four vols. 8vo.

SHADWELL, a large village of the county of Middlesex, in the hundred of Ossulston, touching on the city of London, but lower down on the same bank of the Thames, two miles and a half from St Paul's church. It is within the bills of mortality, and is a parish of itself. The population consists chiefly of sea-faring people, and of such as are connected with the building and equipment of shipping. The parish church is a large and handsome building, dedicated to St Paul. The inhabitants amounted in 1821 to 9557, and in 1831 to 9544. Many of the smaller houses, more than two hundred, have been taken down to make space for the docks that have been built, which accounts for the decrease in the population.

SHAFRAS, or Suffras, Gregory Savarof, an Armenian merchant, remarkable only as the person who sold the large and celebrated diamond which is now set in the imperial sceptre of Russia. Shah Nadir, an Indian prince, had two principal diamonds in his throne, one of them denominated the Sun of the Sea, and the other the Moon of the Mountain. When that prince was assassinated, many precious ornaments belonging to the crown were pillaged, and privately disposed of by the soldiers who shared the plunder.

Shafras, who was called *Millionshik* at Astrakhan, had then his residence at Bassora, with two of his brothers. A chief of the Afghans one day applied to him, and proposed to sell the diamond already mentioned for a very moderate sum (probably the Moon of the Mountain), together with a very large emerald, a ruby of considerable size, and other precious stones of less value. Shafras was astonished at the offer; and giving out that he had not a sufficient sum to purchase them, he requested time to consult with his brothers on the subject. The vender did not again make his appearance, probably from suspicious motives. Shafras, with the approbation of his brothers, went directly in search of the stranger with the jewels, but by that time he had left Bassora. Shafras, however, accidentally met him at Bagdad, and paid him 50,000 piastres (L.8958. 6s. 8d.) for all his jewels. Shafras and his brothers, being well aware that the most profound secrecy was absolutely necessary, resolved to remain at Bassora.

At the expiration of twelve years, Shafras set off with the largest of the jewels, directing his route through Sham and Constantinople, and afterwards through Hungary and Silesia to the city of Amsterdam by land, where he publicly offered them for sale.

It is reported that the British government was among the bidders. The Russian court sent for the large diamond, with an offer to reimburse all reasonable expenses if the price could not be agreed on. When the diamond arrived, Count Panin, the Russian minister, made the following offer to Shafras. Besides the patent of hereditary nobility, which the vender demanded, he was to receive an annual pension of 6000 roubles during life, 500,000 roubles in cash (L.112,500 sterling), one fifth of which was to be payable on demand, and the remainder by instalments in the course of ten years. He also claimed the order of nobility for his brothers, persisting so obstinately in his demands, that the diamond was returned.

Shafras was now very much perplexed. He had involved himself in expenses, was forced to pay interest for considerable sums of borrowed money, and he saw no prospect of selling the jewel to advantage. The negociation was recommenced with Russia by Count Gregory Grigorevitsh Orlof, afterwards created a prince of the empire; and the diamond was purchased for 450,000 roubles (L.105,250) ready money, together with a grant of Russian nobility. We are informed that 120,000 roubles (L.27,000) fell to the share of the negociators for commission, interest, and similar expenses. Shafras settled at Astrakhan; and his riches, which by inheritance devolved to his daughters, have been in a great measure dissipated by the extravagance of his sons-in-law.

SHAFTESBURY, a town in the hundred of Rudland, in the county of Dorset, 101 miles from London. It stands on a hill, is not well supplied with water, and the houses are generally of an humble character. It contains three parishes, with their respective churches. It is an ancient town, supposed to have been founded by Alfred. It is a borough, with a mayor, recorder, and twelve burgesses, and returned two members to parliament till 1832, but now elects only one. The chief trade is making shirt-buttons. The population in 1821 amounted to 2903, and in 1831 to 3061.

SHAGREEN, or Chagreen, in *Commerce*, a kind of grained leather prepared of the skin of a species of squalus, and much used in covering cases, books, and other articles. The best is that which is brought from Constantinople, and is of a brownish colour; the white is the worst. It is extremely hard, yet, when steeped in water, it becomes very soft and pliable; and hence it is of great use among case-makers. It takes any colour that is given to it, red, green, yellow, or black. It is frequently counterfeited, by using morocco formed like shagreen; but this last is distinguished by its peeling off, which the first does not.

SHAHABAD, an extensive town and district of Hindustan, province of Bahar, most advantageously situated between the rivers Soane and Ganges. It is fertile and tolerably well cultivated, and produces barley, wheat, tobacco, and some pease of a small kind. It is estimated to contain more than a million of inhabitants, in the proportion of nineteen Hindus to one Mahommedan. Its chief towns are Chunar, Boujepore, and Arrah. The town is situated on the east side of the Gurrah river, in the district of Khyrabad. It was formerly a large place, but has now fallen greatly to decay. Long. 79. 55 E. Lat. 27. 39. N. There is another town of this name, in the province of Delhi, belonging to the Sikhs, which has also fallen into decay. It is 105 miles north by west from Delhi. Long. 76. 28. E. Lat. 30. 12. N.

SHAHJEHANPOOR, a considerable town of Hindustan, in the Mahratta territories, province of Malwah, situated on the banks of the Sagormutty river, forty miles north-north-east from Oojain. Long. 76. 18. E. Lat. 23. 28. N. There is another town of the same name, in the province of Delhi, district of Bareilly, situated on the Gurrah river, ninety-five miles north-east from Lucknow. Long. 79. 53. E. Lat. 27. 51. N. Both these towns are called after Shah Jehan, who reigned in the middle of the seventeenth century.

SHAHNOOR, Sanore, Sevanore, or Savanoor, a town of Hindustan, in the province of Bejapoor, fifty miles south-south-east from Darwar, and capital of a district of the same name. It was formerly a fortified town, and contained a palace and many good buildings, the greater part of which are now in ruins. It is a place of no strength, though it is enclosed by a wall and ditch. Outside the wall to the northward are several long streets of houses, mostly uninhabited. This place was conquered from the Hindus by the Bhamenee sovereigns in 1397; it afterwards became the capital of a small Patan state, its hereditary possessor receiving the title of nabob. Abdul Hakeem Khan, the seventh lineal descendant, reigned in 1792, and was tributary to Tippoo till 1784, when he accepted the protection of the Mahrattas, on which his territories were ravaged by the armies of Tippoo, the palaces and public buildings were destroyed and razed, and the whole country was laid waste. In 1792 it was wrested from him and restored to the nabob. The district is now under the peishwa's government, being part of the territory received in exchange from the British government for an equivalent in Bundelcund. Long. 75. 22. E. Lat. 15. 1. N.

SHAHPOOR, a town of Hindustan, in the province of Berar, in the Nagpoor rajah's territories, seventy miles north by west from Ellichpoor. Long. 78. 23. E. Lat. 22. 19. N. There is another Shahpoor in the province of Berar, sixty-five miles north-east from Jalnapoor. Long. 78. 1. E. Lat. 19. 49. N. Also one in the Sikh territories, province of Lahore, situated on the east side of the Ravey river, sixty miles north-east from the city of Lahore. Long. 74. 45. E. Lat. 32. 19. N. There are various other towns in Hindustan of this name, which signifies King's Town, many of them of too little consequence to merit any particular notice.

SHAIRGHUR, a town of Hindustan, in the province of Delhi, twenty-six miles north from Bareilly. Long. 79. 21. E. Lat. 28. 40. N.

SHAKSPEARE.[1]

Shakspeare.

William Shakspeare, the protagonist on the great arena of modern poetry, and the glory of the human intellect, was born at Stratford-upon-Avon, in the county of Warwick, in the year 1564, and upon some day, not precisely ascertained, in the month of April. It is certain that he was baptized on the 25th; and from that fact, combined with some shadow of a tradition, Malone has inferred that he was born on the 23d. There is doubtless, on the one hand, no absolute necessity deducible from law or custom, as either operated in those times, which obliges us to adopt such a conclusion; for children might be baptized, and were baptized. at various distances from their birth: yet, on the other hand, the 23d is as likely to have been the day as any other; and more likely than any earlier day, upon two arguments. First, because there was probably a tradition floating in the seventeenth century, that Shakspeare died upon his birth-day: now it is beyond a doubt that he died upon the 23d of April. Secondly, because it is a reasonable presumption, that no parents, living in a simple community, tenderly alive to the pieties of household duty, and in an age still clinging reverentially to the ceremonial ordinances of religion, would much delay the adoption of their child into the great family of Christ. Considering the extreme frailty of an infant's life during its two earliest years, to delay would often be to disinherit the child of its Christian privileges; privileges not the less eloquent to the feelings from being profoundly mysterious, and, in the English church, forced not only upon the attention, but even upon the eye, of the most thoughtless. According to the discipline of the English church, the unbaptized are buried with "maimed rites," shorn of their obsequies, and sternly denied that "sweet and solemn farewell" by which otherwise the church expresses her final charity with all men; and not only so, but they are even *locally* separated and sequestrated. Ground the most hallowed, and populous with Christian burials of households,

> That died in peace with one another,
> Father, sister, son, and brother.

opens to receive the vilest malefactor; by which the church symbolically expresses her maternal willingness to gather back into her fold those even of her flock who have strayed from her by the most memorable aberrations; and yet, with all this indulgence, she banishes to unhallowed ground the innocent bodies of the unbaptized. To them and to suicides she turns a face of wrath. With this gloomy fact offered to the very external senses, it is difficult to suppose that any parents would risk their own reproaches by putting the fulfilment of so grave a duty on the hazard of a convulsion fit. The case of royal children is different; their baptisms, it is true, were often delayed for weeks; but the household chaplains of the palace were always at hand, night and day, to baptize them in the very agonies of death.[2] We must presume, therefore, that William Shakspeare was born on some day very little anterior to that of his baptism; and the more so because the season of the year was lovely and genial, the 23d of April in 1564 corresponding in fact with what we now call the 3d of May, so that, whether the child was to be carried abroad, or the clergyman to be summoned, no hindrance would arise from the weather. One only argument has sometimes struck us for supposing that the 22d might be the day, and not the 23d; which is, that Shakspeare's sole grand-daughter, Lady Barnard, was married on the 22d of April 1626, ten years exactly from the poet's death; and the reason for choosing this day *might* have had a reference to her illustrious grandfather's birthday; which, there is good reason for thinking, would be celebrated as a festival in the family for generations. Still this choice *may* have been an accident, or governed merely by reason of convenience. And, on the whole, it is as well perhaps to acquiesce in the old belief, that Shakspeare was born and died on the 23d of April. We cannot do wrong if we drink to his memory on both 22d and 23d.

On a first review of the circumstances, we have reason to feel no little perplexity in finding the materials for a life of this transcendent writer so meagre and so few; and amongst them the larger part of doubtful authority. All the energy of curiosity directed upon this subject, through a period of one hundred and fifty years (for so long it is since Betterton the actor began to make researches) has availed us little or nothing. Neither the local traditions of his provincial birth-place, though sharing with London through half a century the honour of his familiar presence, nor the recollections of that brilliant literary circle with whom he lived in the metropolis, have yielded much more than such an outline of his history as is oftentimes to be gathered from the penurious records of a grave-stone. That he lived, and that he died, and that he was "a little lower than the angels;"—these make up pretty nearly the amount of our undisputed report. It may be doubted indeed whether at this day we are as accurately acquainted with the life of Shakspeare as with that of Chaucer, though divided from each other by an interval of two centuries, and (what should have been more effectual towards oblivion) by the wars of the two roses. And yet the traditional memory of a rural and a sylvan region, such as Warwickshire at that time was, is usually exact as well as tenacious; and, with respect to Shakspeare in particular, we may presume it to have been full and circumstantial through the generation succeeding to his own, not only from the curiosity, and perhaps something of a scandalous interest, which would pursue the motions of one living so large a part of his life at a distance from his wife, but also from the final reverence and honour which would settle upon the memory of a poet so pre-eminently successful; of one who, in a space of five-and-twenty years, after running a bright career in the capital city of his native land, and challenging notice from the throne, had retired with an ample fortune, created by his personal efforts, and by labours purely intellectual.

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[1] Mr Campbell, the latest editor of Shakspeare's dramatic works, observes that "the poet's name has been variously written Shaxpeare, Shackspeare, Shakspeare, and Shakspere;" to which varieties might be added Shagspere, from the Worcester Marriage License, published in 1836. But the fact is, that by combining with all the differences in spelling the first syllable, all those in spelling the second, more than twenty-five distinct varieties of the name may be expanded (like an algebraic series), for the choice of the curious in mis-spelling. Above all things, those varieties which arise from the intercalation of the middle *e* (that is, the *e* immediately before the final syllable *spear*), can never be overlooked by those who remember, at the opening of the Dunciad, the note upon this very question about the orthography of Shakspeare's name, as also upon the other great question about the title of the immortal Satire, Whether it ought not to have been the Dunceiade, seeing that Dunce, its great author and progenitor, cannot possibly dispense with the letter *e*. Meantime we must remark, that the first three of Mr Campbell's variations are mere caprices of the press; as is Shagspere; or, more probably, this last euphonious variety arose out of the gross clownish pronunciation of the two hiccuping "*marksmen*" who rode over to Worcester for the license; and one cannot forbear laughing at the bishop's secretary for having been so misled by two varlets, professedly incapable of signing their own names. The same drunken villains had cut down the bride's name *Hathaway* into *Hathwey*. Finally, to treat the matter with seriousness, Sir Frederick Madden has shown, in his recent letter to the Society of Antiquaries, that the poet himself in all probability wrote the name uniformly *Shakspere*. Orthography, both of proper names, of appellatives, and of words universally, was very unsettled up to a period long subsequent to that of Shakspeare. Still it must usually have happened that names written variously and laxly by others, would be written uniformly by the owners; especially by those owners who had occasion to sign their names frequently, and by literary people, whose attention was often, as well as consciously, directed to the proprieties of spelling. *Shakspeare* is now too familiar to the eye for any alteration to be attempted; but it is pretty certain that Sir Frederick Madden is right in stating the poet's own signature to have been uniformly *Shakspere*. It is so written twice in the course of his will, and it is so written on a blank leaf of Florio's English translation of Montaigne's Essays; a book recently discovered, and sold, on account of its autograph, for a hundred guineas.

[2] But, as a proof that, even in the case of royal christenings, it was not thought pious to "tempt God," as it were, by delay, Edward VI. the only son of Henry VIII. was born on the 12th day of October in the year 1537. And there was a delay on account of the sponsors, since the birth was not in London. Yet how little that delay was made, may be seen by this fact: The birth took place in the dead of the night, the day was Friday; and yet, in spite of all delay, the christening was most pompously celebrated on the succeeding Monday. And Prince Arthur, the elder brother of Henry VIII. was christened on the very next Sunday succeeding to his birth, notwithstanding an inevitable delay, occasioned by the distance of Lord Oxford, his godfather, and the excessive rains, which prevented the earl being reached by couriers, or himself reaching Winchester, without extraordinary exertions.

How are we to account, then, for that deluge, as if from Lethe, which has swept away so entirely the traditional memorials of one so illustrious? Such is the fatality of error which overclouds every question connected with Shakspeare, that two of his principal critics, Steevens and Malone, have endeavoured to solve the difficulty by cutting it with a falsehood. They deny in effect that he *was* illustrious in the century succeeding to his own, however much he has since become so. We shall first produce their statements in their own words, and we shall then briefly review them.

Steevens delivers *his* opinion in the following terms:—"How little Shakspeare was once read, may be understood from Tate, who, in his dedication to the altered play of King Lear, speaks of the original as an obscure piece, recommended to his notice by a friend; and the author of the Tatler, having occasion to quote a few lines out of Macbeth, was content to receive them from Davenant's alteration of that celebrated drama, in which almost every original beauty is either awkwardly disguised or arbitrarily omitted." Another critic, who cites this passage from Steevens, pursues the hypothesis as follows:—"In fifty years after his death, Dryden mentions that he was then become *a little obsolete.* In the beginning of the last century, Lord Shaftesbury complains of his *rude unpolished style, and his antiquated phrase and wit.* It is certain that, for nearly a hundred years after his death, partly owing to the immediate revolution and rebellion, and partly to the licentious taste encouraged in Charles II.'s time, and perhaps partly to the incorrect state of his works, he was ALMOST ENTIRELY NEGLECTED." This critic then goes on to quote with approbation the opinion of Malone,—"that if he had been read, admired, studied, and imitated, in the same degree as he is now, the enthusiasm of some one or other of his admirers in the last age would have induced him to make some inquiries concerning the history of his theatrical career, and the anecdotes of his private life." After which this enlightened writer re-affirms and clenches the judgment he has quoted by saying,—"His admirers, however, *if he had admirers in that age,* possessed no portion of such enthusiasm."

It may perhaps be an instructive lesson to young readers, if we now show them, by a short sifting of these confident dogmatists, how easy it is for a careless or a half-read man to circulate the most absolute falsehoods under the semblance of truth; falsehoods which impose upon himself as much as they do upon others. We believe that not one word or illustration is uttered in the sentences cited from these three critics, which is not *virtually* in the very teeth of the truth.

To begin with Mr Nahum Tate:—This poor grub of literature, if he did really speak of Lear as "an *obscure* piece, recommended to his notice by a friend," of which we must be allowed to doubt, was then uttering a conscious falsehood. It happens that Lear was one of the few Shakspearian dramas which had kept the stage unaltered. But it is easy to see a mercenary motive in such an artifice as this. Mr Nahum Tate is not of a class of whom it can be safe to say that they are "well known:" they and their desperate tricks are essentially obscure, and good reason he has to exult in the felicity of such obscurity; for else this same vilest of travesties, Mr Nahum's Lear, would consecrate his name to everlasting scorn. For himself, he belonged to the age of Dryden rather than of Pope: he "flourished," if we can use such a phrase of one who was always withering, about the era of the Revolution; and his Lear, we believe, was arranged in the year 1682. But the family to which he belongs is abundantly recorded in the Dunciad; and his own name will be found amongst its catalogues of heroes.

With respect to *the author of the Tatler*, a very different explanation is requisite. Steevens means the reader to understand Addison; but it does not follow that the particular paper in question was from his pen. Nothing, however, could be more natural than to quote from the common form of the play as then in possession of the stage. It was *there*, beyond a doubt, that a fine gentleman living upon town, and not professing any deep scholastic knowledge of literature (a light in which we are always to regard the writers of the Spectator, Guardian, &c.), would be likely to have learned anything he quoted from Macbeth. This we say generally of the writers in those periodical papers; but, with reference to Addison in particular, it is time to correct the popular notion of his literary character, or at least to mark it by severer lines of distinction. It is already pretty well known, that Addison had no very intimate acquaintance with the literature of his own country. It is known also, that he did not think such an acquaintance any ways essential to the character of an elegant scholar and *littérateur*. Quite enough he found it, and more than enough for the time he had to spare, if he could maintain a tolerable familiarity with the foremost Latin poets, and a very slender one indeed with the Grecian. *How* slender, we can see in his "Travels." Of modern authors, none as yet had been published with notes, commentaries, or critical collations of the text; and, accordingly, Addison looked upon all of them, except those few who professed themselves followers in the retinue and equipage of the ancients, as creatures of a lower race. Boileau, as a mere imitator and propagator of Horace, he read, and probably little else, amongst the French classics. Hence it arose that he took upon himself to speak sneeringly of Tasso. To this, which was a bold act for his timid mind, he was emboldened by the countenance of Boileau. Of the elder Italian authors, such as Ariosto, and, *a fortiori*, Dante, he knew absolutely nothing. Passing to our own literature, it is certain that Addison was profoundly ignorant of Chaucer and of Spenser. Milton only,—and why? simply because he was a brilliant scholar, and stands like a bridge between the Christian literature and the Pagan,—Addison had read and esteemed. There was also in the very constitution of Milton's mind, in the majestic regularity and planetary solemnity of its *epic* movements, something which he could understand and appreciate: as to the meteoric and incalculable eccentricities of the *dramatic* mind, as it displayed itself in the heroic age of our drama, amongst the Titans of 1590–1630, they confounded and overwhelmed him.

In particular, with regard to Shakspeare, we shall now proclaim a discovery which we made some twenty years ago. We, like others, from seeing frequent references to Shakspeare in the Spectator, had acquiesced in the common belief, that, although Addison was no doubt profoundly unlearned in Shakspeare's language, and thoroughly unable to do him justice (and this we might well assume, since his great rival Pope, who had expressly studied Shakspeare, was, after all, so memorably deficient in the appropriate knowledge),—yet, that of course he had a vague popular knowledge of the mighty poet's cardinal dramas. Accident only led us into a discovery of our mistake. Twice or thrice we had observed, that if Shakspeare were quoted, that paper turned out not to be Addison's; and at length, by express examination, we ascertained the curious fact, that Addison has never in one instance quoted or made any reference to Shakspeare. But was this, as Steevens most disingenuously pretends, to be taken as an exponent of the public feeling towards Shakspeare? Was Addison's neglect representative of a general neglect? If so, whence came Rowe's edition, Pope's, Theobald's, Sir Thomas Hanmer's, Bishop Warburton's, all upon the heels of one another? With such facts staring him in the face, how shameless must be that critic who could, in support of such a thesis, refer to "*the author of the Tatler*," contemporary with all these editors. The truth is, Addison was well aware of Shakspeare's hold on the popular mind; too well aware of it. The feeble constitution of the poetic faculty, as existing in himself, forbade his sympathising with Shakspeare; the proportions were too colossal for his delicate vision; and yet, as one who sought popularity himself, he durst not shock what perhaps he viewed as a national prejudice. Those who have happened, like ourselves, to see the effect of passionate music and "deep-inwoven harmonics" upon the feeling of an idiot,[1] may conceive what we mean. Such music does not utterly revolt the idiot; on the contrary, it has a strange but a horrid fascination for him: it alarms, irritates, disturbs, makes him profoundly unhappy; and chiefly by unlocking imperfect glimpses of thoughts and slumbering instincts, which it is for his peace to have entirely obscured, because for him they can be revealed only partially, and with the sad effect of throwing a baleful gleam upon his blighted condition. Do we mean, then, to compare Addison with an idiot? Not generally, by any means. Nobody can more sincerely admire him where he was a man of real genius, viz. in his delineations of character and manners, or in the exquisite delicacies of his humour. But assuredly Addison, as a poet, was amongst the sons of the feeble; and between the authors of Cato and of King Lear there was a gulf never to be bridged over.[2]

But Dryden, we are told, pronounced Shakspeare already in *his* day "*a little obsolete*." Here now we have wilful, deliberate falsehood. *Obsolete*, in Dryden's meaning, does not imply that he was so with regard to his popularity (the question then at issue), but with regard to his diction and choice of words. To cite Dryden as a witness for any purpose against Shakspeare,—Dryden, who of all men had the most ransacked wit and exhausted language in celebrating the supremacy of Shakspeare's genius, does indeed require as much shamelessness in feeling as mendacity in principle.

But then Lord Shaftesbury, who may be taken as half way between Dryden and Pope (Dryden died in 1700, Pope was then twelve years old, and Lord S. wrote chiefly, we believe, between 1700 and 1710), "complains," it seems, "of his rude unpolished style, and his antiquated phrase and wit." What if he does? Let the whole truth be told, and then we shall see how much stress is to be laid upon such a judgment. The second Lord Shaftesbury, the author of the Characteristics, was the grandson of that famous political agitator, the Chancellor Shaftesbury, who passed his whole life in storms of his own creation. The second Lord Shaftesbury was a man of crazy constitution, querulous from ill health, and had received an eccentric education from his eccentric grandfather. He was practised daily in *talking* Latin, to which afterwards he added a competent study of the Greek; and finally he became unusually learned for his rank, but the most absolute and undistinguishing pedant that perhaps literature has to show. He sneers continually at the regular-built academic pedant; but he himself, though no academic, was essentially the very impersonation of pedantry. No thought however beautiful, no image however magnificent, could conciliate his praise as long as it was clothed in English; but present him with the most trivial common-places in Greek, and he unaffectedly fancied them divine; mistaking the pleasurable sense of his own power in a difficult and rare accomplishment for some peculiar force or beauty in the passage. Such was the outline of his literary taste. And was it upon Shakspeare only, or upon him chiefly, that he lavished his pedantry? Far from it. He attacked Milton with no less fervour; he attacked Dryden with a thousand times more. Jeremy Taylor he quoted only to ridicule; and even Locke, the confidential friend of his grandfather, he never alludes to without a sneer. As to Shakspeare, so far from Lord Shaftesbury's censures arguing his deficient reputation, the very fact of his noticing him at all proves his enormous popularity; for upon system he noticed those only who ruled the public taste. The insipidity of his objections to Shakspeare may be judged from this, that he comments in a spirit of absolute puerility upon the name *Desdemona*, as though intentionally formed from the Greek word for *superstition*. In fact, he had evidently read little beyond the list of names in Shakspeare; yet there is proof enough that the irresistible beauty of what little he *had* read was too much for all his pedantry, and startled him exceedingly; for ever afterwards he speaks of Shakspeare as one who, with a little aid from Grecian sources, really had something great and promising about him. As to modern authors, neither this Lord Shaftesbury nor Addison read anything for the latter years of their life but Bayle's Dictionary. And most of the little scintillations of erudition which may be found in the notes to the Characteristics, and in the Essays of Addison, are derived, almost without exception, and uniformly without acknowledgment, from Bayle.[3]

very common failing

Finally, with regard to the sweeping assertion, that "for nearly a hundred years after his death Shakspeare was almost entirely neglected," we shall meet this scandalous falsehood by a rapid view of his fortunes during the century in question. The tradition has always been, that Shakspeare was honoured by the especial notice of Queen Elizabeth, as well as by that of James I. At one time we were disposed to question the truth of this tradition; but that was for want of having read attentively the lines of Ben Jonson to the memory of Shakspeare, those generous lines which have so absurdly been taxed with faint praise. Jonson could make no mistake on this point: he, as one of Shakspeare's familiar companions, must have witnessed at the very time, and accompanied with friendly sympathy, every motion of royal favour towards Shakspeare. Now he, in words which leave no room for doubt, exclaims

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[1] A great modern poet refers to this very case of music entering "the mouldy chambers of the dull idiot's brain;" but in support of what seems to us a baseless hypothesis.

[2] Probably Addison's fear of the national feeling was a good deal strengthened by his awe of Milton and of Dryden, both of whom had expressed a homage towards Shakspeare which language cannot transcend. Amongst his political friends also were many intense admirers of Shakspeare.

[3] He who is weak enough to kick and spurn his own native literature, even if it were done with more knowledge than is shown by Lord Shaftesbury, will usually be kicked and spurned in his turn; and accordingly it has been often remarked, that the Characteristics are unjustly neglected in our days. For Lord Shaftesbury, with all his pedantry, was a man of great talents. Leibnitz had the sagacity to see this through the mists of a translation.

> Sweet swan of Avon, what a sight it were
> To see thee in our waters yet appear;
> And make those flights upon the banks of Thames
> *That so did take Eliza and our James.*

These princes, then, *were* taken, were fascinated, with some of Shakspeare's dramas. In Elizabeth the approbation would probably be sincere. In James we can readily suppose it to have been assumed; for he was a pedant in a different sense from Lord Shaftesbury; not from undervaluing modern poetry, but from caring little or nothing for any poetry, although he wrote about its mechanic rules. Still the royal *imprimatur* would be influential and serviceable no less when offered hypocritically than in full sincerity. Next let us consider, at the very moment of Shakspeare's death, who were the leaders of the British youth, the *principes juventutis*, in the two fields, equally important to a great poet's fame, of rank and of genius? The Prince of Wales and John Milton; the first being then about sixteen years old, the other about eight. Now these two great powers, as we may call them, these presiding stars over all that was English in thought and action, were both impassioned admirers of Shakspeare. Each of them counts for many thousands. The Prince of Wales[1] had learned to appreciate Shakspeare, not originally from reading him, but from witnessing the court representations of his plays at Whitehall. Afterwards we know that he made Shakspeare his closet companion, for he was reproached with doing so by Milton. And we know also, from the just criticism pronounced upon the character and diction of Caliban by one of Charles's confidential counsellors, Lord Falkland, that the king's admiration of Shakspeare had impressed a determination upon the court reading. As to Milton, by double prejudices, puritanical and classical, his mind had been preoccupied against the full impressions of Shakspeare. And we know that there is such a thing as keeping the sympathies of love and admiration in a dormant state, or state of abeyance; an effort of self-conquest realized in more cases than one by the ancient fathers, both Greek and Latin, with regard to the profane classics. Intellectually they admired, and would not belie their admiration; but they did not give their hearts cordially, they did not abandon themselves to their natural impulses. They averted their eyes and weaned their attention from the dazzling object. Such, probably, was Milton's state of feeling towards Shakspeare after 1642, when the theatres were suppressed, and the fanatical fervour in its noontide heat. Yet even then he did not belie his reverence intellectually for Shakspeare; and in his younger days we know that he had spoken more enthusiastically of Shakspeare than he ever did again of any uninspired author. Not only did he address a sonnet to his memory, in which he declares that kings would wish to die, if by dying they could obtain such a monument in the hearts of men; but he also speaks of him in his *Il Penseroso* as the tutelary genius of the English stage. In this transmission of the torch (λαμπαδοφορια) Dryden succeeds to Milton; he was born nearly thirty years later; about thirty years they were contemporaries; and by thirty years, or nearly, Dryden survived his great leader. Dryden, in fact, lived out the seventeenth century. And we have now arrived within nine years of the era when the critical editions started in hot succession to one another. The names we have mentioned were the great influential names of the century. But of inferior homage there was no end. How came Betterton the actor, how came Davenant, how came Rowe, or Pope, by their intense (if not always sound) admiration for Shakspeare, unless they had found it fuming upwards like incense to the Pagan deities in ancient times from altars erected at every turning upon all the paths of men?

But it is objected that inferior dramatists were sometimes preferred to Shakspeare; and again, that vile travesties of Shakspeare were preferred to the authentic dramas. As to the first argument, let it be remembered, that if the saints of the chapel are always in the same honour, because *there* men are simply discharging a duty, which once due will be due for ever; the saints of the theatre, on the other hand, must bend to the local genius, and to the very reasons for having a theatre at all. Men go thither for amusement: this is the paramount purpose; and even acknowledged merit or absolute superiority must give way to it. Does a man at Paris expect to see Molière reproduced in proportion to his admitted precedency in the French drama? On the contrary, that very precedency argues such a familiarization with his works, that those who are in quest of relaxation will reasonably prefer any recent drama to that which, having lost all its novelty, has lost much of its excitement. We speak of ordinary minds; but in cases of *public* entertainments, deriving part of their power from scenery and stage pomp, novelty is for all minds an essential condition of attraction. Moreover, in some departments of the comic, Beaumont and Fletcher, when writing in combination, really had a freedom and breadth of manner which excels the comedy of Shakspeare. As to the altered Shakspeare as taking precedency of the genuine Shakspeare, no argument can be so frivolous. The public were never allowed a choice; the great majority of an audience even now cannot be expected to carry the real Shakspeare in their mind, so as to pursue a comparison between that and the alteration. Their comparisons must be exclusively amongst what they have opportunities of seeing; that is, between the various pieces presented to them by the managers of theatres. Further than this it is impossible for them to extend their office of judging and collating; and the degenerate taste which substituted the caprices of Davenant, the rants of Dryden, or the filth of Tate, for the jewellery of Shakspeare, cannot with any justice be charged upon the public, not one in a thousand of whom was furnished with any means of comparing, but exclusively upon those (viz. theatrical managers) who had the very amplest. Yet even in excuse for *them* much may be said. The very length of some plays compelled them to make alterations. The best of Shakspeare's dramas, King Lear, is the least fitted for representation; and, even for the vilest alteration, it ought in candour to be considered that possession is nine points of the law. He who would not have introduced, was often obliged to retain.

Finally, it is urged, that the small number of editions through which Shakspeare passed in the seventeenth century, furnishes a separate argument, and a conclusive one, against his popularity. We answer, that, considering the bulk of his plays collectively, the editions were *not* few: compared with any known case, the copies sold of Shakspeare were quite as many as could be expected under the circumstances. Ten or fifteen times as much consideration went to the purchase of one great folio like Shakspeare, as would attend the purchase of a little volume like Waller or Donne. Without reviews, or newspapers, or advertisements to diffuse the knowledge of books, the progress of literature was necessarily slow, and its expansion narrow. But this is a topic which has always been treated unfairly, not with regard to Shakspeare only, but to Milton, as well as many others. The truth is, we have not facts enough to guide us; for the number of editions often tells nothing accurately as to the number of copies. With respect to Shakspeare it is certain, that, had his masterpieces been gathered into small volumes, Shakspeare would have had a most extensive sale. As it was, there can be no doubt, that from his own generation, throughout the seventeenth century, and until the eighteenth began to accommodate, not any greater popularity in *him*, but a greater taste for reading in the public, his fame never ceased to be viewed as a national trophy of honour; and the most illustrious men of the seventeenth century were no whit less fervent in their admiration than those of the eighteenth and the nineteenth, either as respected its strength and sincerity, or as respected its open profession.[1]

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[1] Perhaps the most bitter political enemy of Charles I. will have the candour to allow that, for a prince of those times, he was truly and eminently accomplished. His knowledge of the arts was considerable; and, as a patron of art, he stands foremost amongst all British sovereigns to this hour. He said truly of himself, and wisely as to the principle, that he understood English law as well as a gentleman ought to understand it; meaning that an attorney's minute knowledge of forms and technical niceties was illiberal. Speaking of him as an author, we must remember that the *Eikon Basiliké* is still unappropriated; that question is still open. But supposing the king's claim negatived, still, in his controversy with Henderson, in his negotiations at the Isle of Wight and elsewhere, he discovered a power of argument, a learning, and a strength of memory, which are truly admirable; whilst the whole of his accomplishments are recommended by a modesty and a humility as rare as they are unaffected.

It is therefore a false notion, that the general sympathy with the merits of Shakspeare ever beat with a languid or intermitting pulse. Undoubtedly, in times when the functions of critical journals and of newspapers were not at hand to diffuse or to strengthen the impressions which emanated from the capital, all opinions must have travelled slowly into the provinces. But even then, whilst the perfect organs of communication were wanting, indirect substitutes were supplied by the necessities of the times, or by the instincts of political zeal. Two channels especially lay open between the great central organ of the national mind, and the remotest provinces. Parliaments were occasionally summoned (for the judges' circuits were too brief to produce much effect); and during their longest suspensions, the nobility, with large retinues, continually resorted to the court. But an intercourse more constant and more comprehensive was maintained through the agency of the two universities. Already, in the time of James I., the growing importance of the gentry, and the consequent birth of a new interest in political questions, had begun to express itself at Oxford, and still more so at Cambridge. Academic persons stationed themselves as sentinels at London, for the purpose of watching the court and the course of public affairs. These persons wrote letters, like those of the celebrated Joseph Mede, which we find in Ellis's Historical Collections, reporting to their fellow-collegians all the novelties of public life as they arose, or personally carried down such reports, and thus conducted the general feelings at the centre into lesser centres, from which again they were diffused into the ten thousand parishes of England; for (with a very few exceptions in favour of poor benefices, Welch or Cumbrian), every parish priest must unavoidably have spent his three years at one or other of the English universities. And by this mode of diffusion it is that we can explain the strength with which Shakspeare's thoughts and diction impressed themselves from a very early period upon the national literature, and even more generally upon the national thinking and conversation.[2]

The question therefore revolves upon us in threefold difficulty, How, having stepped thus prematurely into this inheritance of fame, leaping, as it were, thus abruptly into the favour alike of princes and the enemies of princes, had it become possible that in his native place (honoured still more in the final testimonies of his preference when founding a family mansion), such a man's history, and the personal recollections which cling so affectionately to the great intellectual potentates who have recommended themselves by gracious manners, could so soon and so utterly have been obliterated?

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[1] The necessity of compression obliges us to omit many arguments and references by which we could demonstrate the fact, that Shakspeare's reputation was always in a progressive state; allowing only for the interruption of about seventeen years, which this poet, in common with all others, sustained, not so much from the state of war (which did not fully occupy four of those years), as from the triumph of a gloomy fanaticism. Deduct the twenty-three years of the seventeenth century which had elapsed before the first folio appeared, to this space add seventeen years of fanatical madness, during fourteen of which *all* dramatic entertainments were suppressed, the remainder is sixty years. And surely the sale of four editions of a vast folio in that space of time was an expression of an abiding interest. *No other poet, except Spenser, continued to sell throughout the century.* Besides, in arguing the case of a *dramatic* poet, we must bear in mind, that although readers of learned books might be diffused over the face of the land, the readers of poetry would be chiefly concentred in the metropolis; and such persons would have no need to buy what they heard at the theatres. But then comes the question, whether Shakspeare kept possession of the theatres. And we are really humiliated by the gross want of sense which has been shown, by Malone chiefly, but also by many others, in discussing this question. From the Restoration to 1682, says Malone, no more than four plays of Shakspeare's were performed by a principal company in London. "Such was the lamentable taste of those times, that the plays of Fletcher, Jonson, and Shirley, were much oftener exhibited than those of our author." What cant is this! If that taste were "lamentable;" what are we to think of our own times, when plays a thousand times below those of Fletcher, or even of Shirley, continually displace Shakspeare? Shakspeare would himself have exulted in finding that he gave way only to dramatists so excellent. And, as we have before observed, both then and now, it is the very familiarity with Shakspeare which often banishes him from audiences honestly in quest of relaxation and amusement. Novelty is the very soul of such relaxation; but in our closets, when we are *not* unbending, when our minds are in a state of tension from intellectual cravings, then it is that we resort to Shakspeare; and oftentimes those who honour him most, like ourselves, are the most impatient of seeing his divine scenes disfigured by unequal representation (good, perhaps, in a single personation, bad in all the rest); or to hear his divine thoughts mangled in the recitation; or (which is worst of all) to hear them dishonoured and defeated by imperfect apprehension in the audience, or by defective sympathy. Meantime, if one theatre played only four of Shakspeare's dramas, another played at least seven. But the grossest folly of Malone is, in fancying the numerous alterations so many insults to Shakspeare, whereas they expressed as much homage to his memory as if the unaltered dramas had been retained. The substance *was* retained. The changes were merely concessions to the changing views of scenical propriety; sometimes, no doubt, made with a simple view to the revolution effected by Davenant at the restoration, in bringing *scenes* (in the painter's sense) upon the stage; sometimes also with a view to the altered fashions of the audience during the suspensions of the action, or perhaps to the introduction of *after-pieces*, by which, of course, the time was abridged for the main performance. A volume might be written upon this subject. Meantime let us never be told, that a poet was losing, or had lost his ground, who found in his lowest depression, amongst his almost idolatrous supporters, a great king distracted by civil wars, a mighty republican poet distracted by puritanical fanaticism, the greatest successor by far of that great poet, a papist and a bigoted royalist, and finally, the leading actor of the century, who gave and reflected the ruling impulses of his age.

[2] One of the profoundest tests by which we can measure the congeniality of an author with the national genius and temper, is the degree in which his thoughts or his phrases interweave themselves with our daily conversation, and pass into the currency of the language. *Few French authors, if any, have imparted one phrase to the colloquial idiom;* with respect to Shakspeare, a large dictionary might be made of such phrases as "win golden opinions," "in my mind's eye," "patience on a monument," "o'erstep the modesty of nature," "more honour'd in the breach than in the observance," "palmy state," "my poverty and not my will consents," and so forth, without end. This reinforcement of the general language, by aids from the mintage of Shakspeare, had already commenced in the seventeenth century.

Malone, with childish irreflection, ascribes the loss of such memorials to the want of enthusiasm in his admirers. Local researches into private history had not then commenced. Such a taste, often petty enough in its management, was the growth of after-ages. Else how came Spenser's life and fortunes to be so utterly overwhelmed in oblivion? No poet of a high order could be more popular.

The answer we believe to be this: Twenty-six years after Shakspeare's death commenced the great parliamentary war: this it was, and the local feuds arising to divide family from family, brother from brother, upon which we must charge the extinction of traditions and memorials, doubtless abundant up to that era. The parliamentary contest, it will be said, did not last above three years; the king's standard having been first raised at Nottingham in August 1642, and the battle of Naseby (which terminated the open warfare) having been fought in June 1645. Or even if we extend its duration to the surrender of the last garrison, that war terminated in the spring of 1646. And the brief explosions of insurrection or of Scottish invasion which occurred on subsequent occasions were all locally confined; and none came near to Warwickshire, except the battle of Worcester, more than five years after. This is true; but a short war will do much to efface recent and merely personal memorials. And the following circumstances of the war were even more important than the general fact.

First of all, the very mansion founded by Shakspeare became the military head-quarters for the queen in 1644, when marching from the eastern coast of England to join the king in Oxford; and one such special visitation would be likely to do more serious mischief in the way of extinction, than many years of general warfare. Secondly, as a fact, perhaps, equally important, Birmingham, the chief town of Warwickshire, and the adjacent district, the seat of our hardware manufactures, was the very focus of disaffection towards the royal cause. Not only, therefore, would this whole region suffer more from internal and spontaneous agitation, but it would be the more frequently traversed vindictively from without, and harassed by flying parties from Oxford, or others of the king's garrisons. Thirdly, even apart from the political aspects of Warwickshire, this county happens to be the central one of England, as regards the roads between the north and south; and Birmingham has long been the great central axis,[1] in which all the radii from the four angles of England proper meet and intersect. Mere accident, therefore, of local position, much more when united with that avowed inveteracy of malignant feeling, which was bitter enough to rouse a re-action of bitterness in the mind of Lord Clarendon, would go far to account for the wreck of many memorials relating to Shakspeare, as well as for the subversion of that quiet and security for humble life, in which the traditional memory finds its best *nidus*. Thus we obtain one solution, and perhaps the main one, of the otherwise mysterious oblivion which had swept away all traces of the mighty poet, by the time when those quiet days revolved upon England, in which again the solitary agent of learned research might roam in security from house to house, gleaning those personal remembrances which, even in the fury of civil strife, might long have lingered by the chimney corner. But the fierce furnace of war had probably, by its *local* ravages, scorched this field of natural tradition, and thinned the gleaner's inheritance by three parts out of four. This, we repeat, may be one part of the solution to this difficult problem.

And if another is still demanded, possibly it may be found in the fact, hostile to the perfect consecration of Shakspeare's memory, that after all he was a player. Many a coarse-minded country gentleman, or village pastor, who would have held his town glorified by the distinction of having sent forth a great judge or an eminent bishop, might disdain to cherish the personal recollections which surrounded one whom custom regarded as little above a mountebank, and the illiberal law as a vagabond. The same degrading appreciation attached both to the actor in plays and to their author. The contemptuous appellation of "play-book," served as readily to degrade the mighty volume which contained Lear and Hamlet, as that of "play-actor," or "player-man," has always served with the illiberal or the fanatical to dishonour the persons of Roscius or of Garrick, of Talma or of Siddons. Nobody, indeed, was better aware of this than the noble-minded Shakspeare; and feelingly he has breathed forth in his sonnets this conscious oppression under which he lay of public opinion, unfavourable by a double title to his own pretensions; for, being both dramatic author and dramatic performer, he found himself heir to a two-fold opprobrium, and at an era of English society when the weight of that opprobrium was heaviest. In reality, there was at this period a collision of forces acting in opposite directions upon the estimation of the stage and scenical art, and therefore of all the ministers in its equipage. Puritanism frowned upon these pursuits, as ruinous to public morals; on the other hand, loyalty could not but tolerate what was patronized by the sovereign; and it happened that Elizabeth, James, and Charles I., were all alike lovers and promoters of theatrical amusements, which were indeed more indispensable to the relief of court ceremony, and the monotony of aulic pomp, than in any other region of life. This royal support, and the consciousness that any brilliant success in these arts implied an unusual share of natural endowments, did something in mitigation of a scorn which must else have been intolerable to all generous natures.

But whatever prejudice might thus operate against the perfect sanctity of Shakspeare's posthumous reputation, it is certain that the splendour of his worldly success must have done much to obliterate that effect; his admirable colloquial talents a good deal, and his gracious affability still more. The wonder therefore will still remain, that Betterton, in less than a century from his death, should have been able to glean so little. And for the solution of this wonder we must throw ourselves chiefly upon the explanations we have made as to the parliamentary war, and the local ravages of its progress in the very district, of the very town, and the very house.

If further arguments are still wanted to explain this mysterious abolition, we may refer the reader to the following succession of disastrous events, by which it should seem that a perfect malice of misfortune pursued the vestiges of the mighty poet's steps. In 1613, the Globe theatre, with which he had been so long connected, was burned to the ground. Soon afterwards a great fire occurred in Stratford; and next (without counting upon the fire of London, just fifty years after his death, which, however, would consume many an important record from periods far more remote), the house of Ben Jonson, in which probably, as Mr Campbell suggests, might be parts of his correspondence, was also burned. Finally, there was an old tradition that Lady Barnard, the sole grand-daughter of Shakspeare, had carried off many of his papers from Stratford; and these papers have never since been traced.

In many of the elder lives it has been asserted, that John Shakspeare, the father of the poet, was a butcher, and in others that he was a woolstapler. It is now settled beyond dispute that he was a glover. This was his professed occupation in Stratford, though it is certain that, with this leading trade, from which he took his denomination, he combined some collateral pursuits; and it is possible enough that, as openings offered, he may have meddled with many. In that age, and in a provincial town, nothing like the exquisite subdivision of labour was attempted which we now see realized in the great cities of Christendom. And one trade is often found to play into another with so much reciprocal advantage, that even in our own days we do not much wonder at an enterprising man, in country places, who combines several in his own person. Accordingly John Shakspeare is known to have united with his town calling the rural and miscellaneous occupations of a farmer.

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[1] In fact, by way of representing to himself the system or scheme of the English roads, the reader has only to imagine one great letter X, or a St Andrew's cross, laid down from north to south, and decussating at Birmingham. Even Coventry, which makes a slight variation for one or two roads, and so far disturbs this decussation, by shifting it eastwards, is still in Warwickshire.

Meantime his avowed business stood upon a very different footing from the same trade as it is exercised in modern times. Gloves were in that age an article of dress more costly by much, and more elaborately decorated, than in our own. They were a customary present from some cities to the judges of assize, and to other official persons; a custom of ancient standing, and in some places, we believe, still subsisting; and in such cases it is reasonable to suppose that the gloves must originally have been more valuable than the trivial modern article of the same name. So also, perhaps, in their origin, of the gloves given at funerals. In reality, whenever the simplicity of an age makes it difficult to renew the parts of a wardrobe except in capital towns of difficult access, prudence suggests that such wares should be manufactured of more durable materials; and, being so, they become obviously susceptible of more lavish ornament. But it will not follow, from this essential difference in the gloves of Shakspeare's age, that the glover's occupation was more lucrative. Doubtless he sold more costly gloves, and upon each pair had a larger profit; but for that very reason he sold fewer. Two or three gentlemen "of worship" in the neighbourhood might occasionally require a pair of gloves, but it is very doubtful whether any inhabitant of Stratford would ever call for so mere a luxury.

The practical result, at all events, of John Shakspeare's various pursuits does not appear permanently to have met the demands of his establishment; and in his maturer years there are indications still surviving that he was under a cloud of embarrassment. He certainly lost at one time his social position in the town of Stratford; but there is a strong presumption, in *our* construction of the case, that he finally retrieved it; and for this retrieval of a station which he had forfeited by personal misfortunes or neglect, he was altogether indebted to the filial piety of his immortal son.

Meantime the earlier years of the elder Shakspeare wore the aspect of rising prosperity, however unsound might be the basis on which it rested. There can be little doubt that William Shakspeare, from his birth up to his tenth or perhaps his eleventh year, lived in careless plenty, and saw nothing in his father's house but that style of liberal housekeeping which has ever distinguished the upper yeomanry and the rural gentry of England. Probable enough it is that the resources for meeting this liberality were not strictly commensurate with the family income, but were sometimes allowed to entrench, by means of loans or mortgages, upon capital funds. The stress upon the family finances was perhaps at times severe; and that it was borne at all, must be imputed to the large and even splendid portion which John Shakspeare received with his wife.

This lady, for such she really was in an eminent sense, by birth as well as by connections, bore the beautiful name of Mary Arden, a name derived from the ancient forest district[1] of the county; and doubtless she merits a more elaborate notice than our slender materials will furnish. To have been *the mother of Shakspeare*,—how august a title to the reverence of infinite generations, and of centuries beyond the vision of prophecy. A plausible hypothesis has been started in modern times, that the facial structure, and that the intellectual conformation, may be deduced more frequently from the corresponding characteristics in the mother than in the father. It is certain that no very great man has ever existed, but that his greatness has been rehearsed and predicted in one or other of his parents. And it cannot be denied, that in the most eminent men, where we have had the means of pursuing the investigation, the mother has more frequently been repeated and reproduced than the father. We have known cases where the mother has furnished all the intellect, and the father all the moral sensibility; upon which assumption, the wonder ceases that Cicero, Lord Chesterfield, and other brilliant men, who took the utmost pains with their sons, should have failed so conspicuously; for possibly the mothers had been women of excessive and even exemplary stupidity. In the case of Shakspeare, each parent, if we had any means of recovering their characteristics, could not fail to furnish a study of the most profound interest; and with regard to his mother in particular, if the modern hypothesis be true, and if we are indeed to deduce from *her* the stupendous intellect of her son, in that case she must have been a benefactress to her husband's family beyond the promises of fairyland or the dreams of romance; for it is certain that to her chiefly this family was also indebted for their worldly comfort.

Mary Arden was the youngest daughter and the heiress of Robert Arden of Wilmecote, Esq. in the county of Warwick. The family of Arden was even then of great antiquity. About one century and a quarter before the birth of William Shakspeare, a person bearing the same name as his maternal grandfather had been returned by the commissioners in their list of the Warwickshire gentry; he was there styled Robert Arden, Esq. of Bromich. This was in 1433, or the 12th year of Henry VI. In Henry VII.'s reign, the Ardens received a grant of lands from the crown; and in 1568, four years after the birth of William Shakspeare, Edward Arden, of the same family, was sheriff of the county. Mary Arden was therefore a young lady of excellent descent and connections, and an heiress of considerable wealth. She brought to her husband, as her marriage portion, the landed estate of Asbies, which, upon any just valuation, must be considered as a handsome dowry for a woman of her station. As this point has been contested, and as it goes a great way towards determining the exact social position of the poet's parents, let us be excused for sifting it a little more narrowly than might else seem warranted by the proportions of our present life. Every question which it can be reasonable to raise at all, it must be reasonable to treat with at least so much of minute research as may justify the conclusions which it is made to support.

The estate of Asbies contained fifty acres of arable land, six of meadow, and a right of commonage. What may we assume to have been the value of its fee-simple? Malone, who allows the total fortune of Mary Arden to have been L.110. 13s. 4d., is sure that the value of Asbies could not have been more than one hundred pounds. But why? Because, says he, the "average" rent of land at that time was no more than three shillings per acre. This we deny; but upon that assumption, the total yearly rent of fifty-six acres would be exactly eight guineas.[1] And therefore, in assigning the value of Asbies at one hundred pounds, it appears that Malone must have estimated the land at no more than twelve years' purchase, which would carry the value to L.100. 16s. "Even at this estimate," as the latest annotator[2] on this subject *justly* observes, "Mary Arden's portion was a larger one than was usually given to a landed gentleman's daughter." But this writer objects to Malone's principle of valuation. "We find," says he, "that John Shakspeare also farmed the meadow of Tugton, containing sixteen acres, at the rate of eleven shillings per acre. Now what proof has Mr Malone adduced that the acres of Asbies were not as valuable as those of Tugton? And if they were so, the former estate must have been worth between three and four hundred pounds." In the main drift of his objections we concur with Mr Campbell. But as they are liable to some criticism, let us clear the ground of all plausible cavils, and then see what will be the result. Malone, had he been alive, would probably have answered, that Tugton was a farm specially privileged by nature; and that if any man contended for so unusual a rent as eleven shillings an acre for land not known to him, the *onus probandi* would lie upon *him*. Be it so; eleven shillings is certainly above the ordinary level of rent, but three shillings is below it. We contend, that for tolerably good land, situated advantageously, that is, with a ready access to good markets and good fairs, such as those of Coventry, Birmingham, Gloucester, Worcester, Shrewsbury, &c., one noble might be assumed as the annual rent; and that in such situations twenty years' purchase was not a valuation, even in Elizabeth's reign, very unusual. Let us, however, assume the rent at only five shillings, and land at sixteen years' purchase: upon this basis, the rent would be L.14, and the value of the fee-simple L.224. Now, if it were required to equate that sum with its present value, a very operose[3] calculation might be requisite. But contenting ourselves with the gross method of making such equations between 1560 and the current century, that is, multiplying by five, we shall find the capital value of the estate to be eleven hundred and twenty pounds, whilst the annual rent would be exactly seventy. But if the estate had been sold, and the purchase-money lent upon mortgage (the only safe mode of investing money at that time), the annual interest would have reached L.28, equal to L.140 of modern money; for mortgages in Elizabeth's age readily produced ten per cent.

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[1] And probably so called by some remote ancestor who had emigrated from the forest of Ardennes, in the Netherlands, and *now* for ever memorable to English ears from its proximity to Waterloo.

A woman who should bring at this day an annual income of L.140 to a provincial tradesman, living in a sort of *rus in urbe*, according to the simple fashions of rustic life, would assuredly be considered as an excellent match. And there can be little doubt that Mary Arden's dowry it was which, for some ten or a dozen years succeeding to his marriage, raised her husband to so much social consideration in Stratford. In 1550 John Shakspeare is supposed to have first settled in Stratford, having migrated from some other part of Warwickshire. In 1557 he married Mary Arden; in 1565, the year subsequent to the birth of his son William, his third child, he was elected one of the aldermen; and in the year 1568 he became first magistrate of the town, by the title of high bailiff. This year we may assume to have been that in which the prosperity of this family reached its zenith; for in this year it was, over and above the presumptions furnished by his civic honours, that he obtained a grant of arms from Clarencieux of the Heralds' College. On this occasion he declared himself worth five hundred pounds derived from his ancestors. And we really cannot understand the right by which critics, living nearly three centuries from his time, undertake to know his affairs better than himself, and to tax him with either inaccuracy or falsehood. No man would be at leisure to court heraldic honours when he knew himself to be embarrassed, or apprehended that he soon might be so. A man whose anxieties had been fixed at all upon his daily livelihood would, by this chase after the aërial honours of heraldry, have made himself a butt for ridicule such as no fortitude could enable him to sustain.

In 1568, therefore, when his son William would be moving through his fifth year, John Shakspeare (now honoured by the designation of *Master*) would be found at times in the society of the neighbouring gentry. Ten years in advance of this period he was already in difficulties. But there is no proof that these difficulties had then reached a point of degradation, or of memorable distress. The sole positive indications of his decaying condition are, that in 1578 he received an exemption from the small weekly assessment levied upon the aldermen of Stratford for the relief of the poor; and that in the following year, 1579, he is found enrolled amongst the defaulters in the payment of taxes. The latter fact undoubtedly goes to prove that, like every man who is falling back in the world, he was occasionally in arrears. Paying taxes is not like the honours awarded or the processions regulated by Clarencieux; no man is ambitious of precedency there; and if a laggard pace in that duty is to be received as evidence of pauperism, nine tenths of the English people might occasionally be classed as paupers. With respect to his liberation from the weekly assessment, that may bear a construction different from the one which it has received. This payment, which could never have been regarded as a burthen, not amounting to five pounds annually of our present money, may have been held up as an exponent of wealth and consideration; and John Shakspeare may have been required to resign it as an honourable distinction, not suitable to the circumstances of an embarrassed man. Finally, the fact of his being indebted to Robert Sadler, a baker, in the sum of five pounds, and his being under the necessity of bringing a friend as security for the payment, proves nothing at

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[1] Let not the reader impute to us the gross anachronism of making an estimate for Shakspeare's days in a coin which did not exist until a century, within a couple of years, after Shakspeare's birth, and did not settle to the value of twenty-one shillings until a century after his death. The nerve of such an anachronism would lie in putting the estimate into a mouth of that age. And this is precisely the blunder into which the foolish forger of Vortigern, &c. has fallen. He does not indeed directly mention guineas; but indirectly and virtually he does, by repeatedly giving us accounts imputed to Shakspearian contemporaries, in which the sum-total amounts to L.5. 5s.; or to L.26. 5s.; or, again, to L.17. 17s. 6d. A man is careful to subscribe L.14. 14s. and so forth. But how could such amounts have arisen unless under a secret reference to guineas, which were not in existence until Charles II.'s reign; and, moreover, to guineas at their final settlement by law into twenty-one shillings each, which did not take place until George I.'s reign.

[2] Thomas Campbell the poet, in his eloquent Remarks on the Life and Writings of William Shakspeare, prefixed to a popular edition of the poet's dramatic works. London, 1838.

[3] After all the assistance given to such equations between different times or different places by Sir George Shuckborough's tables, and other similar investigations, it is still a very difficult problem, complex, and, after all, merely tentative in the results, to assign the true value in such cases; not only for the obvious reason, that the powers of money have varied in different directions with regard to different objects, and in different degrees where the direction has on the whole continued the same, but because the very objects to be taken into computation are so indeterminate, and vary so much, not only as regards century and century, kingdom and kingdom, but also, even in the same century and the same kingdom, as regards rank and rank. That which is a mere necessary to one, is a luxurious superfluity to another. And, in order to ascertain these differences, it is an indispensable qualification to have studied the habits and customs of the several classes concerned, together with the variations of those habits and customs.

all. There is not a town in Europe in which opulent men cannot be found that are backward in the payment of their debts. And the probability is, that Master Sadler acted like most people who, when they suppose a man to be going down in the world, feel their respect for him sensibly decaying, and think it wise to trample him under foot, provided only in that act of trampling they can squeeze out of him their own individual debt. Like that terrific chorus in Spohr's oratorio of St Paul, "*stone him to death*" is the cry of the selfish and the illiberal amongst creditors, alike towards the just and the unjust amongst debtors.

It was the wise and beautiful prayer of Agar, "Give me neither poverty nor riches;" and, doubtless, for quiet, for peace, and the *latentis semita vitæ*, that is the happiest dispensation. But, perhaps, with a view to a school of discipline and of moral fortitude, it might be a more salutary prayer, "Give me riches *and* poverty, and afterwards neither." For the transitional state between riches and poverty will teach a lesson both as to the baseness and the goodness of human nature, and will impress that lesson with a searching force, such as no borrowed experience ever can approach. Most probable it is that Shakspeare drew some of his powerful scenes in the Timon of Athens, those which exhibit the vileness of ingratitude and the impassioned frenzy of misanthropy, from his personal recollections connected with the case of his own father. Possibly, though a cloud of 270 years now veils it, this very Master Sadler, who was so urgent for his five pounds, and who so little apprehended that he should be called over the coals for it in the Encyclopædia Britannica, may have sate for the portrait of that Lucullus who says of Timon—

> Alas, good lord! a noble gentleman 'tis, if he would not keep so good a house. Many a time and often I have dined with him, and told him on't; and come again to supper to him, of purpose to have him spend less: and yet he would embrace no counsel, take no warning by my coming. Every man has his fault, and honesty is his; I have told him on't, but I could never get him from it.

For certain years, perhaps, John Shakspeare moved on in darkness and sorrow:

> His familiars from his buried fortunes
> Slunk all away; left their false vows with him,
> Like empty purses pick'd: and his poor self,
> A dedicated beggar to the air,
> With his disease of all-shunn'd poverty,
> Walk'd, like contempt, alone.

We, however, at this day are chiefly interested in the case as it bears upon the education and youthful happiness of the poet. Now if we suppose that from 1568, the high noon of the family prosperity, to 1578, the first year of their mature embarrassments, one half the interval was passed in stationary sunshine, and the latter half in the gradual twilight of declension, it will follow that the young William had completed his tenth year before he heard the first signals of distress; and for so long a period his education would probably be conducted on as liberal a scale as the resources of Stratford would allow. Through this earliest section of his life he would undoubtedly rank as a gentleman's son, possibly as the leader of his class, in Stratford. But what rank he held through the next ten years, or, more generally, what was the standing in society of Shakspeare until he had created a new station for himself by his own exertions in the metropolis, is a question yet unsettled, but which has been debated as keenly as if it had some great dependencies. Upon this we shall observe, that could we by possibility be called to settle beforehand what rank were best for favouring the development of intellectual powers, the question might wear a face of deep practical importance; but when the question is simply as to a matter of fact, what *was* the rank held by a man whose intellectual development has long ago been completed, this becomes a mere question of curiosity. The tree has fallen; it is confessedly the noblest of all the forest; and we must therefore conclude that the soil in which it flourished was either the best possible, or, if not so, that any thing bad in its properties had been disarmed and neutralized by the vital forces of the plant, or by the benignity of nature. If any future Shakspeare were likely to arise, it might be a problem of great interest to agitate, whether the condition of a poor man or of a gentleman were best fitted to nurse and stimulate his faculties. But for the actual Shakspeare, since what he was he was, and since nothing greater can be imagined, it is now become a matter of little moment whether his course lay for fifteen or twenty years through the humilities of absolute poverty, or through the chequered paths of gentry lying in the shade. Whatever *was*, must, in this case at least, have been the best, since it terminated in producing Shakspeare; and thus far we must all be optimists.

Yet still, it will be urged, the curiosity is not illiberal which would seek to ascertain the precise career through which Shakspeare ran. This we readily concede; and we are anxious ourselves to contribute any thing in our power to the settlement of a point so obscure. What we have wished to protest against is the spirit of partisanship in which this question has too generally been discussed. For, whilst some with a foolish affectation of plebeian sympathies overwhelm us with the insipid commonplaces about birth and ancient descent, as honours containing nothing meritorious, and rush eagerly into an ostentatious exhibition of all the circumstances which favour the notion of a humble station and humble connections; others, with equal forgetfulness of true dignity, plead with the intemperance and partiality of a legal advocate for the pretensions of Shakspeare to the hereditary rank of gentleman. Both parties violate the majesty of the subject. When we are seeking for the sources of the Euphrates or the St Lawrence, we look for no proportions to the mighty volume of waters in that particular summit amongst the chain of mountains which embosoms its earliest fountains, nor are we shocked at the obscurity of these fountains. Pursuing the career of Mahommed, or of any man who has memorably impressed his own mind or agency upon the revolutions of mankind, we feel solicitude about the circumstances which might surround his cradle to be altogether unseasonable and impertinent. Whether he were born in a hovel or a palace, whether he passed his infancy in squalid poverty, or hedged around by the glittering spears of body-guards, as mere questions of fact may be interesting; but, in the light of either accessories or counteragencies to the native majesty of the subject, are trivial and below all philosophic valuation. So with regard to the creator of Lear and Hamlet, of Othello and Macbeth; to him from whose golden urns the nations beyond the far Atlantic, the multitude of the isles, and the generations unborn in Australian climes, even to the realms ot the rising sun (the ἀνατολαι ἠελιοιο), must in every age draw perennial streams of intellectual life, we feel that the little accidents of birth and social condition are so unspeakably below the grandeur of the theme, are so irrelevant and disproportioned to the real interest at issue, so incommensurable with any of its relations, that a biographer of Shakspeare at once denounces himself as below his subject if he can entertain such a question as seriously affecting the glory of the poet. In some legends of saints, we find that they were born with a lambent circle or golden aureola about their heads. This angelic coronet shed light alike upon the chambers of a cottage or a palace, upon the gloomy limits of a dungeon or the vast expansion of a cathedral; but the cottage, the palace, the dungeon, the cathedral, were all equally incapable of adding one ray of colour or one pencil of light to the supernatural halo.

Having therefore thus pointedly guarded ourselves from misconstruction, and consenting to entertain the question as one in which we, the worshippers of Shakspeare, have an interest of curiosity, but in which he, the object of our worship, has no interest of glory, we proceed to state what appears to us the result of the scanty facts surviving when collated with each other.

By his mother's side, Shakspeare was an authentic gentleman. By his father's he would have stood in a more dubious position; but the effect of municipal honours to raise and illustrate an equivocal rank has always been acknowledged under the popular tendencies of our English political system. From the sort of lead, therefore, which John Shakspeare took at one time amongst his fellow-townsmen, and from his rank of first magistrate, we may presume that, about the year 1568, he had placed himself at the head of the Stratford community. Afterwards he continued for some years to descend from this altitude; and the question is, at what point this gradual degradation may be supposed to have settled. Now we shall avow it as our opinion, that the composition of society in Stratford was such that, even had the Shakspeare family maintained their superiority, the main body of their daily associates must still have been found amongst persons below the rank of gentry. The poet must inevitably have mixed chiefly with mechanics and humble tradesmen, for such people composed perhaps the total community. But had there even been a gentry in Stratford, since they would have marked the distinctions of their rank chiefly by greater reserve of manners, it is probable that, after all, Shakspeare, with his enormity of delight in exhibitions of human nature, would have mostly cultivated that class of society in which the feelings are more elementary and simple, in which the thoughts speak a plainer language, and in which the restraints of factitious or conventional decorum are exchanged for the restraints of mere sexual decency. It is a noticeable fact to all who have looked upon human life with an eye of strict attention, that the abstract image of womanhood, in its loveliness, its delicacy, and its modesty, nowhere makes itself more impressive or more advantageously felt than in the humblest cottages, because it is there brought into immediate juxtaposition with the grossness of manners and the careless license of language incident to the fathers and brothers of the house. And this is more especially true in a nation of unaffected sexual gallantry,[1] such as the English and the Gothic races in general; since, under the immunity which their women enjoy from all servile labours of a coarse or out-of-doors order, by as much lower as they descend in the scale of rank, by so much more do they benefit under the force of contrast with the men of their own level. A young man of that class, however noble in appearance, is somewhat degraded in the eyes of women, by the necessity which his indigence imposes of working under a master; but a beautiful young woman, in the very poorest family, unless she enters upon a life of domestic servitude (in which case her labours are light, suited to her sex, and withdrawn from the public eye), so long in fact as she stays under her father's roof, is as perfectly her own mistress and *sui juris* as the daughter of an earl. This personal dignity, brought into stronger relief by the mercenary employments of her male connections, and the feminine gentleness of her voice and manners, exhibited under the same advantages of contrast, oftentimes combine to make a young cottage beauty as fascinating an object as any woman of any station.

Hence we may in part account for the great event of Shakspeare's early manhood, his premature marriage. It has always been known, or at least traditionally received for a fact, that Shakspeare had married whilst yet a boy; and that his wife was unaccountably older than himself. In the very earliest biographical sketch of the poet, compiled by Rowe, from materials collected by Betterton the actor, it was stated (and that statement is now ascertained to have been correct), that he had married Anne Hathaway, "the daughter of a substantial yeoman." Further than this nothing was known. But in September 1836 was published a very remarkable document, which gives the assurance of law to the time and fact of this event, yet still, unless collated with another record, does nothing to lessen the mystery which had previously surrounded its circumstances. This document consists of two parts: the first, and principal, according to the logic of the case, though second according to the arrangement, being a *license* for the marriage of William Shakspeare with Anne Hathaway, under the condition "of *once* asking of the bannes of matrimony," that is, in effect, dispensing with two out of the three customary askings; the second or subordinate part of the document being a *bond* entered into by two sureties, viz. Fulke Sandells and John Rychardson, both described as *agricolæ* or yeomen, and both marksmen (that is, incapable of writing, and therefore subscribing by means of *marks*), for the payment of forty pounds sterling, in the event of Shakspeare, yet a minor, and incapable of binding himself, failing to fulfil the conditions of the license. In the bond, drawn up in Latin, there is no mention of Shakspeare's name; but in the license, which is altogether English, *his* name, of course, stands foremost; and as it may gratify the reader to see the very words and orthography of the original, we here extract the *operative* part of this document, prefacing only, that the license is attached by way of explanation to the bond. "The condition of this obligation is suche, that if herafter there shall not appere any lawfull lett or impediment, by reason of any precontract, &c., but that Willm. Shagspere, one thone ptie" [on the one party), "and Anne Hathwey of Stratford, in the diocess of Worcester, maiden, may lawfully solemnize matrimony together; and in the same afterwards remaine and continew like man and wiffe. And, moreover, if the said Willm. Shagspere do not proceed to solemnization of mariadg with the said Anne Hathwey, without the consent of hir frinds;—then the said obligation" [viz. to pay forty pounds] "to be voyd and of none effect, or els to stand & abide in full force and vertue."

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[1] Never was the *esse quam videri* in any point more strongly discriminated than in this very point of gallantry to the female sex, as between England and France. In France, the verbal homage to woman is so excessive as to betray its real purpose, viz. that it is a mask for secret contempt. In England, little is *said*; but, in the mean time, we allow our sovereign ruler to be a woman; which in France is impossible. Even that fact is of some importance, but less so than what follows. In every country whatsoever, if any principle has a deep root in the moral feelings of the people, we may rely upon its showing itself, by a thousand evidences, amongst the very lowest ranks, and in their daily intercourse, and their *undress* manners. Now in England there is, and always has been, a manly feeling, most widely diffused, of unwillingness to see labours of a coarse order, or requiring muscular exertions, thrown upon women. Pauperism, amongst other evil effects, has sometimes locally disturbed this predominating sentiment of Englishmen; but never at any time with such depth as to kill the root of the old hereditary manliness. Sometimes at this day a gentleman, either from carelessness, or from over-ruling force of convenience, or from real defect of gallantry, will allow a female servant to carry his portmanteau for him; though, after all, that spectacle is a rare one. And everywhere women of all ages engage in the pleasant, nay elegant, labours of the hay field; but in Great Britain women are never suffered to mow, which is a most athletic and exhausting labour, nor to load a cart, nor to drive a plough or hold it. In France, on the other hand, before the Revolution (at which period the pseudo-homage, the lip-honour, was far more ostentatiously professed towards the female sex than at present), a Frenchman of credit, and vouching for his statement by the whole weight of his name and personal responsibility (M. Simond, now an American citizen), records the following abominable scene as one of no uncommon occurrence: A woman was in some provinces yoked side by side with an ass to the plough or the harrow; and M. Simond protests that it excited no horror to see the driver distributing his lashes impartially between the woman and her brute yoke-fellow. So much for the wordy pomps of French gallantry. In England, we trust, and we believe, that any man, caught in such a situation, and in such an abuse of his power (supposing the case otherwise a possible one), would be killed on the spot.

What are we to think of this document? Trepidation and anxiety are written upon its face. The parties are not to be married by a special license; not even by an ordinary license; in that case no proclamation of banns, no public asking at all, would have been requisite. Economical scruples are consulted; and yet the regular movement of the marriage "through the bell-ropes"[1] is disturbed. Economy, which retards the marriage, is here evidently in collision with some opposite principle which precipitates it. How is all this to be explained? Much light is afforded by the date when illustrated by another document. The bond bears date on the 28th day of November in the 25th year of our lady the queen, that is, in 1582. Now the baptism of Shakspeare's eldest child, Susanna, is registered on the 26th of May in the year following. Suppose, therefore, that his marriage was solemnized on the 1st day of December; it was barely possible that it could be earlier, considering that the sureties, drinking, perhaps, at Worcester throughout the 28th of November, would require the 29th, in so dreary a season, for their return to Stratford; after which some preparation might be requisite to the bride, since the marriage was *not* celebrated at Stratford. Next suppose the birth of Miss Susanna to have occurred, like her father's, two days before her baptism, viz. on the 24th of May. From December the 1st to May the 24th, both days inclusively, are 175 days; which, divided by seven, gives precisely twenty-five weeks, that is to say, six months short by one week. Oh, fie, Miss Susanna, you came rather before you were wanted.

Mr Campbell's comment upon the affair is, that "*if* this was the case," viz. if the baptism were really solemnized on the 26th of May, "the poet's first child would *appear* to have been born only six months and eleven days after the bond was entered into." And he then concludes that, on this assumption, "Miss Susanna Shakspeare came into the world a little prematurely." But this is to doubt where there never was any ground for doubting; the baptism was *certainly* on the 26th of May; and, in the next place, the calculation of six months and eleven days is sustained by substituting lunar months for calendar, and then only by supposing the marriage to have been celebrated on the very day of subscribing the bond in Worcester, and the baptism to have been coincident with the birth; of which suppositions the latter is improbable, and the former, considering the situation of Worcester, impossible.

Strange it is, that, whilst all biographers have worked with so much zeal upon the most barren dates or most baseless traditions in the great poet's life, realising in a manner the chimeras of Laputa, and endeavouring "to extract sunbeams from cucumbers," such a story with regard to such an event, no fiction of village scandal, but involved in legal documents, a story so significant and so eloquent to the intelligent, should formerly have been dismissed without notice of any kind, and even now, after the discovery of 1836, with nothing beyond a slight conjectural insinuation. For our parts, we should have been the last amongst the biographers to unearth any forgotten scandal, or, after so vast a lapse of time, and when the grave had shut out all but charitable thoughts, to point any moral censures at a simple case of natural frailty, youthful precipitancy of passion, of all trespasses the most venial, where the final intentions are honourable. But in this case there seems to have been something more in motion than passion or the ardour of youth. "I like not," says Parson Evans (alluding to Falstaff in masquerade), "I like not when a woman has a great peard; I spy a great peard under her muffler." Neither do we like the spectacle of a mature young woman, five years past her majority, wearing the semblance of having been led astray by a boy who had still two years and a half to run of his minority. Shakspeare himself, looking back on this part of his youthful history from his maturest years, breathes forth pathetic counsels against the errors into which his own inexperience had been ensnared. The disparity of years between himself and his wife he notices in a beautiful scene of the Twelfth Night. The Duke Orsino, observing the sensibility which the pretended Cesario had betrayed on hearing some touching old snatches of a love strain, swears that his beardless page must have felt the passion of love, which the other admits. Upon this the dialogue proceeds thus:

Duke. What kind of woman is't?
Viola. Of your complexion.
Duke. She is not worth thee then:—What years?
Viola. I' faith,
About your years, my lord.
Duke. Too old, by heaven. *Let still the woman take*
An elder than herself: so wears she to him,
So sways she level in her husband's heart.
For, boy, however we do praise ourselves,
Our fancies are more giddy and unfirm,
More longing, wavering, sooner lost and worn,
Than women's are.
Viola. I think it well, my lord.
Duke. Then *let thy love be younger than thyself,*
Or thy affection cannot hold the bent;
For women are as roses, whose fair flower,
Being once display'd, doth fall that very hour.

These counsels were uttered nearly twenty years after the event in his own life to which they probably look back; for this play is supposed to have been written in Shakspeare's thirty-eighth year. And we may read an earnestness in pressing the point as to the *inverted* disparity of years, which indicates pretty clearly an appeal to the lessons of his personal experience. But his other indiscretion, in having yielded so far to passion and opportunity as to crop by prelibation, and before they were hallowed, those flowers of paradise which belonged to his marriage-day; this he adverts to with even more solemnity of sorrow, and with more pointed energy of moral reproof, in the very last drama which is supposed to have proceeded from his pen, and therefore with the force and sanctity of testamentary counsel. The Tempest is all but ascertained to have been composed in 1611, that is, about five years before the poet's death; and indeed could not have been composed much earlier; for the very incident which suggested the basis of the plot, and of the local scene, viz. the shipwreck of Sir George Somers on the Bermudas (which were in consequence denominated the Somers' Islands), did not occur until the year 1609. In the opening of the fourth act, Prospero formally betrothes his daughter to Ferdinand; and in doing so he pays the prince a well-merited compliment of having "worthily purchas'd" this rich jewel, by the patience with which, for her sake, he had supported harsh usage, and other painful circumstances of his trial. But, he adds solemnly,

If thou dost break her virgin knot before
All sanctimonious ceremonies may
With full and holy rite be minister'd;

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[1] Amongst people of humble rank in England, who only were ever asked in church, until the new-fangled systems of marriage came up within the last ten or fifteen years, during the currency of the three Sundays on which the banns were proclaimed by the clergyman from the reading desk, the young couple elect were said jocosely to be "hanging in the bell-ropes;" alluding perhaps to the joyous peal contingent on the final completion of the marriage.

in that case what would follow?

> No sweet aspersion shall the heavens let fall,
> To make this contract grow; *but barren hate,*
> *Sour-ey'd disdain and discord, shall bestrew*
> *The union of your bed with weeds so loathly*
> *That you shall hate it both.* Therefore take heed,
> As Hymen's lamps shall light you.

The young prince assures him in reply, that no strength of opportunity, concurring with the uttermost temptation, not

> the murkiest den,
> The most opportune place, the strong'st suggestion
> Our worser genius can———

should ever prevail to lay asleep his jealousy of self-control, so as to take any advantage of Miranda's innocence. And he adds an argument for this abstinence, by way of reminding Prospero, that not honour only, but even prudential care of his own happiness, is interested in the observance of his promise. Any unhallowed anticipation would, as he insinuates,

> take away
> The edge of that day's celebration,
> When I shall think, or Phœbus' steeds are founder'd,
> Or night kept chain'd below;

that is, when even the winged hours would seem to move too slowly. Even thus Prospero is not quite satisfied: during his subsequent dialogue with Ariel, we are to suppose that Ferdinand, in conversing apart with Miranda, betrays more impassioned ardour than the wise magician altogether approves. The prince's caresses have not been unobserved; and thus Prospero renews his warning:

> Look thou be true: do not give dalliance
> Too much the rein: the strongest oaths are straw
> To the fire i' the blood: be more abstemious,
> Or else—good night your vow.

The royal lover re-assures him of his loyalty to his engagements; and again the wise father, so honourably jealous for his daughter, professes himself satisfied with the prince's pledges.

Now in all these emphatic warnings, uttering the language "of that sad wisdom folly leaves behind," who can avoid reading, as in subtile hieroglyphics, the secret record of Shakspeare's own nuptial disappointments? We, indeed, that is, universal posterity through every age, have reason to rejoice in these disappointments; for to them, past all doubt, we are indebted for Shakspeare's subsequent migration to London, and his public occupation, which, giving him a deep pecuniary interest in the productions of his pen, such as no other literary application of his powers could have approached in that day, were eventually the means of drawing forth those divine works which have survived their author for our everlasting benefit.

Our own reading and deciphering of the whole case is as follows. The Shakspeares were a handsome family, both father and sons. This we assume upon the following grounds: First, on the presumption arising out of John Shakspeare's having won the favour of a young heiress higher in rank than himself; secondly, on the presumption involved in the fact of three amongst his four sons having gone upon the stage, to which the most obvious (and perhaps in those days a *sine qua non*) recommendation would be a good person and a pleasing countenance; thirdly, on the direct evidence of Aubrey, who assures us that William Shakspeare was a handsome and a well-shaped man; fourthly, on the implicit evidence of the Stratford monument, which exhibits a man of good figure and noble countenance; fifthly, on the confirmation of this evidence by the Chandos portrait, which exhibits noble features, illustrated by the utmost sweetness of expression; sixthly, on the selection of theatrical parts, which it is known that Shakspeare personated, most of them being such as required some dignity of form, viz. kings, the athletic (though aged) follower of an athletic young man, and supernatural beings. On these grounds, direct or circumstantial, we believe ourselves warranted in assuming that William Shakspeare was a handsome and even noble-looking boy. Miss Anne Hathaway had herself probably some personal attractions; and, if an indigent girl, who looked for no pecuniary advantages, would probably have been early sought in marriage. But as the daughter of "a substantial yeoman," who would expect some fortune in his daughter's suitors, she had, to speak coarsely, a little outlived her market. Time she had none to lose. William Shakspeare pleased her eye; and the gentleness of his nature made him an apt subject for female blandishments, possibly for female arts. Without imputing, however, to this Anne Hathaway any thing so hateful as a settled plot for ensnaring him, it was easy enough for a mature woman, armed with such inevitable advantages of experience and of self-possession, to draw onward a blushing novice; and, without directly creating opportunities, to place him in the way of turning to account such as naturally offered. Young boys are generally flattered by the condescending notice of grown-up women; and perhaps Shakspeare's own lines upon a similar situation, to a young boy adorned with the same natural gifts as himself, may give us the key to the result:

> Gentle thou art, and therefore to be won;
> Beauteous thou art, therefore to be assail'd;
> And, when a woman woos, what woman's son
> Will sourly leave her till he have prevail'd?

Once, indeed, entangled in such a pursuit, any person of manly feelings would be sensible that he had no retreat: *that* would be—to insult a woman, grievously to wound her sexual pride, and to insure her lasting scorn and hatred. These were consequences which the gentle-minded Shakspeare could not face: he pursued his good fortunes, half perhaps in heedlessness, half in desperation, until he was roused by the clamorous displeasure of her family upon first discovering the situation of their kinswoman. For such a situation there could be but one atonement, and that was hurried forward by both parties; whilst, out of delicacy towards the bride, the wedding was not celebrated in Stratford (where the register contains no notice of such an event); nor, as Malone imagined, in Weston-upon-Avon, that being in the diocese of Gloucester; but in some parish, as yet undiscovered, in the diocese of Worcester.

But now arose a serious question as to the future maintenance of the young people. John Shakspeare was depressed in his circumstances, and he had other children besides William, viz. three sons and a daughter. The elder lives have represented him as burdened with ten; but this was an error, arising out of the confusion between John Shakspeare the glover and John Shakspeare a shoemaker. This error has been thus far of use, that, by exposing the fact of two John Shakspeares (not kinsmen) residing in Stratford-upon-Avon, it has satisfactorily proved the name to be amongst those which are locally indigenous to Warwickshire. Meantime it is now ascertained that John Shakspeare the glover had only eight children, viz. four daughters and four sons. The order of their succession was this: Joan, Margaret, WILLIAM, Gilbert, a second Joan, Anne, Richard, and Edmund. Three of the daughters, viz. the two eldest of the family, Joan and Margaret, together with Anne, died in childhood: all the rest attained mature ages, and of these William was the eldest. This might give him some advantage in his father's regard; but in a question of pecuniary provision precedency amongst the children of an insolvent is nearly nominal. For the present John Shakspeare could do little for his son; and, under these circumstances, perhaps the father of Anne Hathaway would come forward to assist the new-married couple. This condition of dependency would furnish matter for painful feelings and irritating words: the youthful husband, whose mind would be expanding as rapidly as the leaves and blossoms of spring-time in polar latitudes, would soon come to appreciate the sort of wiles by which he had been caught. The female mind is quick, and almost gifted with the power of witchcraft, to decipher what is passing in the thoughts of familiar companions. Silent and forbearing as William Shakspeare might be, Anne, his staid wife, would read his secret reproaches; ill would she dissemble her wrath, and the less so from the consciousness of having deserved them. It is no uncommon case for women to feel anger in connection with one subject, and to express it in connection with another; which other, perhaps (except as a serviceable mask), would have been a matter of indifference to their feelings. Anne would therefore reply to those inevitable reproaches which her own sense must presume to be lurking in her husband's heart, by others equally stinging, on his inability to support his family, and on his obligations to her father's purse. Shakspeare, we may be sure, would be ruminating every hour on the means of his deliverance from so painful a dependency; and at length, after four years' conjugal discord, he would resolve upon that plan of solitary emigration to the metropolis, which, at the same time that it released him from the humiliation of domestic feuds, succeeded so splendidly for his worldly prosperity, and with a train of consequences so vast for all future ages.

Such, we are persuaded, was the real course of Shakspeare's transition from school-boy pursuits to his public career: and upon the known temperament of Shakspeare, his genial disposition to enjoy life without disturbing his enjoyment by fretting anxieties, we build the conclusion, that had his friends furnished him with ampler funds, and had his marriage been well assorted or happy, we—the world of posterity—should have lost the whole benefit and delight which we have since reaped from his matchless faculties. The motives which drove him *from* Stratford are clear enough; but what motives determined his course *to* London, and especially to the stage, still remains to be explained. Stratford-upon-Avon, lying in the high road from London through Oxford to Birmingham (or more generally to the north), had been continually visited by some of the best comedians during Shakspeare's childhood. One or two of the most respectable metropolitan actors were natives of Stratford. These would be well known to the elder Shakspeare. But, apart from that accident, it is notorious that mere legal necessity and usage would compel all companies of actors, upon coming into any town, to seek, in the first place, from the chief magistrate, a license for opening a theatre, and next, over and above this public sanction, to seek his personal favour and patronage. As an alderman, therefore, but still more whilst clothed with the official powers of chief magistrate, the poet's father would have opportunities of doing essential services to many persons connected with the London stage. The conversation of comedians acquainted with books, fresh from the keen and sparkling circles of the metropolis, and filled with racy anecdotes of the court, as well as of public life generally, could not but have been fascinating, by comparison with the stagnant society of Stratford. Hospitalities on a liberal scale would be offered to these men: not impossibly this fact might be one principal key to those dilapidations which the family estate had suffered. These actors, on *their* part, would retain a grateful sense of the kindness they had received, and would seek to repay it to John Shakspeare, now that he was depressed in his fortunes, as opportunities might offer. His eldest son, growing up a handsome young man, and beyond all doubt from his earliest days of most splendid colloquial powers (for assuredly of *him* it may be taken for granted,

> Nec licuit populis parvum te, Nile, videre),

would be often reproached in a friendly way for burying himself in a country life. These overtures, prompted alike by gratitude to the father, and a real selfish interest in the talents of the son, would at length take a definite shape; and, upon some clear understanding as to the terms of such an arrangement, William Shakspeare would at length (about 1586, according to the received account, that is, in the fifth year of his married life, and the twenty-third or twenty-fourth of his age), unaccompanied by wife or children, translate himself to London. Later than 1586 it could not well be; for already in 1589 it has been recently ascertained that he held a share in the property of a leading theatre.

We must here stop to notice, and the reader will allow us to notice with summary indignation, the slanderous and idle tale which represents Shakspeare as having fled to London in the character of a criminal, from the persecutions of Sir Thomas Lucy of Charlecot. This tale has long been propagated under two separate impulses: chiefly, perhaps, under the vulgar love of pointed and glaring contrasts; the splendour of the man was in this instance brought into a sort of epigrammatic antithesis with the humility of his fortunes; secondly, under a baser impulse, the malicious pleasure of seeing a great man degraded. Accordingly, as in the case of Milton,[1] it has been affirmed that Shakspeare had suffered corporal chastisement, in fact (we abhor to utter such words), that he had been judicially whipped. Now, first of all, let us mark the inconsistency of this tale: the poet was whipped, that is, he was punished most disproportionately, and yet he fled to avoid punishment. Next, we are informed that his offence was deer-stealing, and from the park of Sir Thomas Lucy. And it has been well ascertained that Sir Thomas had no deer, and had no park. Moreover, deer-stealing was regarded by our ancestors exactly as poaching is regarded by us. Deer ran wild in all the great forests; and no offence was looked upon as so venial, none so compatible with a noble Robin-Hood style of character, as this very trespass upon what were regarded as *feræ naturæ*, and not at all as domestic property. But had it been otherwise, a trespass was not punishable with whipping; nor had Sir Thomas Lucy the power to irritate a whole community like Stratford-upon-Avon, by branding with permanent disgrace a young man so closely connected with three at least of the best families in the neighbourhood. Besides, had Shakspeare suffered any dishonour of that kind, the scandal would infallibly have pursued him at his very heels to London; and in that case Greene, who has left on record, in a posthumous work of 1592, his malicious feelings towards Shakspeare, could not have failed to notice it. For, be it remembered, that a judicial flagellation contains a twofold ignominy: flagellation is ignominious in its own nature, even though unjustly inflicted, and by a ruffian; secondly, any judicial punishment is ignominious, even though not wearing a shade of personal degradation. Now a judicial flagellation includes both features of dishonour. And is it to be imagined that an enemy, searching with the diligence of malice for matter against Shakspeare, should have failed, six years after the event, to hear of that very memorable disgrace which had exiled him from Stratford, and was the very occasion of his first resorting to London; or that a leading company of players in the metropolis, *one of whom*, and a chief one, *was his own townsman*, should cheerfully adopt into their society, as an honoured partner, a young man yet flagrant from the lash of the executioner or the beadle?

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[1] In a little memoir of Milton, which the author of this article drew up some years ago for a public society, and which is printed in an abridged shape, he took occasion to remark, that Dr Johnson, who was meanly anxious to revive this slander against Milton, as well as some others, had supposed Milton himself to have this flagellation in his mind, and indirectly to confess it, in one of his Latin poems, where, speaking of Cambridge, and declaring that he has no longer any pleasure in the thoughts of revisiting that university, he says,

> "Nec duri libet usque minas perferre magistri,
> Cæteraque ingenio non subeunda meo."

This last line the malicious critic would translate—"And other things insufferable to a man of my temper." But, as we then observed, *ingenium* is properly expressive of the *intellectual* constitution, whilst it is the *moral* constitution that suffers degradation from personal chastisement—the sense of honour, of personal dignity, of justice, &c. *Indoles* is the proper term for this latter idea; and in using the word *ingenium*, there cannot be a doubt that Milton alluded to the dry scholastic disputations, which were shocking and odious to his fine poetical genius. If, therefore, the vile story is still to be kept up in order to dishonour a great man, at any rate let it not in future be pretended that any countenance to such a slander can be drawn from the confessions of the poet himself.

This tale is fabulous, and rotten to its core; yet even this does less dishonour to Shakspeare's memory than the sequel attached to it. A sort of scurrilous rondeau, consisting of nine lines, so loathsome in its brutal stupidity, and so vulgar in its expression, that we shall not pollute our pages by transcribing it, has been imputed to Shakspeare ever since the days of the credulous Rowe. The total point of this idiot's drivel consists in calling Sir Thomas "an asse;" and well it justifies the poet's own remark, "Let there be gall enough in thy ink, no matter though thou write with a goose pen." Our own belief is, that these lines were a production of Charles II.'s reign, and applied to a Sir Thomas Lucy, not very far removed, if at all, from the age of him who first picked up the precious filth: the phrase "parliament *member*," we believe to be quite unknown in the colloquial use of Queen Elizabeth's reign.

But, that we may rid ourselves once and for ever of this outrageous calumny upon Shakspeare's memory, we shall pursue the story to its final stage. Even Malone has been thoughtless enough to accredit this closing chapter, which contains, in fact, such a superfetation of folly as the annals of human dulness do not exceed. Let us recapitulate the points of the story. A baronet, who has no deer and no park, is supposed to persecute a poet for stealing these aerial deer out of this aerial park, both lying in *nephelococcygia*. The poet sleeps upon this wrong for eighteen years; but at length, hearing that his persecutor is dead and buried, he conceives bloody thoughts of revenge. And this revenge he purposes to execute by picking a hole in his dead enemy's coat-of-arms. Is this coat-of-arms, then, Sir Thomas Lucy's? Why, no: Malone admits that it is not. For the poet, suddenly recollecting that this ridicule would settle upon the son of his enemy, selects another coat-of-arms, with which his dead enemy never had any connection, and he spends his thunder and lightning upon this irrelevant object; and, after all, the ridicule itself lies in a Welchman's mispronouncing one single heraldic term—a Welchman who mispronounces all words. The last act of the poet's malice recalls to us a sort of jest-book story of an Irishman, the vulgarity of which the reader will pardon in consideration of its relevancy. The Irishman having lost a pair of silk stockings, mentions to a friend that he has taken steps for recovering them by an advertisement, offering a reward to the finder. His friend objects that the costs of advertising, and the reward, would eat out the full value of the silk stockings. But to this the Irishman replies, with a knowing air, that he is not so green as to have overlooked *that;* and that, to keep down the reward, he had advertised the stockings as worsted. Not at all less flagrant is the bull ascribed to Shakspeare, when he is made to punish a dead man by personalities meant for his exclusive ear, through his coat-of-arms, but at the same time, with the express purpose of blunting and defeating the edge of his own scurrility, is made to substitute for the real arms some others which had no more relation to the dead enemy than they had to the poet himself. This is the very sublime of folly, beyond which human dotage cannot advance.

It is painful, indeed, and dishonourable to human nature, that whenever men of vulgar habits and of poor education wish to impress us with a feeling of respect for a man's talents, they are sure to cite, by way of evidence, some gross instance of malignity. Power, in their minds, is best illustrated by malice or by the infliction of pain. To this unwelcome fact we have some evidence in the wretched tale which we have just dismissed; and there is another of the same description to be found in all lives of Shakspeare, which we will expose to the contempt of the reader whilst we are in this field of discussion, that we may not afterwards have to resume so disgusting a subject.

This poet, who was a model of gracious benignity in his manners, and of whom, amidst our general ignorance, thus much is perfectly established, that the term *gentle* was almost as generally and by prescriptive right associated with his name as the affix of *venerable* with Bede, or *judicious* with Hooker, is alleged to have insulted a friend by an imaginary epitaph beginning "*Ten in the Hundred*," and supposing him to be damned, yet without wit enough (which surely the Stratford bellman could have furnished) for devising any, even fanciful, reason for such a supposition; upon which the comment of some foolish critic is, "The *sharpness of the satire* is said to have stung the man so much that he never forgave it." We have heard of the sting in the tail atoning for the brainless head; but in this doggerel the tail is surely as stingless as the head is brainless. For, 1*st*, *Ten in the Hundred* could be no reproach in Shakspeare's time, any more than to call a man *Three-and-a-half-per-cent.* in this present year 1838; except, indeed, amongst those foolish persons who built their morality upon the Jewish ceremonial law. Shakspeare himself took ten per cent. 2*dly*, It happens that John Combe, so far from being the object of the poet's scurrility, or viewing the poet as an object of implacable resentment, was a Stratford friend; that one of his family was affectionately remembered in Shakspeare's will by the bequest of his sword; and that John Combe himself recorded his perfect charity with Shakspeare by leaving him a legacy of L.5 sterling. And in this lies the key to the whole story. For, 3*dly*, the four lines were written and printed before Shakspeare was born. The name Combe is a common one; and some stupid fellow, who had seen the name in Shakspeare's will, and happened also to have seen the lines in a collection of epigrams, chose to connect the cases by attributing an identity to the two John Combes, though at war with chronology.

Finally, there is another specimen of doggerel attributed to Shakspeare, which is not equally unworthy of him, because not equally malignant, but otherwise equally below his intellect, no less than his scholarship; we mean the inscription on his grave-stone. This, as a sort of *siste viator* appeal to future sextons, is worthy of the grave-digger or the parish-clerk, who was probably its author. Or it may have been an antique formula, like the vulgar record of ownership in books—

Anthony Timothy Dolthead's book,
God give him grace therein to look.

Thus far the matter is of little importance; and it might have been supposed that malignity itself could hardly have imputed such trash to Shakspeare. But when we find, even in this short compass, scarcely wider than the posy of a ring, room found for traducing the poet's memory, it becomes important to say, that the leading sentiment, the horror expressed at any disturbance offered to his bones, is not one to which Shakspeare could have attached the slightest weight; far less could have outraged the sanctities of place and subject, by affixing to any sentiment whatever (and, according to the fiction of the case, his farewell sentiment) the sanction of a curse.

Filial veneration and piety towards the memory of this great man have led us into a digression that might have been unseasonable in any cause less weighty than one having for its object to deliver his honoured name from a load of the most brutal malignity. Never more, we hope and venture to believe, will any thoughtless biographer impute to Shakspeare the asinine doggerel with which the uncritical blundering of his earliest biographer has caused his name to be dishonoured. We now resume the thread of our biography. The stream of history is centuries in working itself clear of any calumny with which it has once been polluted.

Most readers will be aware of an old story, according to which Shakspeare gained his livelihood for some time after coming to London by holding the horses of those who rode to the play. This legend is as idle as any one of those which we have just exposed. No custom ever existed of riding on horseback to the play. Gentlemen, who rode valuable horses, would assuredly not expose them systematically to the injury of standing exposed to cold for two or even four hours; and persons of inferior rank would not ride on horseback in the town. Besides, had such a custom ever existed, stables (or sheds at least) would soon have arisen to meet the public wants; and in some of the dramatic sketches of the day, which noticed every fashion as it arose, this would not have been overlooked. The story is traced originally to Sir William Davenant. Betterton the actor, who professed to have received it from him, passed it onwards to Rowe, he to Pope, Pope to Bishop Newton the editor of Milton, and Newton to Dr Johnson. This pedigree of the fable, however, adds nothing to its credit, and multiplies the chances of some mistake. Another fable, not much less absurd, represents Shakspeare as having from the very first been borne upon the establishment of the theatre, and so far contradicts the other fable, but originally in the very humble character of *call-boy* or deputy prompter, whose business it was to summon each performer according to his order of coming upon the stage. This story, however, quite as much as the other, is irreconcileable with the discovery recently made by Mr Collier, that in 1589 Shakspeare was a shareholder in the important property of a principal London theatre. It seems destined that all the undoubted facts of Shakspeare's life should come to us through the channel of legal documents, which are better evidence even than imperial medals; whilst, on the other hand, all the fabulous anecdotes, not having an attorney's seal to them, seem to have been the fictions of the wonder-maker. The plain presumption from the record of Shakspeare's situation in 1589, coupled with the fact that his first arrival in London was possibly not until 1587, but according to the earliest account not before 1586, a space of time which leaves but little room for any remarkable changes of situation, seems to be, that, either in requital of services done to the players by the poet's family, or in consideration of money advanced by his father-in-law, or on account of Shakspeare's personal accomplishments as an actor, and as an adapter of dramatic works to the stage; for one of these reasons, or for all of them united, William Shakspeare, about the 23d year of his age, was adopted into the partnership of a respectable histrionic company, possessing a first-rate theatre in the metropolis. If 1586 were the year in which he came up to London, it seems probable enough that his immediate motive to that step was the increasing distress of his father; for in that year John Shakspeare resigned the office of alderman. There is, however, a bare possibility that Shakspeare might have gone to London about the time when he completed his twenty-first year, that is, in the spring of 1585, but not earlier. Nearly two years after the birth of his eldest daughter Susanna, his wife lay in for a second and a *last* time; but she then brought her husband twins, a son and a daughter. These children were baptized in February of the year 1585; so that Shakspeare's whole family of three children were born and baptized two months before he completed his majority. The twins were baptized by the names of Hamnet and Judith, those being the names of two amongst their sponsors, viz. Mr Sadler and his wife. Hamnet, which is a remarkable name in itself, becomes still more so from its resemblance to the immortal name of Hamlet[1] the Dane; it was, however, the real baptismal name of Mr Sadler, a friend of Shakspeare's, about fourteen years older than himself. Shakspeare's son must then have been most interesting to his heart, both as a twin child and as his only boy. He died in 1596, when he was about eleven years old. Both daughters survived their father; both married; both left issue, and thus gave a chance for continuing the succession from the great poet. But all the four grandchildren died without offspring.

Of Shakspeare personally, at least of Shakspeare the man, as distinguished from the author, there remains little more to record. Already in 1592, Greene, in his posthumous Groat's-worth of Wit, had expressed the earliest vocation of Shakspeare in the following sentence:—"There is an upstart crow, beautified with our feathers; in his own conceit the only *Shakscene* in a country!" This alludes to Shakspeare's office of re-casting, and even re-composing, dramatic works, so as to fit them for representation; and Master Greene, it is probable, had suffered in his self-estimation, or in his purse, by the alterations in some piece of his own which the duty of Shakspeare to the general interests of the theatre had obliged him to make. In 1591 it has been supposed that Shakspeare wrote his first drama, the Two Gentlemen of Verona; the least characteristically marked of all his plays, and, with the exception of Love's Labour's Lost, the least interesting.

From this year, 1591 to that of 1611, are just twenty years, within which space lie the whole dramatic creations of Shakspeare, averaging nearly one for every six months. In 1611 was written the Tempest, which is supposed to have been the last of all Shakspeare's works. Even on that account, as Mr Campbell feelingly observes, it has "a sort of sacredness;" and it is a most remarkable fact, and one calculated to make a man superstitious, that in this play the great enchanter Prospero, in whom, "*as if conscious*," says Mr Campbell, "*that this would be his last work*, the poet has been *inspired to typify himself* as a wise, potent, and *benevolent magician*," of whom, indeed, as of Shakspeare himself, it may be said, that "within that circle" (the circle of his own art) "none durst tread but he," solemnly and for ever renounces his mysterious functions, symbolically breaks his enchanter's wand, and declares that he will bury his books, his science, and his secrets

> Deeper than did ever plummet sound.

Nay, it is even ominous, that in this play, and from the voice of Prospero, issues that magnificent prophecy of the total destruction which should one day swallow up

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[1] And singular enough it is, as well as interesting, that Shakspeare had so entirely superseded to his own ear and memory the name Hamnet by the dramatic name of Hamlet, that in writing his will, he actually mis-spells the name of his friend Sadler, and calls him Hamlet. His son, however, who should have familiarized the true name to his ear, had then been dead for twenty years.

> The solemn temples, the great globe itself,
> Yea all which it inherit.

And this prophecy is followed immediately by a most profound ejaculation, gathering into one pathetic abstraction the total philosophy of life:

> We are such stuff
> As dreams are made of; and our little life
> Is rounded by a sleep;

that is, in effect, our life is a little tract of feverish vigils, surrounded and islanded by a shoreless ocean of sleep—sleep before birth, sleep after death.

These remarkable passages were probably not undesigned; but if we suppose them to have been thrown off without conscious notice of their tendencies, then, according to the superstition of the ancient Grecians, they would have been regarded as prefiguring words, prompted by the secret genius that accompanies every man, such as insure along with them their own accomplishment. With or without intention, however, it is believed that Shakspeare wrote nothing more after this exquisite romantic drama. With respect to the remainder of his personal history, Dr Drake and others have supposed, that during the twenty years from 1591 to 1611, he visited Stratford often, and latterly once a year.

In 1589 he had possessed some share in a theatre; in 1596 he had a considerable share. Through Lord Southampton, as a surviving friend of Lord Essex, who was viewed as the martyr to his Scottish politics, there can be no doubt that Shakspeare had acquired the favour of James I.; and accordingly, on the 29th of May 1603, about two months after the king's accession to the throne of England, a patent was granted to the company of players who possessed the Globe theatre; in which patent Shakspeare's name stands second. This patent raised the company to the rank of his majesty's servants, whereas previously they are supposed to have been simply the servants of the Lord Chamberlain. Perhaps it was in grateful acknowledgment of this royal favour that Shakspeare afterwards, in 1606, paid that sublime compliment to the house of Stuart which is involved in the vision shown to Macbeth. This vision is managed with exquisite skill: it was impossible to display the whole series of princes from Macbeth to James I.; but he beholds the posterity of Banquo, one "gold-bound brow" succeeding to another, until he comes to an eighth apparition of a Scottish king,

> Who bears a glass
> Which shows him many more; and some he sees
> Who *twofold* balls and *treble* sceptres carry;

thus bringing down without tedium the long succession to the very person of James I. by the symbolic image of the two crowns united on one head.

About the beginning of the century Shakspeare had become rich enough to purchase the best house in Stratford, called *The Great House*, which name he altered to *New Place*; and in 1602 he bought 107 acres adjacent to this house for a sum (L.320) corresponding to about 1500 guineas of modern money. Malone thinks that he purchased the house as early as 1597; and it is certain that about that time he was able to assist his father in obtaining a renewed grant of arms from the Heralds' College, and therefore, of course, to re-establish his father's fortunes. Ten years of well-directed industry, viz. from 1591 to 1601, and the prosperity of the theatre in which he was a proprietor, had raised him to affluence; and after another ten years, improved with the same success, he was able to retire with an income of L.300, or (according to the customary computations) in modern money of L.1500, per annum. Shakspeare was in fact the first man of letters, Pope the second, and Sir Walter Scott the third, who, in Great Britain, has ever realized a large fortune by literature; or in Christendom, if we except Voltaire, and two dubious cases in Italy. The four or five latter years of his life Shakspeare passed in dignified ease, in profound meditation, we may be sure, and in universal respect, at his native town of Stratford; and there he died, on the 23d of April 1616.[1]

His daughter Susanna had been married on the 5th of June of the year 1607, to Dr John Hall,[2] a physician in Stratford. The doctor died in November 1635, aged sixty; his wife, at the age of sixty-six, on July 11, 1640. They had one child, a daughter, named Elizabeth, born in 1608, married April 22, 1626, to Thomas Nashe, Esq. left a widow in 1647, and subsequently remarried to Sir John Barnard; but this Lady Barnard, the sole grand-daughter of the poet, had no children by either marriage. The other daughter Judith, on February 10, 1616 (about ten weeks before her father's death) married Mr Thomas Quiney of Stratford, by whom she had three sons, Shakspeare, Richard, and Thomas. Judith was about thirty-one years old at the time of her marriage; and living just forty-six years afterwards, she died in February 1662, at the age of seventy-seven. Her three sons died without issue; and thus, in the direct lineal descent, it is certain that no representative has survived of this transcendent poet, the most august amongst created intellects.

After this review of Shakspeare's life, it becomes our duty to take a summary survey of his works, of his intellectual powers, and of his station in literature, a station which is now irrevocably settled, not so much (which happens in other cases) by a vast overbalance of favourable suffrages, as by acclamation; not so much by the *voices* of those who admire him up to the verge of idolatry, as by the *acts* of those who everywhere seek for his works among the primal necessities of life, demand them, and crave them as they do their daily bread; not so much by eulogy openly proclaiming itself, as by the silent homage recorded in the endless multiplication of what he has bequeathed us; not so much by his own compatriots, who, with regard to almost every other author,[3] compose the total amount of his

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[1] "I have heard that Mr Shakspeare was a natural wit, without any art at all. Hee frequented the plays all his younger time, but in his elder days lived at Startford, and supplied the stage with two plays every year, and for itt had an allowance so large, that he spent at the rate of 1,000*l*. a-year, as I have heard. Shakespeare, Drayton, and Ben Jonson, had a merie meeting, and it seems drank too hard, for Shakespear died of a feavour there contracted." (Diary of the Rev. John Ward, A. M. Vicar of Stratford-upon-Avon, extending from 1648 to 1679, p. 183. Lond. 1839, 8vo.)

[2] It is naturally to be supposed that Dr Hall would attend the sick-bed of his father-in-law; and the discovery of this gentleman's medical diary promised some gratification to our curiosity as to the cause of Shakspeare's death. Unfortunately, it does not commence until the year 1617.

[3] An exception ought perhaps to be made for Sir Walter Scott and for Cervantes; but with regard to all other writers, Dante, suppose, or Ariosto amongst Italians, Camoens amongst those of Portugal, Schiller amongst Germans, however ably they may have been naturalized in foreign languages, as all of those here mentioned (excepting only Ariosto) have in one part of their works been most powerfully naturalized in English, it still remains true (and the very sale of the books is proof sufficient) that an alien author never does take root in the general sympathies out of his own country; he takes his station in libraries, he is read by the man of learned leisure, he is known and valued by the refined and the elegant, but he is not (what Shakspeare is for Germany and America) in any proper sense a *popular* favourite.

effective audience, as by the unanimous "all hail!" of intellectual Christendom; finally, not by the hasty partisanship of his own generation, nor by the biassed judgment of an age trained in the same modes of feeling and of thinking with himself, but by the solemn award of generation succeeding to generation, of one age correcting the obliquities or peculiarities of another; by the verdict of two hundred and thirty years, which have now elapsed since the very *latest* of his creations, or of two hundred and forty-seven years if we date from the earliest; a verdict which has been continually revived and re-opened, probed, searched, vexed, by criticism in every spirit, from the most genial and intelligent, down to the most malignant and scurrilously hostile which feeble heads and great ignorance could suggest when co-operating with impure hearts and narrow sensibilities; a verdict, in short, sustained and countersigned by a longer series of writers, many of them eminent for wit or learning, than were ever before congregated upon any inquest relating to any author, be he who he might, ancient[1] or modern, Pagan or Christian. It was a most witty saying with respect to a piratical and knavish publisher, who made a trade of insulting the memories of deceased authors by forged writings, that he was "among the new terrors of death." But in the gravest sense it may be affirmed of Shakspeare, that he is among the modern luxuries of life; that life, in fact, is a new thing, and one more to be coveted, since Shakspeare has extended the domains of human consciousness, and pushed its dark frontiers into regions not so much as dimly descried or even suspected before his time, far less illuminated (as now they are) by beauty and tropical luxuriance of life. For instance,—a single instance, indeed one which in itself is a world of new revelation,—the possible beauty of the female character had not been seen as in a dream before Shakspeare called into perfect life the radiant shapes of Desdemona, of Imogene, of Hermione, of Perdita, of Ophelia, of Miranda, and many others. The Una of Spenser, earlier by ten or fifteen years than most of these, was an idealized portrait of female innocence and virgin purity, but too shadowy and unreal for a dramatic reality. And as to the Grecian classics, let not the reader imagine for an instant that any prototype in this field of Shakspearian power can be looked for there. The *Antigone* and the *Electra* of the tragic poets are the two leading female characters that classical antiquity offers to our respect, but assuredly not to our impassioned love, as disciplined and exalted in the school of Shakspeare. They challenge our admiration, severe, and even stern, as impersonations of filial duty, cleaving to the steps of a desolate and afflicted old man; or of sisterly affection, maintaining the rights of a brother under circumstances of peril, of desertion, and consequently of perfect self-reliance. Iphigenia, again, though not dramatically coming before us in her own person, but according to the beautiful report of a spectator, presents us with a fine statuesque model of heroic fortitude, and of one whose young heart, even in the very agonies of her cruel immolation, refused to forget, by a single indecorous gesture, or so much as a moment's neglect of her own princely descent, and that she herself was "a lady in the land." These are fine marble groups, but they are not the warm breathing realities of Shakspeare; there is "no speculation" in their cold marble eyes; the breath of life is not in their nostrils; the fine pulses of womanly sensibilities are not throbbing in their bosoms. And besides this immeasurable difference between the cold moony reflexes of life, as exhibited by the power of Grecian art, and the true sunny life of Shakspeare, it must be observed that the Antigones, &c. of the antique put forward but one single trait of character, like the aloe with its single blossom: this solitary feature is presented to us as an abstraction, and as an insulated quality; whereas in Shakspeare all is presented in the *concrete*; that is to say, not brought forward in relief, as by some effort of an anatomical artist; but embodied and imbedded, so to speak, as by the force of a creative nature, in the complex system of a human life; a life in which all the elements move and play simultaneously, and with something more than mere simultaneity or co-existence, acting and re-acting each upon the other, nay, even acting by each other and through each other. In Shakspeare's characters is felt for ever a real *organic* life, where each is for the whole and in the whole, and where the whole is for each and in each. They only are real incarnations.

The Greek poets could not exhibit any approximations to *female* character, without violating the truth of Grecian life, and shocking the feelings of the audience. The drama with the Greeks, as with us, though much less than with us, was a picture of human life; and that which could not occur in life could not wisely be exhibited on the stage. Now, in ancient Greece, women were secluded from the society of men. The conventual sequestration of the γυναικωνίτις, or female apartment[2] of the house, and the Mahommedan consecration of its threshold against the ingress of males, had been transplanted from Asia into Greece thousands of years perhaps before either convents or Mahommed existed. Thus barred from all open social intercourse, women could not develope or express any character by word or action. Even to *have* a character, violated, to a Grecian mind, the ideal portrait of feminine excellence; whence, perhaps, partly the too generic, too little individualized, style of Grecian beauty. But prominently to *express* a character was impossible under the common tenor of Grecian life, unless when high tragical catastrophes transcended the decorums of that tenor, or for a brief interval raised the curtain which veiled it. Hence the subordinate part which women play upon the Greek stage in all but some half dozen cases. In the paramount tragedy on that stage, the model tragedy, the *Œdipus Tyrannus* of Sophocles, there is virtually no woman at all; for Jocasta is a party to the story merely as the dead Laius or the self-murdered Sphinx was a party, viz. by her contributions to the fatalities of the event, not by any thing she does or says spontaneously. In fact, the

Polyxena

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[1] It will occur to many readers, that perhaps Homer may furnish the sole exception to this sweeping assertion: any *but* Homer is clearly and ludicrously below the level of the competition; but even Homer, "with his tail on" (as the Scottish Highlanders say of their chieftains when belted by their ceremonial retinues), musters nothing like the force which *already* follows Shakspeare; and be it remembered, that Homer sleeps and has long slept as a subject of criticism or commentary, while in Germany as well as England, and *now even in France*, the gathering of wits to the vast equipage of Shakspeare is advancing in an accelerated ratio. There is, in fact, a great delusion current upon this subject. Innumerable references to Homer, and brief critical remarks on this or that pretension of Homer, this or that scene, this or that passage, lie scattered over literature ancient and modern; but the express works dedicated to the separate service of Homer are, after all, not many. In Greek we have only the large Commentary of Eustathius, and the Scholia of Didymus, &c.; in French little or nothing before the prose translation of the seventeenth century, which Pope esteemed "elegant," and the skirmishings of Madame Dacier, La Motte, &c.; in English, besides the various translations and their prefaces (which, by the way, began as early as 1555), nothing of much importance until the elaborate preface of Pope to the Iliad, and his elaborate postscript to the Odyssey—nothing certainly before that, and very little indeed since that, except Wood's Essay on the Life and Genius of Homer. On the other hand, of the books written in illustration or investigation of Shakspeare, a very considerable library might be formed in England, and another in Germany.

[2] Apartment is here used, as the reader will observe, in its true and continental acceptation, as a division or *compartment* of a house including many rooms; a suite of chambers, but a suite which is partitioned off (as in palaces), not a single chamber; a sense so commonly and so erroneously given to this word in England.

Greek poet, if a wise poet, could not address himself genially to a task in which he must begin by shocking the sensibilities of his countrymen. And hence followed, not only the dearth of female characters in the Grecian drama, but also a second result still more favourable to the sense of a new power evolved by Shakspeare. Whenever the common law of Grecian life did give way, it was, as we have observed, to the suspending force of some great convulsion or tragical catastrophe. This for a moment (like an earthquake in a nunnery) would set at liberty even the timid, fluttering Grecian women, those doves of the dove-cot, and would call some of them into action. But which? Precisely those of energetic and masculine minds; the timid and feminine would but shrink the more from public gaze and from tumult. Thus it happened, that such female characters as *were* exhibited in Greece, could not but be the harsh and the severe. If a gentle Ismene appeared for a moment in contest with some energetic sister Antigone (and chiefly, perhaps, by way of drawing out the fiercer character of that sister), she was soon dismissed as unfit for scenical effect. So that not only were female characters few, but, moreover, of these few the majority were but repetitions of masculine qualities in female persons. Female agency being seldom summoned on the stage except when it had received a sort of special dispensation from its sexual character, by some terrific convulsions of the house or the city, naturally it assumed the style of action suited to these circumstances. And hence it arose, that not woman as she differed from man, but woman as she resembled man—woman, in short, seen under circumstances so dreadful as to abolish the effect of sexual distinction, was the woman of the Greek tragedy.[1] And hence generally arose for Shakspeare the wider field, and the more astonishing by its perfect novelty, when he first introduced female characters, not as mere varieties or echoes of masculine characters, a Medea or Clytemnestra, or a vindictive Hecuba, the mere tigress of the tragic tiger, but female characters that had the appropriate beauty of female nature; woman no longer grand, terrific, and repulsive, but woman "after her kind"—the other hemisphere of the dramatic world; woman running through the vast gamut of womanly loveliness; woman as emancipated, exalted, ennobled, under a new law of Christian morality; woman the sister and co-equal of man, no longer his slave, his prisoner, and sometimes his rebel. "It is a far cry to Loch Awe;" and from the Athenian stage to the stage of Shakspeare, it may be said, is a prodigious interval. True; but prodigious as it is, there is really nothing between them. The Roman stage, at least the tragic stage, as is well known, was put out, as by an extinguisher, by the cruel amphitheatre, just as a candle is made pale and ridiculous by daylight. Those who were fresh from the real murders of the bloody amphitheatre regarded with contempt the mimic murders of the stage. Stimulation too coarse and too intense had its usual effect in making the sensibilities callous. Christian emperors arose at length, who abolished the amphitheatre in its bloodier features. But by that time the genius of the tragic muse had long slept the sleep of death. And that muse had no resurrection until the age of Shakspeare. So that, notwithstanding a gulf of nineteen centuries and upwards separates Shakspeare from Euripides, the last of the surviving Greek tragedians, the one is still the nearest successor of the other, just as Connaught and the islands in Clew Bay are next neighbours to America, although three thousand watery columns, each of a cubic mile in dimensions, divide them from each other.

A second reason, which lends an emphasis of novelty and effective power to Shakspeare's female world, is a peculiar fact of contrast which exists between that and his corresponding world of men. Let us explain. The purpose and the intention of the Grecian stage was not primarily to develope human *character*, whether in men or in women; human *fates* were its object; great tragic situations under the mighty control of a vast cloudy destiny, dimly descried at intervals, and brooding over human life by mysterious agencies, and for mysterious ends. Man, no longer the representative of an august *will*, man the passion-puppet of fate, could not with any effect display what we call a character, which is a distinction between man and man, emanating originally from the will, and expressing its determinations, moving under the large variety of human impulses. The will is the central pivot of character; and this was obliterated, thwarted, cancelled, by the dark fatalism which brooded over the Grecian stage. That explanation will sufficiently clear up the reason why marked or complex variety of character was slighted by the great principles of the Greek tragedy. And every scholar who has studied that grand drama of Greece with feeling,—that drama, so magnificent, so regal, so stately,—and who has thoughtfully investigated its principles, and its difference from the English drama, will acknowledge that powerful and elaborate character, character, for instance, that could employ the fiftieth part of that profound analysis which has been applied to Hamlet, to Falstaff, to Lear, to Othello, and applied by Mrs Jamieson so admirably to the full development of the Shakspearian heroines, would have been as much wasted, nay, would have been defeated, and interrupted the blind agencies of fate, just in the same way as it would injure the shadowy grandeur of a ghost to individualize it too much. Milton's angels are slightly touched, superficially touched, with differences of character; but they are such differences, so simple and general, as are just sufficient to rescue them from the reproach applied to Virgil's "*fortemque Gyan, fortemque Cloanthem*;" just sufficient to make them knowable apart. Pliny speaks of painters who painted in one or two colours; and, as respects the angelic characters, Milton does so; he is *monochromatic*. So, and for reasons resting upon the same ultimate philosophy, were the mighty architects of the Greek tragedy. They also were monochromatic; they also, as to the characters of their persons, painted in one colour. And so far there might have been the same novelty in Shakspeare's men as in his women. There *might* have been; but the reason why there is *not*, must be sought in the fact, that History, the muse of History, had there even been no such muse as Melpomene, would have forced us into an acquaintance with human character. History, as the representative of actual life, of real man, gives us powerful delineations of character in its chief agents, that is, in men; and therefore it is that Shakspeare, the absolute creator of female character, was but the mightiest of all painters with regard to male character. Take a single instance. The Antony of Shakspeare, immortal for its execution, is found, after all, as regards the primary conception, in history: Shakspeare's delineation is but the expansion of the germ already pre-existing, by way of scattered fragments, in Cicero's Philippics, in Cicero's Letters, in Appian, &c. But Cleopatra, equally fine, is a pure creation of art: the situation and the scenic circumstances belong to history, but the character belongs to Shakspeare.

In the great world therefore of woman, as the interpreter of the shifting phases and the lunar varieties of that mighty changeable planet, that lovely satellite of man, Shakspeare stands not the first only, not the original only, but is yet the sole authentic oracle of truth. Woman, therefore, the beauty of the female mind, *this* is one great field of his power. The supernatural world, the world of apparitions, *that* is another: for reasons which it would be easy to give, reasons emanating from the gross mythology of the ancients, no Grecian,[1] no Roman, could have conceived a ghost. That shadowy conception, the protesting apparition, the awful projection of the human conscience, belongs to the Christian mind: and in all Christendom, who, let us ask, who, who but Shakspeare has found the power for effectually working this mysterious mode of being? In summoning back to earth "the majesty of buried Denmark," how like an awful necromancer does Shakspeare appear! All the pomps and grandeurs which religion, which the grave, which the popular superstition had gathered about the subject of apparitions, are here converted to his purpose, and bend to one awful effect. The wormy grave brought into antagonism with the scenting of the early dawn; the trumpet of resurrection suggested, and again as an antagonist idea to the crowing of the cock (a bird ennobled in the Christian mythus by the part he is made to play at the Crucifixion); its starting "as a guilty thing" placed in opposition to its majestic expression of offended dignity when struck at by the partisans of the sentinels; its awful allusions to the secrets of its prison-house; its ubiquity, contrasted with its local presence; its aerial substance, yet clothed in palpable armour; the heart-shaking solemnity of its language, and the appropriate scenery of its haunt, viz. the ramparts of a capital fortress, with no witnesses but a few gentlemen mounting guard at the dead of night,—what a mist, what a *mirage* of vapour, is here accumulated, through which the dreadful being in the centre looms upon us in far larger proportions than could have happened had it been insulated and left naked of this circumstantial pomp! In the *Tempest*, again, what new modes of life, preternatural, yet far as the poles from the spiritualities of religion. Ariel in antithesis to Caliban! What is most ethereal to what is most animal! A phantom of air, an abstraction of the dawn and of vesper sun-lights, a bodiless sylph on the one hand; on the other a gross carnal monster, like the Miltonic Asmodai, "the fleshliest incubus" among the fiends, and yet so far ennobled into interest by his intellectual power, and by the grandeur of misanthropy![2] In the *Midsummer-Night's Dream*, again, we have the old traditional fairy, a lovely mode of preternatural life, remodified by Shakspeare's eternal talisman. Oberon and Titania remind us at first glance of Ariel: they approach, but how far they recede: they are like—"like, but, oh, how different!" And in no other exhibition of this dreamy population of the moonlight forests and forest-lawns, are the circumstantial proprieties of fairy life so exquisitely imagined, sustained, or expressed. The dialogue between Oberon and Titania is, of itself, and taken separately from its connection, one of the most delightful poetic scenes that literature affords. The witches in Macbeth are another variety of supernatural life, in which Shakspeare's power to enchant and to disenchant are alike portentous. The circumstances of the blasted heath, the army at a distance, the withered attire of the mysterious hags, and the choral litanies of their fiendish Sabbath, are as finely imagined in their kind as those which herald and which surround the ghost in Hamlet. There we see the *positive* of Shakspeare's superior power. But now turn and look to the *negative*. At a time when the trials of witches, the royal book on demonology, and popular superstition (all so far useful, as they prepared a basis of undoubting faith for the poet's serious use of such agencies) had degraded and polluted the ideas of these mysterious beings by many mean associations, Shakspeare does not fear to employ them in high tragedy (a tragedy moreover which, though not the very greatest of his efforts as an intellectual whole, nor as a struggle of passion, is *among* the greatest in any view, and positively *the* greatest for scenical grandeur, and in that respect makes the nearest approach of all English tragedies to the Grecian model); he does not fear to introduce, for the same appalling effect as that for which Æschylus introduced the Eumenides, a triad of old women, concerning whom an English wit has remarked this grotesque peculiarity in the popular creed of that day,—that although potent over winds and storms, in league with powers of darkness, they yet stood in awe of the constable,—yet relying on his own supreme power to disenchant as well as to enchant, to create and to uncreate, he mixes these women and their dark machineries with the power of armies, with the agencies of kings, and the fortunes of martial kingdoms. Such was the sovereignty of this poet, so mighty its compass!

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[1] And hence, by parity of reason, under the opposite circumstances, under the circumstances which, instead of abolishing, most emphatically drew forth the sexual distinctions, viz. in the *comic* aspects of social intercourse, the reason that we see no women on the Greek stage; the Greek comedy, unless when it affects the extravagant fun of farce, rejects women.

A third fund of Shakspeare's peculiar power lies in his teeming fertility of fine thoughts and sentiments. From his works alone might be gathered a golden bead-roll of thoughts the deepest, subtilest, most pathetic, and yet most catholic and universally intelligible; the most characteristic, also, and appropriate to the particular person, the situation, and the case, yet, at the same time, applicable to the circumstances of every human being, under all the accidents of life, and all vicissitudes of fortune. But this subject offers so vast a field of observation, it being so eminently the prerogative of Shakspeare to have thought more finely and more extensively than all other poets combined, that we cannot wrong the dignity of such a theme by doing more, in our narrow limits, than simply noticing it as one of the emblazonries upon Shakspeare's shield.

Fourthly, we shall indicate (and, as in the last case, *barely* indicate, without attempting in so vast a field to offer any inadequate illustrations) one mode of Shakspeare's dramatic excellence which hitherto has not attracted any special or separate notice. We allude to the forms of life, and natural human passion, as apparent in the structure of his dialogue. Among the many defects and infirmities of the

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[1] It may be thought, however, by some readers, that Æschylus, in his fine phantom of Darius, has approached the English ghost. As a foreign ghost, we would wish (and we are sure that our excellent readers would wish) to show every courtesy and attention to this apparition of Darius. It has the advantage of being royal, an advantage which it shares with the ghost of the royal Dane. Yet how different, how removed by a total world, from that or any of Shakspeare's ghosts! Take that of Banquo, for instance: how shadowy, how unreal, yet how real! Darius is a mere state ghost—a diplomatic ghost. But Banquo—he exists only for Macbeth; the guests do not see him, yet how solemn, how real, how heart-searching he is.

[2] Caliban has not yet been thoroughly fathomed. For all Shakspeare's great creations are like works of nature, subjects of unexhaustible study. It was this character of whom Charles I. and some of his ministers expressed such fervent admiration; and, among other circumstances, most justly they admired the new language almost with which he is endowed, for the purpose of expressing his fiendish and yet carnal thoughts of hatred to his master. Caliban is evidently not meant for scorn, but for abomination mixed with fear and partial respect. He is purposely brought into contrast with the drunken Trinculo and Stephano, with an advantageous result. He is much more intellectual than either, uses a more elevated language, not disfigured by vulgarisms, and is not liable to the low passion for plunder as they are. He is mortal, doubtless, as his "dam" (for Shakspeare will not call her mother) Sycorax. But he inherits from her such qualities of power as a witch could be supposed to bequeath. He trembles indeed before Prospero; but that is, as we are to understand, through the moral superiority of Prospero in Christian wisdom; for when he finds himself in the presence of dissolute and unprincipled men, he rises at once into the dignity of intellectual power.

French and of the Italian drama, indeed we may say of the Greek, the dialogue proceeds always by independent speeches, replying indeed to each other, but never modified in its several openings by the momentary effect of its several terminal forms immediately preceding. Now, in Shakspeare, who first set an example of that most important innovation, in all his impassioned dialogues, each reply or rejoinder seems the mere rebound of the previous speech. Every form of natural interruption, breaking through the restraints of ceremony under the impulses of tempestuous passion; every form of hasty interrogative, ardent reiteration when a question has been evaded; every form of scornful repetition of the hostile words; every impatient continuation of the hostile statement; in short, all modes and formulæ by which anger, hurry, fretfulness, scorn, impatience, or excitement under any movement whatever, can disturb or modify or dislocate the formal bookish style of commencement,—these are as rife in Shakspeare's dialogue as in life itself; and how much vivacity, how profound a verisimilitude, they add to the scenic effect as an imitation of human passion and real life, we need not say. A volume might be written illustrating the vast varieties of Shakspeare's art and power in this one field of improvement; another volume might be dedicated to the exposure of the lifeless and unnatural result from the opposite practice in the foreign stages of France and Italy. And we may truly say, that were Shakspeare distinguished from them by this single feature of nature and propriety, he would on that account alone have merited a great immortality. (w. w. w.)

The dramatic works of Shakspeare generally acknowledged to be genuine consist of thirty-five pieces. The following is the chronological order in which they are supposed to have been written, according to Mr Malone as given in his second edition of Shakspeare, and by Mr George Chalmers in his Supplemental Apology for the Believers in the Shakspeare Papers.

	Chalmers.	Malone.
1. The Comedy of Errors,	1591	1592
2. Love's Labour's Lost,	1592	1594
3. Romeo and Juliet,	1592	1596
4. Henry VI. the First Part,	1593	1589
5. Henry VI. the Second Part,	1595	1591
6. Henry VI. the Third Part,	1595	1591
7. The Two Gentlemen of Verona,	1595	1591
8. Richard III.	1596	1593
9. Richard II.	1596	1593
10. The Merry Wives of Windsor,	1596	1601
11. Henry IV. the First Part,	1597	1597
12. Henry IV. the Second Part,	1597	1599
13. Henry V.	1597	1599
14. The Merchant of Venice,	1597	1594
15. Hamlet,	1598	1600
16. King John,	1598	1596
17. A Midsummer-Night's Dream,	1598	1594
18. The Taming of the Shrew,	1599	1596
19. All's Well that Ends Well,	1599	1606
20. Much Ado about Nothing,	1599	1600
21. As You Like It,	1602	1599
22. Troilus and Cressida,	1610	1602
23. Timon of Athens,	1611	1610
24. The Winter's Tale,	1601	1611
25. Measure for Measure,	1604	1603
26. King Lear,	1605	1605
27. Cymbeline,	1606	1609
28. Macbeth,	1606	1606
29. Julius Cæsar,	1607	1607
30. Antony and Cleopatra,	1608	1608
31. Coriolanus,	1619	1610
32. The Tempest,	1613	1611
33. The Twelfth Night,	1613	1607
34. Henry VIII.	1613	1603
35. Othello,	1614	1604

Pericles and Titus Andronicus, although inserted in all the late editions of Shakspeare's Plays, are omitted in the above list, both by Malone and Chalmers, as not being Shakspeare's.

The first edition of the Works was published in 1623, in a folio volume entitled Mr William Shakspeare's Comedies, Histories, and Tragedies. The second edition was published in 1632, the third in 1664, and the fourth in 1685, all in folio; but the edition of 1623 is considered the most authentic. Rowe published an edition in seven vols. 8vo in 1709. Editions were published by Pope, in six vols. 4to, in 1725; by Warburton, in eight vols. 8vo, in 1747; by Dr Johnson, in eight vols. 8vo, in 1765; by Stevens, in four vols. 8vo, in 1766; by Malone, in ten vols. 8vo, in 1789; by Alexander Chalmers, in nine vols. 8vo, in 1811; by Johnson and Stevens, revised by Isaac Reed, in twenty-one vols. 8vo, in 1813; and the Plays and Poems, with notes by Malone, were edited by James Boswell, and published in twenty-one vols. 8vo, in 1821. Besides these, numerous editions have been published from time to time.

SHALLOP, Shalloop, or Sloop, is a light vessel, with only a small main-mast and fore-mast, and lug-sails, to haul up and let down on occasion. Shallops are commonly good sailers, and are therefore often used as tenders upon men-of-war.

SHAMANS are wizards or conjurers, in high repute among several idolatrous nations inhabiting different parts of Russia. By their enchantments they pretend to cure diseases, to divert misfortunes, and to foretell futurity. They are great observers of dreams, by the interpretation of which they judge of good or bad fortune. They pretend likewise to chiromancy, and to foretell a man's good or ill success by the lines of his hand. By these and such like means they have a very great ascendency over the understandings, and a great influence on the conduct, of those people.

SHAMBLES, among miners, a sort of niches or landing places, left at such distances in the adits of the mines, that the shovel-men may conveniently throw up the ore from shamble to shamble, till it comes to the top of the mine.

SHAMLY, a town of Hindustan, in the province of Delhi. It is about two miles in circumference, and contains many handsome houses, with a large bazaar, and the remains of a mint. The streets intersect each other at right angles, and have separate gates, which are shut at night. It is sixty miles north by east from Delhi. Long. 77. 10. E. Lat. 29. 33. N.

SHAMOIS, or Chamois, a kind of leather, either dressed in oil or tanned, much esteemed for its softness and pliancy. It is prepared from the skin of the chamois, or shamois, a kind of wild goat, called also isard, inhabiting the mountains of Dauphiné, Savoy, Piedmont, and the Pyrenees. Besides the softness and warmth of the leather, it has the faculty of bearing soap without damage, which renders it very useful on many accounts.

SHANAVAZ, a town of the Afghan territories, in the province of Mooltan, seventy-eight miles east from the city of Mooltan. Long. 72. 39. E. Lat. 30. 41. N.

SHANDORAH, a town of Hindustan, in the province of Delhi, 120 miles from the city of Delhi. Long. 77. E. Lat. 30. 26. N.

SHANK'S Island, in the South Pacific Ocean, about annon || harp, ames.

fifteen miles from east to west, and eighteen from north to south, discovered in 1802. Long. 163. E. Lat. 28. S.

SHANNON, the largest river in Ireland, and one of the finest in the British dominions, not only on account of its running two hundred miles, but also of its great depth in most places, and the gentleness of its current, by which it might be made exceedingly serviceable to the improvement of the country, the communication of its inhabitants, and consequently the promoting of inland trade through the greater part of its long course. But the peculiar prerogative of the Shannon is its situation, running from north to south, and separating the province of Connaught from Leinster and Munster, and of consequence dividing the greater part of Ireland into that which lies on the east and west of the river; watering in its passage the valuable counties of Leitrim, Roscommon, Galway, and Clare; the small shire of Longford, King's County, and Meath in Leinster, Tipperary, Limerick, and Kerry in Munster; visiting ten counties in its passage, and having on its banks Leitrim, Jamestown, Lanesborough, Athlone, Clonfert, Killaloe, and Limerick. It at last joins its waters to the sea, being navigable all this way for the largest vessels.

SHAPOORAH, a town of Hindustan, in the province of Ajmeer and district of Harowty. It is a large and well-built town, surrounded by a strong wall of stone and a ditch. It is sixty-five miles south by east from the city of Ajmeer. Long. 75. 9. E. Lat. 25. 43. N.

SHAPOUR, an ancient city of Persia, which existed prior to the era of Alexander, but of which the former magnificence is now only marked by masses of ruins. It is situated immediately under a range of mountains, on the banks of a small but rapid river, amid rocks and precipices, many of which are decorated with sculpture.

SHARP, James, archbishop of St Andrews, was born of a good family in Banffshire in the year 1618. He devoted himself early to the church, and was educated for that purpose in the university of Aberdeen. When the solemn league and covenant was framed in 1638, the learned men in that seminary, and young Sharp in particular, declared themselves decidedly against it. To avoid the insults and indignities to which he was subjected in consequence of this conduct, he retired to England, where he contracted an acquaintance with some of the most celebrated divines in that country.

At the commencement of the civil wars he returned to Scotland. During his journey thither, he accidentally met with Lord Oxenford, who was so charmed with his conversation that he invited him to his house. While he resided with that nobleman, he became known to the Earl of Rothes, who procured him a professorship at St Andrews. By the interest of the Earl of Crawford, he was soon afterwards appointed minister of Crail, where he conducted himself, it is said, in an exemplary manner.

Sharp had always inclined to the cause of royalty, and had for some time kept up a correspondence with his exiled prince. After this he began to declare himself more openly, and seems to have enjoyed a great share of the confidence of Monk, who was at that time planning the restoration of Charles II. When that general marched to London, the presbyterians sent Sharp to attend him, in order to support their interests. At the request of General Monk and the chief presbyterians in Scotland, Mr Sharp was sent over to the king at Breda, to procure from him, if possible, the establishment of presbytery. On his return, he assured his friends that "he had found the king very affectionate to Scotland, and resolved not to wrong the settled government of the church; but he apprehended they were mistaken who went about to establish the presbyterian government."

Charles was soon afterwards restored without any terms. All the laws passed in Scotland since the year 1633 were repealed; the king and his ministers resolved at all hazards to restore prelacy. Mr Sharp, who had been commissioned by the Scotch presbyterians to manage their interests with the king, was prevailed upon to abandon the party; and as a reward for his compliance, he was made archbishop of St Andrews. This conduct rendered him very odious in Scotland. He was accused of treachery and perfidy, and reproached by his old friends as a traitor and renegade. The absurd and wanton cruelties which were afterwards committed, and which were imputed in a great measure to the archbishop, rendered him still more detested. Nor is it probable that these accusations were without foundation. The very circumstance of his having formerly been of the presbyterian party would induce him, after forsaking them, to treat them with severity. Besides, it is certain, that when, after the rout at Pentland Hills, he received an order from the king to stop the executions, he kept it for some time before he produced it to the council.

Sharp.

There was one Mitchell, a preacher, and a desperate fanatic, who had formed the design of taking vengeance for these cruelties by assassinating the archbishop. He fired a pistol at him as he was sitting in his coach; but the bishop of Orkney, lifting up his hand at the moment, intercepted the ball. Though this happened in the midst of Edinburgh, the primate was so much detested, that nobody stopped the assassin, who, having walked leisurely home, and thrown off his disguise, returned, and mixed unsuspected with the crowd. Some years afterwards, the archbishop observing a man eyeing him with keenness, suspected that he was the assassin, and ordered him to be brought before him. It was Mitchell. Two loaded pistols were found in his pocket. The primate offered him a pardon if he would confess the crime. The man complied; but Sharp, regardless of his promise, conducted him to the council. The council also gave him a solemn promise of pardon if he would confess his guilt, and discover his accomplices. They were much disappointed to hear that only one man was privy to his purpose, who was since dead. Mitchell was then brought before a court of justice, and ordered to make a third confession, which he refused. He was imprisoned for several years, and then tried. His own confession was urged against him. It was in vain for him to plead the illegality of that evidence, and to appeal to the promise of pardon previously given. The council took an oath that they had given no such promise, and Mitchell was condemned. Lauderdale, who at that time governed Scotland, would have pardoned him, but the primate insisted on his execution, observing, that if assassins were permitted to go unpunished, his life must be continually in danger. Mitchell was accordingly executed.

Sharp had a servant, one Carmichael, who by his cruelty had rendered himself particularly odious to the zealots. Nine men formed the resolution of waylaying him in Magus Moor, about three miles from St Andrews. While they were waiting for this man, the primate himself appeared, with very few attendants. This they looked upon as a declaration of heaven in their favour; and calling out, "the Lord has delivered him into our hands," they ran up to the carriage. They fired at him without effect; a circumstance which was afterwards imputed to magic. They then despatched him with their swords, regardless of the tears and entreaties of his daughter, who accompanied him.

Thus fell Archbishop Sharp, whose memory is even at present detested by the common people of Scotland. His abilities were certainly good, and in the early part of his life he appears with honour and dignity. But his conduct afterwards was too cruel and insincere to merit approbation. His treatment of Mitchell was mean and vindictive. How far he contributed to the measures adopted against the presbyterians is not certain. They were equally cruel and impolitic; nor did their effects cease with the measures themselves. The unheard-of cruelties exercised by the ministers of Charles II. against the adherents of the covenant, raised such a flame of enthusiasm and bigotry as is not yet entirely extinguished.

Sharp, *Dr John*, Archbishop of York, was descended from the Sharps of Little Norton, a family of Bradford Dale in Yorkshire; and was son of an eminent tradesman of Bradford, where he was born in 1644. He was educated at Cambridge, and in 1667 entered into orders. The same year he became domestic chaplain to Sir Heneage Finch, then attorney-general. In 1672 he was collated to the archdeaconry of Berkshire. In 1675 he was installed a prebendary in the cathedral church of Norwich; and the year following was instituted into the rectory of St Bartholomew, near the Royal Exchange, London. In 1681 he was, by the interest of his patron Sir Heneage Finch, then lord high chancellor of England, made dean of Norwich, but in 1686 was suspended for taking occasion, in some of his sermons, to vindicate the doctrine of the Church of England in opposition to Popery. In 1688 he was sworn chaplain to James II. being then probably restored after his suspension; for it is certain that he was chaplain to Charles II. and attended as a court chaplain at the coronation of James II. In 1689 he was declared dean of Canterbury, but never could be persuaded to fill up any of the vacancies made by the deprived bishops. Upon the death of Dr Lamplugh, he was promoted to the see of York. In 1702 he preached the sermon at the coronation of Queen Anne; and the same year he was sworn of the privy council, and made lord almoner to her majesty. He died at Bath in 1713, and was interred in the cathedral of York, where a monument was erected to his memory. His sermons were collected after his death, and published in seven vols. 8vo.

Sharp, *Abraham*, an eminent English mathematician and astronomer, was born at Little Horton, near Bradford, in the year 1651. He was put as apprentice to a merchant at Manchester; but so strongly was he inclined to the study of mathematics, that he soon found his situation both irksome and disagreeable. By the mutual consent, therefore, of his master and himself, he quitted the business of a merchant. He then removed to Liverpool, where he devoted himself wholly to mathematical studies, and where, for a subsistence, he taught writing and accounts.

Soon after this, a merchant from London, in whose house the celebrated Flamsteed then lodged, engaged Sharp to be his book-keeper. With this eminent astronomer he soon contracted an intimate friendship, and by his recommendation he obtained a more profitable employment in the dock-yard of Chatham, where he continued till his friend and patron called him to his assistance. Mr Sharp was chiefly employed in the construction of the mural arch, which he finished in the course of fourteen months, so entirely to the satisfaction of Flamsteed, that he spoke of him in terms of the highest praise. In the opinion of Smeaton, this was the first good instrument of the kind, and Sharp the first artist who cut delicate divisions on astronomical instruments. When this instrument was constructed, Sharp was but twenty-five and Flamsteed thirty years of age. Mr Sharp assisted his friend in making a catalogue of nearly three thousand fixed stars, with their longitudes and magnitudes, their right ascensions and polar distances, with the variations of the same while they change their longitude by one degree.

But, from the fatigue of constantly observing the stars by night in a cold thin air, added to a weakly constitution, his health was much impaired. For the recovery of it he requested leave to retire to his house at Horton, where, as soon as he felt himself recovering, he began to fit up an observatory of his own; and the telescopes he made use of were all of his own construction, and the lenses ground and adjusted with his own hands.

It was about this time that he assisted Flamsteed in calculating most of the tables in the second volume of his *Historia Cœlestis*, as appears by their letters, to be seen in the hands of Sharp's friends at Horton. The mathematician, says Dr Hutton, meets with something extraordinary in Sharp's elaborate treatise of Geometry Improved; by a large and accurate table of segments of circles, its construction and various uses in the solution of several difficult problems, with compendious tables for finding a true proportional part; and their use in these or any other tables exemplified in making logarithms, or their natural numbers, to sixty places of figures, there being a table of them for all primes to 1100, true to sixty-one figures. His concise treatise of Polyedra, or solid bodies of many bases, both of the regular ones and others, to which are added twelve new ones, with various methods of forming them, and their exact dimensions in surds and in numbers; illustrated with a variety of copperplates, neatly engraved by his own hands. Indeed few of the mathematical instrument makers could exceed him in exactly graduating or neatly engraving mathematical or astronomical instruments. He possessed a remarkably clear head for contriving, and an extraordinary hand for executing, any thing, not only in mechanics, but likewise in drawing, writing, and making the most beautiful figures, in all his calculations and constructions.

The quadrature of the circle was undertaken by him for his own amusement, in the year 1699, deduced from two different series, by which the truth of it was proved to seventy-two places of figures, as may be seen in Sherwin's Tables of Logarithms. In the same book may likewise be seen his ingenious improvements on the making of logarithms, and the constructing of the natural sines, tangents, and secants.

Mr Sharp kept up a correspondence with most of the eminent mathematicians and astronomers of his time, as Flamsteed, Newton, Halley, Wallis, Hodgson, the answers to whose letters are all written on the backs or empty spaces of the letters he received, in a short hand of his own invention. Being one of the most accurate and indefatigable computers who ever existed, he was many years the common resource for Flamsteed, Sir Jonas Moor, Halley, and others, in all sorts of troublesome and delicate calculations.

Sharp was never married, and spent his time as a hermit. He was of a middle stature, very thin, of a weakly constitution, and remarkably feeble during the last three or four years before his death, which happened on the 18th of July 1742, in the ninety-first year of his age.

He was very irregular as to his meals, and uncommonly sparing in his diet. A little square hole, resembling a window, formed a communication between the room where he usually studied, and another where a servant could enter; and before this hole he had contrived a sliding board. It often happened, that the breakfast, dinner, and supper, have remained untouched, when the servant had gone to remove what was left, so deeply was he engaged in calculations.

Sharp, in *Music*. See Music.

SHASTER or Shastrah, the name of a sacred book, in high estimation among the idolaters of Hindustan, containing all the dogmas of the religion of the Brahmins, and all the ceremonies of their worship, and serving as a commentary on the Vedam.

The term *Shaster* denotes science or system; and is applied to other works of astronomy and philosophy, which have no relation to the religion of the Indians. None but the Brahmins and rajahs of India are allowed to read the Vedam; the priests of the Banians, called Shuderis, may read the Shaster; and the people in general are allowed to read only the Paran or Pouran, which is a commentary on the Shaster.

The Shaster is divided into three parts, the first containing the moral law of the Indians; the second, the rites and ceremonies of their religion; and the third, the distribution of the people into tribes or classes, with the duties pertaining to each class.

The principal precepts of morality, contained in the first part of the Shaster, are the following. That no animal be killed, because the Indians attribute souls to brute animals as well as to mankind; that they neither hear nor speak evil, nor drink wine, nor eat flesh, nor touch any thing that is unclean; that they observe the feasts, prayers, and washings which their law prescribes; that they tell no lies, nor be guilty of deceit in trade; that they neither oppress nor offer violence to one another; that they celebrate the solemn feasts and fasts, and appropriate certain hours of ordinary sleep to cultivate a disposition for prayer; and that they do not steal or defraud one another.

The ceremonies, contained in the second part of the Shaster, are these. That they wash often in the rivers, thereby obtaining the pardon of their sins; that they mark their forehead with red, in token of their relation to the Deity; that they present offerings and prayers under certain trees, set apart for this purpose; that they pray in the temples, make oblations to their pagodas or idols, sing hymns, and make processions; that they make pilgrimages to distant rivers, and especially to the Ganges, there to wash themselves and make offerings; that they make vows to particular saints, according to their respective departments; that they render homage to the Deity at the first sight of the sun; that they pay their respect to the sun and moon, which are the two eyes of the Deity; and that they treat with particular veneration those animals that are deemed more pure than others, because the souls of men have transmigrated into these animals.

The third part of the Shaster records the distribution of the people into four classes; the first being that of the Brahmins or priests, appointed to instruct the people; the second, that of the kutteris or nobles, who are the magistrates; the third, that of the shudderis or merchants; and the fourth, that of the mechanics. Each person is required to remain in the class in which he was born, and to pursue the occupation assigned to him by the Shaster. According to the Brahmins, the Shaster was imparted by God himself to Brahma, and by him to the Brahmins, who communicated the contents of it to the people.

Modern writers have given us very different accounts of the antiquity and importance of the Shaster. Mr Holwell, who had made considerable progress in the translation of this book, apprehends that the mythology as well as the cosmogony of the Egyptians, Greeks, and Romans, was borrowed from the doctrines of the Brahmins contained in it, even to the copying of the exteriors of worship, and the distribution of their idols, though grossly mutilated and adulterated. With respect to the Vedam and Shaster, or scriptures, of the Gentoos, this writer informs us, that Vedam, in the Malabar language, signifies the same as Shaster in the Sanscrit; and that the first book is followed by the Gentoos of the Malabar and Coromandel coasts, and also of the island of Ceylon. The Shaster is followed by the Gentoos of the provinces of Bengal, and by all the Gentoos of the rest of India, commonly called India Proper, along the course of the rivers Ganges and Jumna, to the Indus. Both these books, he says, contain the institutes of their respective religion and worship, as well as the history of their ancient rajahs and princes, often couched under allegory and fable. Their antiquity is contended for by the partisans of each; but he thinks that the similitude of their names, idols, and great part of their worship, leaves little room to doubt, nay plainly evinces, that both these scriptures were originally one. He adds, if we compare the great purity and chaste manners of the Shaster with the great absurdities and impurities of the Vedam, we need not hesitate to pronounce the latter a corruption of the former.

Shaster.

With regard to the high original of these scriptures, the account of the Brahmins is as follows. Brahma, or the Mighty Spirit, about 4866 years ago, assumed the form of man, and the government of Hindustan. He translated the divine law, designed for the restoration of mankind, who had offended in a pre-existent state, and who are now in their last scene of probation, to the dignity from which they were degraded, out of the language of angels, into the well-known Sanscrit language, and called his translation the *Six Scriptures of Divine Words of the Mighty Spirit.* He appointed the Brahmins, deriving their name from him, to preach the word of God; and the doctrines of the Shaster were accordingly preached in their original purity a thousand years. About this time there was published a paraphrase on the Chartah Bhade, or Six Scriptures; and about five hundred years afterwards a second exposition appeared, called the *Eighteen Books of Divine Words*, written in a character compounded of the common Hindustan and the Sanscrit. This innovation produced a schism among the Gentoos; on which occasion, it is said, those of Coromandel and Malabar formed a scripture of their own, which they pretended to be founded on the Chartah Bhade of Brahma, and called it the Vedam of Birmah, or *Divine Words of the Mighty Spirit.* The original Chartah Bhade was thrown aside, and at length wholly unknown, except to a few families, who can still read and expound it in the Sanscrit character. With the establishment of the Aughtorrah Bhade and Vedam, which, according to the Gentoo account, is 3366 years ago, their polytheism commenced; and the principles of religion became so obscure, and their ceremonies so numerous, that every head of a family was obliged to keep a Brahmin as a guide both in faith and practice. Mr Holwell is of opinion that the Chartah Bhade, or original scriptures, are not copied from any other system of theology promulgated to or obtruded upon mankind. The Gentoos do not attribute them to Zoroaster; and Mr Holwell supposes that both Zoroaster and Pythagoras visited Hindustan, not to instruct, but to be instructed.

From the account of Mr Dow, we learn that the books which contain the religion and philosophy of the Hindus are distinguished by the name of *Vedas;* that they are four in number, and, like the sacred writings of other nations, are said to have been penned by the Divinity. Veda, he says, in the Sanscrit language, literally signifies *science;* and these books treat not only of religion and moral duties, but of every branch of philosophical knowledge. The Brahmins maintain that the Vedas are the divine laws which Brahma, at the creation of the world, delivered for the instruction of mankind; but they affirm that their meaning was perverted in the first age by the ignorance and wickedness of some princes, whom they represent as evil spirits, who then haunted the earth.

The first credible account we have of the Vedas is, that about the commencement of the Cal Jug, of which era the year 1768 was the 4886th year, they were written, or rather collected, by a great philosopher and reputed prophet, called Beäss Muni, or Beäss the Inspired.

The Hindus, says Mr Dow, are divided into two great religious sects: the followers of the doctrine of Bedang, which is the original Shaster or commentary upon the Vedas; and those who adhere to the principles of the Neadirsen. The original Shaster is called *Vedang*, and is a commentary upon the Vedas. This book, he says, is erroneously called in Europe the *Vedam.* It is ascribed to Beäss Muni, and is said to have been revised some years after by one Serrider Swami, since which time it has been reckoned sacred, and not subject to any farther alterations.

Almost all the Hindus of the Deccan, and those of the Malabar and Coromandel coasts, are of this sect. The followers of the Vedang Shaster do not allow that any physical evil exists. They maintain that God created all things perfectly good; but that man, being a free agent, may be guilty of moral evil, which may be injurious to himself, but can be of no detriment to the general system of nature. God, they say, being perfectly benevolent, never punished the wicked otherwise than by the pain and affliction which are the natural consequences of evil actions; and hell, therefore, is no other than a consciousness of evil.

The Neadirsen Shaster is said to have been written by a philosopher called Goutam, nearly four thousand years ago. The Brahmins, from Mr Dow's account of their sacred books, appear to believe invariably in the unity, eternity, omniscience, and omnipotence of God; and the polytheism of which they have been accused is no more than a symbolical worship of the divine attributes, which they divide into three classes. Under the name of Brahma, they worship the wisdom and creative power of God; under the appellation of Vishen, his providential and preserving quality; and under that of Shevah, that attribute which tends to destroy.

SHAT-UL-ARAB, a large river, or rather canal, formed by the confluence of the Euphrates and the Tigris, before they enter the Persian Gulf. It forms a broad and splendid stream; and as far as Bassora, seventy miles from its mouth, it is navigable for vessels of 500 tons burden. It is generally supposed to fall into the Persian Gulf by various mouths; but this Colonel Kinneir, in his Geographical Memoir of the Persian Empire, shows to be a mistake, as those streams, supposed to be the mouths of the Shat-ul-Arab, are really the channels through which the great river Karoon pours its waters into the Gulf. With these six eastern channels the Shat-ul-Arab communicates by an artificial cut, and receives the waters of the Karoon.

SHAW, DR THOMAS, known to the learned world by his Travels to Barbary and the Levant, was born at Kendal, in Westmoreland, about the year 1692. He was appointed chaplain to the English consul at Algiers, in which station he continued for several years; and thence took proper opportunities of travelling into different parts. He returned in 1733, was elected fellow of the Royal Society, and published the account of his travels at Oxford, 1738, folio. In 1740 he was nominated principal of St Edmond Hall, which he raised from a ruinous state by his munificence; and was regius professor of Greek at Oxford until his death, which happened in 1751. Dr Clayton, bishop of Clogher, having attacked these Travels in his Description of the East, Dr Shaw published, by way of vindication, a supplement, which is incorporated into the second edition of his Travels, prepared by himself, and published in 1757, 4to.

SHAWABAD, a district of Hindustan, in the province of Bahar, situated principally between the 25th and 26th degrees of north latitude. It has the Ganges on the north, Rotas and Bahar on the south, the district of Bahar on the east, and Chunar and Rotas on the west. This is a populous and fertile country, particularly in the northern quarter, which is watered by the Ganges and the Soane. In answer to queries circulated by the Marquis Wellesley to the collectors of the districts in 1801, it appeared that the population amounted to two millions, in the proportion of one Mahommedan to twenty Hindus. The principal towns are Buxar, Boujepoor, and Arrah; and the chief rivers are the Ganges, Soane, and Caramnassa.

SHAWLS, FIGURED. This article has, within less than forty years, become a very considerable branch of our manufactures. For a long period the district of Cashmere, a province of Hindustan, formerly subject to the king of Candahar, produced articles of this description in such perfection as to make them highly prized both in Europe and in Asia. The date at which this manufacture took its rise is not known; but ever since the British established themselves in India, Cashmere shawls have been considered as one of the most valuable manufactures of the East.

These shawls are made both long and square, the former generally measuring fifty-four inches wide, and a hundred and twenty-six long; the latter are from sixty-three to seventy-two inches square. The finest of them are composed of a material exquisitely soft and warm, surpassing in this respect probably any other material that has ever been fabricated into clothing. It is recorded that, at the most flourishing period of this manufacture, the district of Cashmere had not less than 40,000 looms or frames employed in it. This district produced also a fine article of cloth, which has also been imitated in this country, and is in extensive use, called Cashmeres or Cassimeres. These manufactures were sufficient to draw to the district of Cashmere, merchants and commercial agents from Northern India, Turkey, Persia, and Tartary; and the increasing prosperity of this industrious and ingenious people was only checked by the oppressions of their own government, or the rapacity of the bordering states.

These shawls were not more prized for their fine, soft texture, than for the chaste beautiful-coloured flowering with which they were ornamented. Long practice, united to a natural delicacy of taste, enabled the manufacturers to dye the numerous colours of an unfading and brilliant hue, and to arrange them in such a manner as to produce a harmony and elegance such as no article made in Europe has ever fully equalled. The value put upon them by the traders who brought them to the different markets runs from L.5 to L.100, and those of the finest texture and greatest extent of figure sold for still higher prices. At a time when there was a duty of eighty per cent. upon their importation into this country (when, however, many were smuggled), a celebrated dealer in the article in London possessed a shawl for which he asked five hundred guineas.[1]

As this country became more and more engaged in a variety of manufactures, and the ingenuity of so many persons was put upon the stretch, it was but natural that attention should be turned to a manufacture at once so curious and so much prized. It was long before the manufacturers of this country ascertained the material of which the Cashmerian shawls were made, or by what process they were fabricated; and hence the first specimens that were produced in imitation of them in this country were very inferior. The merit of commencing, and bringing to a high degree of perfection, British shawls, belongs exclusively to Edinburgh, and the principal seat of the manufacture all along has been in Scotland. About thirty-four years ago the late Miss Bowie, who, with her father, had for a number of years been engaged in the gold-lace manufacture, attempted to make square shawls of the more simple patterns, in imitation of the Cashmere, by means of the sewing-needle, from a fabric made of silk, spun from the waste made in reeling the finest Italian silk. This plan was tedious and expensive, and in effect fell far short of the originals.

The manufacture of damask had been carried on in Edinburgh for a long period. The process by which the figures are produced in this elegant fabric first suggested the idea that a similar contrivance might produce a close imitation of the Indian shawls, both in the form of the figures and the distribution of the colours attained. To accomplish this, and to train children to insert the coloured yarn with their fingers, were simultaneously attempted by several manufacturers in Edinburgh; but although this article was manufactured by means of the fingers in Cashmere, it was soon found that the higher price of labour in Britain rendered it hopeless to establish the shawl-manufacture on this principle.

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[1] The duty is now (1840) thirty per cent.

The part of a loom termed a lay was at last constructed, and fitted up with boxes to hold the number of shuttles for the colours required. This the weaver managed by a simple application of the thumb of his left hand, whereby he was enabled, without stopping his loom, to throw in the coloured yarn, and make it catch the threads of the warp as they were raised by the draw-boy, and thus form the intended figure. Patterns required from five to twelve different colours, and consequently as many shuttles. The loom being mounted on a plan similar to that employed for weaving damask, required one, two, and sometimes three boys, according to the extent of the pattern, to draw up the threads in their order, the shuttle being driven through: where not required to form the figure, the coloured yarn remained loose and useless over the whole breadth of the shawl, and required to be cut off with scissors. There was thus a great waste of material; but as one weaver, with one or two boys, could produce as much work in a single week, as a Cashmerian, with still more hands, on his plan of working, could produce in twelve months, the saving was still very great. In place of using any thing like an ordinary loom, the Cashmere manufacturer had the threads called the warp placed in an upright frame, and the piece worked with the fingers much in the same way as tapestry used to be made. A single shawl of some of the most extensive patterns occupied a whole family from one to two years.

The material of which the finest shawls were made, was procured from a goat found in the range of mountains lying to the north and north-west of the district of Cashmere. This animal is called by them the Thibet-goat, after the mountains they inhabit. The skins of these animals are covered with a coat of strong hair five or six inches in length; at the roots of this hair is found, in small quantities, the very soft woolly substance of which the shawls are made. Napoleon caused a breed of these goats to be brought to France, from the hair of which shawls were made; and it has now become an article of commerce, and is spun in considerable quantities both in Britain and in France. France spun and manufactured it for several years before this country succeeded in importing or making it; and to that country we are still indebted for a superior article of yarn, which sells in this country, the doubled or warp at 48s. per pound weight, and the single or weft at 30s. There are two circumstances which must at all times make this article costly: the wool is obtained from the skin after death, and not while the animal is alive; and the fine part requires to be picked from the hairy part by the hand, no machine having yet been found capable of performing the separation adequately. It farther appears that these goats are found, in their natural state, only in ranges of the highest mountains; and as they do not yield a fleece like sheep, it is manifest that the supply of the article must at all times be very limited. During the earlier period of the manufacture of shawls in this country, they were either composed of silk spun from waste, or from a mixture of this article with the finest Saxony wool, carded and spun together; the flowering being composed of the same material, or of worsted; and some of the colours were of cotton only. In this state of the manufacture, the makers in Edinburgh received from L.2 to L.10 sterling for each shawl; and for several years the demand was good.

The shawl-manufacture was soon established in several places, more particularly at Norwich, Glasgow, Paisley, and at Lyons in France, and a variety of trials continued to be made to lessen the expense of production. The plan of mounting, at this stage of the manufacture, in preparing the loom and figure, cost in many instances from L.40 to L.50 before weaving was commenced; each loom requiring one, and some of the large patterns two and even three boys, to draw the cords during the process of weaving. There was also the expense of clipping off all the coloured yarn except such as was taken up to form the figure. To lessen these expenses various means had been tried, but without success.

Shawls, Figured.

During the short peace of Amiens in 1802, a straw-hat maker in Lyons, of the name of Jacquard, happened to see, in an English newspaper, an advertisement offering a premium to any one who should contrive a machine for making nets. This led him to turn his attention to the study of mechanics, and after many fruitless trials he succeeded in contriving a machine which fully answered the purpose. He was sent for, on this account, by Napoleon, and while at Paris, a superb shawl was about to be woven for the Empress Josephine; and for its production they employed a very costly and complicated loom, which had cost more than 20,000 francs. It appeared to Mr Jacquard that the same results might be produced by less complicated machinery. Intense study and perseverance enabled him to produce the machine that now bears his name. Mr Jacquard was rewarded with a decoration of honour, and a pension of a thousand crowns per annum, and sent with his machine to Lyons, the seat of the shawl and figured silk manufactures. This contrivance not only superseded the use of the draw-boy, but also rendered a great deal of tackling unnecessary; thus greatly simplifying and cheapening the production, not only of shawls, but also that of figured articles of every description.

It is a striking instance of the ignorance and shortsightedness of the operatives of Lyons, that when Jacquard introduced his invention, the people broke out into open rebellion. He was denounced as an enemy of the people, and as the man who had been scheming the destruction of their trade, and the starvation of themselves and their families. Three several plots were laid to assassinate him, and twice he was in great danger of losing his life. So strong was the tide of prejudice and indignation, that the machine was ordered to be openly destroyed by the public authorities, and was accordingly broken in pieces in the great square of the city.

The successful competition of foreigners, and the consequent decline of trade at a subsequent period, induced some of the more intelligent manufacturers to think of the man whose discovery was likely to bring some relief to the then depressed manufacturers of Lyons. They made an experiment, and succeeded. Silks of the greatest beauty were introduced at a lower cost, and now (1840) there is not a mechanic, either in France or in Britain, who does not acknowledge the great importance of Mr Jacquard's invention. This may be fully conceived, from the fact, that not only has it been very generally adopted by shawl-manufacturers, but by makers of all kinds of damask, whether of silk or of linen, in Britain. This improvement, together with a machine which the French had also contrived about the same time, for cutting off the spare yarn used in making the figures (which completely superseded hand-labour), were both adopted in France some time before they were introduced into Britain, which, with the advantage they derived from having good yarn from the wool of the Thibet-goat, procured for the French manufactures a decided advantage over the British for several years; and notwithstanding a nominal protecting duty of thirty per cent. (but in reality not affording more than twelve per cent. as facilities for smuggling were such, that any one could have had an insurance for goods being safely delivered in London, on paying to the French merchant twelve per cent. extra), goods were brought over in great quantities, which, together with a general desire for foreign productions, had the effect of ruining several British shawl-makers, as well as some extensive dealers in the article. The improvements invented by the French, however, quickly found their way to this country, and being applied with energy, soon produced a re-action in favour of Scotch manufacturers, and caused the French to suffer in their turn, from having made too large quantities in the hopes of retaining the London trade. British figured shawls are now manufactured equal, in point of elegance, with any produced in France, and superior to those of every other country in lowness of price. They are manufactured from the wool of the Thibet-goat, which is as soft as, and more perfect in figure than, the best Cashmere, and probably less than a tenth part of the cost. The material, however, used for the flowering, being finer, and the colours being more durable in the manufactures of Cashmere, they still retain a superiority over those of Europe.

Edinburgh, from the commencement of this manufacture, has taken the lead in most of the improvements connected with it, always producing the best goods of the kind; but from the circumstance of labour of various kinds being lower in Paisley and Glasgow, the manufacture has mostly been transferred to these places. At one time there were about a thousand hands employed in Edinburgh in this manufacture; now it scarcely gives work to one hundred.

Shawls in imitation of Cashmere are made of a very great variety of qualities. While some of those made of the finest materials and richest patterns still sell for L.8 or L.10 each, there are a great many made of a mixture of silk and cotton, silk and wool, cotton and wool, and some are made wholly of cotton, so that figured shawls can be purchased at five shillings each. It is computed that, at the present time, this description of shawls gives employment to at least 20,000 hands. A great many are exported to America, as well as to other parts of the world. See WEAVING. (B. Y.)

SHAWPOOR, a town of Hindustan, province of Gundwaneh, situated on the Rhair, a considerable river, which runs by the south side of the town, over a bed of rock, which impedes its navigation. It is a straggling town, with a small fort built of rubble-stone and mud. Long. 83. 23. E. Lat. 23. 34. N.

SHEATHING, in the nautical language, is the casing of that part of a ship which is to be under water, with firboard an inch thick; first laying hair and tar mixed together under the boards, and then nailing them on, in order to prevent worms from eating the ship's bottom. Ships of war are now generally sheathed with copper; but copper sheathing is liable to be corroded by the action of salt water, and something is still wanting to effect this purpose. It is very probable that tar might answer very well.

SHEATS, in a ship, are ropes bent to the clews of the sails, serving in the lower sails to haul aft the clews of the sail; but in topsails they serve to haul home the clew of the sail close to the yard-arm.

SHEAVE, in *Mechanics*, a solid cylindrical wheel, fixed in a channel, and moveable about an axis, being used to raise or increase the mechanical powers applied to remove any body.

SHEBBEARE, JOHN, a political writer, was born at Bideford, in Devonshire, in the year 1709. He received the rudiments of his education at the free grammar-school of Exeter. It has often been observed that the future life of a man may be gathered from his puerile character; and accordingly Shebbeare, while a boy at school, gave the strongest indications of his future eminence in misanthropy and learning, by the extraordinary tenaciousness of his memory and the readiness of his wit, as well as the malignity of his disposition. He was universally regarded as a young man of surprising genius, while at the same time he was despised for his malicious temper.

About the age of sixteen, Shebbeare was bound apprentice to an eminent surgeon in his native town, under whom he acquired a considerable share of medical knowledge. His talent for lampoon appeared at this early period, and he could not forbear from exercising it on his master; but the chief marks for the arrows of his wit were the gentlemen of the corporation, some of whom laughed at such trifles, while such as were irritable often commenced prosecutions against him, but without success. He was frequently summoned to appear at the sessions, for daring to speak and write disrespectfully of the magistrates; but the laugh was always on the side of Shebbeare.

When his time was out, he set up for himself, then discovering a taste for chemistry; soon after which he married an amiable young woman with no fortune, but of respectable connections. Failing in business at Bideford, he went to Bristol in 1736, entered into partnership with a chemist, and never afterwards visited his native town.

He was at Paris in 1752, where he obtained, it is said, the degree of doctor in medicine; a fact, however, which many are disposed to question.

His most celebrated performances were a series of letters to the People of England, written in a vigorous and energetic style, well calculated to make an impression on common readers. They galled the ministry, who at first were too eager to punish the author. On the 12th of January 1758, Lord Holdernesse signed a general warrant for apprehending the author, printer, and publishers of a wicked, audacious, and treasonable libel, entitled "A Sixth Letter to the People of England, on the progress of National Ruin; in which is shown that the present grandeur of France and calamities of this nation are owing to the influence of Hanover on the councils of England;" and having found them, to seize and apprehend them, together with their books and papers.

Government having received information that a seventh letter was in the press, all the copies were seized and suppressed by virtue of another warrant, dated the 23d of January. In Easter term an information was filed against him by the attorney-general, and on the 17th of June the information was tried, when Shebbeare was found guilty; and on the 28th of November he received sentence, by which he was fined L.5, ordered to stand in the pillory on the 5th of December at Charing Cross, to be confined three years, and to give security for his good behaviour for seven years, himself in L.500, and two others in L.250 each. During his confinement, he declared he never received as presents more than twenty guineas from all the world.

He was detained in prison during the whole time of the sentence, and with some degree of rigour. At the termination of his sentence, a new reign commenced; and shortly afterwards, during Mr Grenville's administration, a pension of L.200 a year was granted him by the crown, through the influence of Sir John Philips, and he ever after became devoted to the service of government. He was of course abused in almost every periodical work, which he seems in general to have had the good sense to neglect. Dr Smollett introduced him, in no very respectful light, under the name of Ferret, in Sir Launcelot Greaves; and Mr Hogarth made him one of the group in the third election print.

His publications of a satirical, political, and medical nature amount to thirty-four, besides a novel, called Filial Piety, in which hypocrisy and blustering courage are very properly chastised. He died on the 1st of August 1788.

SHEERGOTTA, a town of Hindustan, in the province of Bahar, eighty miles south by west from Patna. Long. 84. 55. E. Lat. 24. 32. N.

SHEERNESS, a town of the county of Kent, situated on the island of Sheppey. It stands at the point where the river Medway forms its junction with the Thames, on the right bank of the former river. It has been long a place of vast importance in a military point of view. The works having been suffered to fall into decay in the war with Holland in the reign of Charles II., the Dutch fleet attacked and destroyed the fortifications, and thus opened the way for an attack on the marine arsenal of Chatham. After the Dutch retired, the works were repaired, and have been from time to time vastly strengthened. It is now a complete marine fortress, and a powerful protection to the important anchorage at the Nore, where, in time of war, especially if the port of Antwerp should be in possession of an enemy, it is necessary always to have a strong naval force ready to act. These fortifications were found of great service during the mutiny of the fleet at the Nore in the year 1796. Many of the crews were soon tired of their state of rebellion, rose upon their committees, and slipping their cables, ran under the guns of the forts, and were protected from their associates.

It is now a regular marine arsenal, chiefly used for repairing ships, and well furnished with every necessary kind of stores, and of late years well supplied with what was previously scarce, good spring-water. It is a part of the parish of Minster, the population of which amounted in 1801 to 5561, in 1811 to 7003, in 1821 to 8414, and in 1831 to 7983. The town itself has diminished from 1422 to sixty-one inhabitants, as dwellings have been removed to make space for ports. It has a market on Saturday, and there is a chapel of ease to Minster church.

SHEFFIELD, an ancient, large, and flourishing market-town in the west riding of the county of York, 160 miles north-north-west from London. It derives its name from the river Sheaf, which here flows into the Don. These rivers descend from the boldly swelling hills west of the town, and form, with their mountain-tributaries, interesting features in that beautiful scenery for which the neighbourhood has always been noted. The town itself, which used formerly to be described as built upon a gentle hill, rising within an ample valley, has long since stretched over the ascending slopes on every side of its original site, particularly to the west, which is a large suburb of beautiful villas. The inequalities of the ground have not been compensated, either by the regularity of the streets, or by any thing like uniformity in the buildings. The town has been said to be black; and certainly the smoke emitted from upwards of one hundred steam-engine chimneys, and ten times that number of forges, workshops, &c., to say nothing of what issues from so many dwellings, in a place where coal is cheap, does occasionally form a considerable cloud; but the houses are not more dingy, and the streets generally much cleaner, than in other manufacturing towns of the same size. Few persons have approached the town in any direction, without being struck with the beauty of the surrounding neighbourhood, resembling, in many respects, the varied character of a nobleman's park; and it would be difficult to find a single street from which a glimpse of the landscape cannot be obtained. Many of the neighbouring villas are built of a light-coloured stone, while those in the town are mostly of a dark-red brick. A great proportion of the latter, particularly in the newer streets, are small, being the residences of the artisans and working classes generally, almost every family living in a separate dwelling. This independent occupancy, added to the fact that in few cases are the labours of the workmen carried on at home, bespeaks a degree of comfort and cleanliness scarcely to be looked for in buildings where a single room serves at once as the workshop of the industrious man and the residence of his family.

Sheffield is the modern capital of a somewhat undefined district, which for ages has been called Hallamshire, the present Hallam, a hamlet west of the town, having been considered the site of the ancient capital, where stood the *aula*, or chief residence of the Saxon lord.

Since the sixteenth century, the records of the place show a singularly rapid increase of the population. In 1615 the town contained 2207 souls, in 1755 this number was multiplied sixfold, in 1796 the census was 29,013, in 1821 the population of the entire parish of Sheffield was 65,275, and in 1831 the inhabitants were 91,692; at present they are estimated at 110,000. Of these, about 96,000 may be said to reside in the town and suburbs, the remainder in the out townships. A proportionate increase has taken place in the number of houses. These in 1831 were stated to be 19,700; they are now 25,000.

Sheffield has no municipal head, no stipendiary magistrate, or other paramount local governor. Some of the west-riding magistrates, generally those nearest, for none of them reside within the township, sit in the town-hall twice a week for the current disposal of offenders and other business. In the same building is held the manor court for the recovery of small debts; and here too are the offices of a night and day police. An attempt was made in 1838 to obtain a corporation, in conformity with the recent act of parliament; but a great majority of the inhabitants opposing the design, it was abandoned.

The vicinity of Sheffield abounds with the natural elements of prosperity; and of these the inhabitants were prompt to avail themselves, long before the means of a perfect intercommunication throughout the country had generalized these advantages. On every side of the town coal has been got, and actually within the town itself, the seams, although wrought for centuries, appearing in some places almost inexhaustible. With the coal is found ironstone, which is smelted in the neighbourhood; while clay, slate, and sandstone are abundant, and of excellent quality. A navigable canal, opened in 1819, completed a water-communication between Sheffield and the German Ocean; and in 1838, a railway to Rotherham (six miles) was finished. The line of a railway between Sheffield and Winchester is in progress, including a tunnel of three miles under the English Apennines. The number and rapid descent of the streams west of the town afford innumerable waterfalls, on which grinding establishments have been built, and in which, previous to the introduction of steam power, all the edge-tools and cutlery made in the district were ground and polished.

Sheffield has long been celebrated, not only throughout Great Britain, but all over the world, for its cutlery manufactures. The origin of this celebrity dates as far back as the reign of Edward III., when "Sheffield whittles," as certain common kinds of knives were then and afterwards called, appear to have been in repute. As early as the middle of the sixteenth century, the staple trade was fostered by the feudal lords of Hallamshire, there being still extant the various "acts and ordinances agreed upon by the whole fellowship of cutlers, and by the assent of George earl of Shrewsbury." About a century afterwards, when, in consequence of the growing reputation of the various articles manufactured at Sheffield, and the insufficiency of the manor court to restrain the making and vending of spurious wares, the credit of the trade was likely to be endangered, an act of parliament was obtained, by which, under certain regulations, the cutlers of Sheffield were constituted a body corporate. This important act, which bears date April 1624, was designed "for the good order and government of the makers of knives, sickles, shears, scissors, and other cutlery wares in Hallamshire, in the county of York, and parts adjoining;" the latter words having reference to a part of Derbyshire immediately south of Sheffield, where vast quantities of scythes and sickles have been made ever since the reign of Elizabeth.

The Cutlers' Company consisted of a master elected annually, two warders, six searchers, twenty-four assistants, and the commonalty. Their duties were generally to register apprentices, grant corporate marks to be struck on the wares of the members, and by other means to maintain the integrity of the staple trades. This corporation continued in force, with a slight modification, until the year 1814, when, by an act (54th Geo. III.), the local manufac-

Sheffield.

tures of Sheffield were placed on an entirely new footing; the liberty of engaging in any of the heretofore incorporated trades, either as masters or journeymen, being extended indifferently to all persons, whether freemen or strangers. The act which thus abolished the old corporation influence and jurisdiction still perpetuated its formal continuance, with power to grant marks, &c., the "master-cutler" being also the returning officer in the election of the two members of parliament for the borough of Sheffield, under the reform act. The corporation have a very handsome hall in Church Street.

Although the throwing open the old corporate trades to unrestrained competition had a considerable effect in multiplying manufacturers, yet the peculiar nature of the handicrafts generally limited in some degree the changes which, under other circumstances, might have resulted from the sudden rush of capital into a new channel. In the first place, a workmanlike expertness in any branch of cutlery cannot be acquired without a considerable period of probation. In the second place, the application of machinery could only be applied, except in the department of grinding, to a very limited extent; and, with this exception, manual labour can hardly be said to be superseded, but rather assisted, by water or steam power. There are other circumstances which have operated in the same direction, especially the division of labour in the production of a single article, which has given the artisans in one branch a control over the others. This has led the workmen generally to act in concert in all questions touching their respective departments of labour, as wages, apprentices, engagements with masters, &c. To maintain what they have considered their rights, or at least their interests, recourse has been had to various compacts formed under the designation of "Trades' Unions," frequently exhibiting all the melancholy results of illegal combinations. Nor has the mischief of these confederations been confined to portentous "strikes," contests between the masters and the journeymen; but nonjuring or suspected individuals among the latter have sometimes become victims to the vigilance and the vengeance of their banded fellows. What has been the entire effect of this system upon the trade of the town generally, and upon the present condition of the parties, it is not very easy to say. It may have kept up wages, but it has more certainly broken down that good understanding which formerly existed between masters and workmen, and driven numerous customers to foreign markets. The number of persons employed in the cutlery workshops is about 10,000.

About 700 tons of Swedish iron are annually landed at the canal wharf, which are converted in the town into the steel which is used in the manufacture of knives, scissors, razors, files, saws, axes, and various other cutting instruments. Of this really "precious metal," however, the greater part is exported to the United States in the form of tilted *cast steel;* that is, steel which, after carbonization in the original bars, is broken up and melted in a crucible, afterwards cast into a mould, and then reduced at the forges into rods of such sizes as the trade requires. Besides, three or four thousand tons of British iron are annually brought into the town, and some portion of it converted into steel for inferior purposes. There are several large establishments for the manufacture of the finer kinds of stoves, grates, and fenders. These articles are often executed in the most superb style, modellers and other artists being constantly employed in devising new patterns.

About a century ago, the art of plating upon copper with silver was discovered in Sheffield; and thus originated a trade of immense importance to the town. For many years past the quantity of wares executed in this beautiful and comparatively cheap material has been very great, including particularly urns, salvers, dishes, epergnes, candelabras, and indeed almost every article which had formerly been made of silver. The silver-plating establishments are among the most respectable in the town; their interests have also been the least fluctuating. These circumstances are due mainly to the fact, that in works of this kind a large capital must be sunk in stamps, dies, and other tools; added to which is the expense of creating new designs, and involving the consideration of taste as well as cost. Sheffield plate, for richness of design, the strength of its more precious material, and for excellence of workmanship, is everywhere in high estimation.

Manufactures in Britannia metal, which are likewise indigenous to the town, are carried on to a great extent, and to a singular degree of perfection. Nearly every one of the articles made in silver-plate are elegantly imitated in this cheap material; with the addition of vast quantities of spoons, which are first cast in metal moulds, and afterwards polished by brushing.

Latterly both the foregoing lucrative branches of trade have encountered some competition from the use of what has been termed German silver, a kind of brass, which combines the colour, lustre, and durability of silver, at a cost not greatly above that of manufactured copper.

Here are two or three large establishments for the manufacture of optical instruments, including especially curious works for the grinding of spectacle-glasses, the greater part of the trade throughout the country being supplied from Sheffield. Several of the manufacturers have show-rooms on their premises for the display of their brilliant wares, which are celebrated for the variety and beauty of the cutlery-goods which they contain; and visiters may here witness the various operations carried on in the workshops.

The town of Sheffield, in every branch of its productive industry, not only carries on a considerable home trade, but its leading wares find a market in every quarter of the globe. It is, however, to the United States of America that the largest and most constant consignments are made; and hence Sheffield participates very largely in every fluctuation which affects Transatlantic mercantile interests.

The inhabitants of Sheffield are largely provided with places for the promotion of religion, education, philanthropy, and intelligence. There are in the parish twelve churches, seven in the town and five in the rural townships, containing in all 15,160 sittings. Holy Trinity, or the parish church, is a noble Gothic structure, enclosing a parallelogram 240 feet in length by 130 feet in width. From near the centre rises a tower, containing ten very well-tuned bells, and surmounted by a lofty spire of handsome proportions. That part of the church now used for divine service was, in 1800, rebuilt from the foundation, and the interior fitted up in a solid, handsome, and commodious manner, so that the chancel alone presents any traces of antiquity.

The living is a vicarage, two parties presenting in turn, as representatives of the original grantees of the advowson in 1544. Independently of the vicarial patronage, three assistant ministers are appointed and maintained by the church burgesses.

In addition to the churches and chapels of the establishment, the Methodists, Independents, Baptists, Quakers, and Roman Catholics, have respectively large, handsome, and commodious places of worship, in the whole not fewer than twenty. Of these, six belong to the Wesleyans, and include some of the largest and most ornamental chapels in the connection.

Here is an old endowed grammar-school; a collegiate school, recently built by shareholders, at an expense of L.3000; and two charity schools, one for sixty boys, and the other for sixty girls, all conducted in conformity with the principles of the Church of England. The Wesleyan Methodists have just erected, outside the town, and at a cost of about L.15,000, a splendid proprietary school, capable of boarding and educating three hundred boys. Besides these establishments, all the religious denominations have week-day and Sunday schools in different parts of the town. A literary and philosophical society was instituted in 1822; they have a museum in the music-hall, containing handsome cabinets of fossils, minerals, objects of natural history, apparatus, &c. and a capital full-length portrait of the poet Montgomery, who has long been regarded as one of the chief ornaments of the town.

There is a large theatre, erected in 1762; and under the same roof a commodious assembly-room; and adjacent, the music-hall, in which concerts and public lectures are usually delivered. A short distance outside the town, on the west, are the botanical gardens, comprising a well-enclosed plot of eighteen acres of ground, laid out in a style of elegance, and commanding an extensive prospect. The glazed conservatories present a frontage of 300 feet. On the opposite slope is a beautiful cemetery.

The general infirmary, which was opened in 1797 for "the sick and lame poor of any nation," is a large and handsome edifice, on the north-west side of the town. A subscription of L.5000 has just been raised for the purpose of adding a fever-hospital to this noble institution. Sheffield has also a medical and anatomical school, a public dispensary, and a capital bath establishment. On a fine eminence, just outside the town, stands the Shrewsbury Hospital, a charity founded in 1673, and consisting of neat houses for eighteen men and eighteen women, the former receiving ten and the latter eight shillings a week, besides coals, coats, &c. Holliss's Hospital, in the town, contains sixteen houses for poor cotters' widows, who have each seven shillings a week. There are various other smaller charities.

From the earliest period of authentic history, the Lovetots, Furnivals, Talbots, and Howards, names of stirring interest in English annals, were successively chiefs of Hallamshire, the present Duke of Norfolk being lord of the manor of Sheffield. With the transactions of these illustrious families, the older records of their ample domain and its industrious inhabitants are so intimately mixed up, that it is hardly possible to give any history of the one without involving details concerning the other. One circumstance especially has given a universality of interest to this association, namely, the committal of the unfortunate Mary Queen of Scots to the custody of George the sixth earl of Shrewsbury, and the fact that she spent the greater part of fourteen years of her troubled life at Sheffield. The residence of the royal prisoner here was chiefly at the castle, a place of strength, formerly standing at the confluence of the rivers Sheaf and Don, at the northern angle of the town, but which was so utterly demolished after the civil wars, that its situation is at present only indicated by the historian, or by the ineffaceable names of adjacent localities. The Talbots had likewise a summer residence, called the "Manour," built on a fine eminence in the ancient "Lark," a mile east of the town: of this residence a shattered and far-conspicuous fragment remains. And here, too, the ill-fated Mary occasionally resided during her captivity; and the spot is often visited by curious or sympathizing individuals on that account. An enthusiastic admirer and apologist of Mary, Samuel Roberts, Esq. has recently erected, at an expense of several thousand pounds, and in a beautiful situation, in Sheffield Lark, a small castle, of the most exquisite architecture, which he calls "Queen's Tower."

The inhabitants of Sheffield are indebted for an elegant and most elaborate history of the ancient and modern state of their town and neighbourhood, to the Reverend Joseph Hunter, a native of the place, who, in 1819, published his "Hallamshire," in one volume folio.

Sheffield, *John*, Duke of Buckinghamshire, an eminent writer of the seventeenth and eighteenth century, of great personal bravery, and an able minister of state, was born about 1650. He lost his father at nine years of age; and his mother having married Lord Ossulston, the care of his education was left entirely to a governor, who did not greatly improve him in his studies. Finding that he was deficient in many parts of literature, he resolved to devote a certain number of hours every day to his studies; and thereby improved himself to the degree of learning which he afterwards attained. Though possessed of a good estate, he did not abandon himself to pleasure and indolence, but entered as a volunteer in the second Dutch war, and was in that famous naval engagement where the Duke of York commanded as admiral; upon which occasion his lordship behaved so gallantly, that he was appointed commander of the Royal Catharine. He afterwards made a campaign in the French service under M. de Turenne. As Tangier was in danger of being taken by the Moors, he offered to head the forces which were sent to defend it, and accordingly was appointed to command them. He was then Earl of Mulgrave, and one of the lords of the bed-chamber to Charles II. The Moors retired on the approach of his majesty's forces; and the result of the expedition was the blowing up of Tangier. He continued in several great posts during the short reign of James II. till that unfortunate prince was dethroned. Lord Mulgrave, though he paid his respects to King William before he was advanced to the throne, yet did not accept of any post in the government until some years afterwards. In the sixth year of William and Mary he was created Marquis of Normanby in the county of Lincoln. He was one of the most active and zealous opponents of the bill which took away Sir John Fenwick's life; and exerted the utmost vigour in carrying through the Treason Bill, and the bill for Triennial Parliaments. He enjoyed some considerable posts under King William, and possessed much of his favour and confidence. In 1702 he was sworn lord privy-seal; and in the same year was appointed one of the commissioners to treat of an union between England and Scotland. In 1703 he was created Duke of Normanby, and soon after Duke of Buckinghamshire. In 1711 he was made steward of her majesty's household, and president of the council. During Queen Anne's reign he was but once out of employment; and then he voluntarily resigned, being attached to what were called the Tory Principles. Her majesty offered to make him lord chancellor, but he declined the office. He was instrumental in the change of the ministry in 1710. A circumstance that reflects the highest honour on him, is the vigour with which he acted in favour of the unhappy Catalans, who were afterwards so inhumanly sacrificed. He was survived by only one legitimate son, who died at Rome in 1735; but he left several natural children. He died in 1721. He was admired by the poets of his age; by Dryden, Prior, and Garth. His Essay on Poetry was applauded by Addison, and his Rehearsal is still read with pleasure. His writings were splendidly printed in 1723, in two volumes 4to, and have since been reprinted in 1729, in two volumes 8vo. The first contains his poems on various subjects; the second, his prose works, consisting of historical memoirs, speeches in parliament, characters, dialogues, critical observations, essays, and letters. It may be proper to observe, that the edition of 1729 is castrated; some particulars relating to the revolution having given offence.

SHEICK, in the oriental customs, the person who has the care of the mosques in Egypt: his duty is the same as that of the imams at Constantinople. There are more or fewer of these to every mosque, according to its size or revenue. One of them is head over the rest, and answers to a parish priest with us, and has under him, in large mosques, the readers, and people who cry out to go to prayers; but in small mosques the sheick is obliged to do all this himself. In such it is their business to open the mosque, to cry to prayers, and to begin their short devotions at the head of the congregation, who stand rank and file in great order, and make all their motions together. Every Friday the sheick makes an harangue to his congregation.

SHEIKPOOR, a town of Hindustan, in the province of Bahar, fifty miles south-east from Patna. Long. 85. 54. E. Lat. 25. 8. N.

SHEKARPOOR, a town in the province of Sewistan or Seistan, situated on the west side of the Indus. It is a large town, with seven gates. The Hindu merchants who visit this country leave their wives and relatives here for security. It is governed by a Mahommedan chief, who pays tribute both to the Afghans and Ameers of Sinde. Long. 69. 49. E. Lat. 28. 47. N.

SHEKEL, the name of a weight and coin current among the ancient Jews. Dr Arbuthnot makes the weight of the shekel equal to 9 pennyweights $2\frac{4}{7}$ grains troy weight, and the value equal to 2s. $3\frac{3}{8}$d. sterling. The golden shekel was worth L.1. 16s. 6d.

SHEKOABAD, a town of Hindustan, in the province of Agra, thirty-five miles east-south-east from the city of Agra. Long. 78. 32. E. Lat. 27. 6. N.

SHELLAM, a town and district of the Upper Carnatic, in the south of India, between the 11th and 12th degrees of north latitude. The town is generally called the Great Shellam, to distinguish it from a smaller town. It is sixty miles west-north-west from Pondicherry. Long. 78. 33. E. Lat. 11. 39. N.

SHELLIUM, a town of Hindustan, in the Carnatic, sixty-five miles west from Madras. Long. 79. 27. E. Lat 13. 8. N.

SHELTON, a township and chapelry in the county of Stafford, in the hundred of North Pirehill, formerly a division of the parish of Stoke-upon-Trent. It is two miles east-north-east from Newcastle-under-Line, and is situated on the Trent and Mersey Canal, by which its trade is much facilitated. In this township are the potteries of the village of Etruria, erected by the scientific Mr Wedgewood, who has a villa in it remarkable for the beauty of its situation, and the classical arrangement of its architectural details. There are more than thirty manufactories in the town, which give occupation to above 5000 of the inhabitants. The place is well paved, and lighted with gas. It has a church, the patronage of which is in the rector of Stoke, in whose parish it was previous to the division of that large living. There are two dissenting places of worship, with Sunday schools, in which 600 children are instructed. The population amounted in 1811 to 5487, in 1821 to 7325, and in 1831 to 9267.

SHENSTONE, William, an admired English poet, the eldest son of a plain country gentleman, who farmed his own estate in Shropshire, was born in November 1714. He learned to read of an old dame, whom his poem of the School-Mistress has delivered to posterity; and he soon received such delight from books, that he was always calling for new entertainment, and expected that, when any of the family went to market, a new book should be brought him, which, when it came, was in fondness carried to bed, and laid beside him. It is said, that when his request had been neglected, his mother wrapped up a piece of wood of the same form, and pacified him for the night. As he grew older, he went for a while to the grammar-school in Hales-Owen, and was placed afterwards with Mr Crumpton, an eminent schoolmaster at Solihul, where he distinguished himself by the quickness of his progress. When he was young (June 1724), he was deprived of his father, and soon afterwards (August 1726) of his grandfather; and, with his brother, who died afterwards unmarried, he was left to the care of his grandmother, who managed the estate. From school he was sent, in 1732, to Pembroke College, Oxford, a society which has for a long time been eminent for English poetry and elegant literature. Here it appears that he found delight and advantage; for he continued his name there ten years, though he took no degree. After the first four years he put on the civilian's gown, but without showing any intention to engage in the profession. About the time when he went to Oxford, the death of his grandmother devolved the care of his affairs on the Reverend Mr Dolman, of Brome, in Staffordshire, whose attention he always mentioned with gratitude. At Oxford he applied to English poetry, and in 1737 published a small Miscellany, without his name. He then for a time wandered about to acquaint himself with life, and was sometimes at London, sometimes at Bath, or any place of public resort; but he did not forget his poetry. He published, in 1740, his Judgment of Hercules, addressed to Mr Lyttleton, whose interest he supported with great warmth at an election. This was two years afterwards followed by the School-Mistress. Mr Dolman, to whose care he was indebted for his ease and leisure, died in 1745, and the care of his fortune now fell upon himself. He tried to escape it a while, and lived at his house with his tenants, who were distantly related; but finding that imperfect possession inconvenient, he took the whole estate into his own hands, an event which rather improved its beauty than increased its produce. Now began his delight in rural pleasures, and his passion for rural elegance; but in time his expenses occasioned clamours that overpowered the bleat of the lamb and song of the linnet, and his groves were haunted by beings very different from fauns or fairies. He spent his estate in adorning it, and his death was probably hastened by his anxieties. He was a lamp that spent its oil in blazing. It is said, that if he had lived a little longer, he would have been assisted by a pension. Such bounty could not have been more properly bestowed; but that it was ever asked is not certain, and it is too certain that it never was enjoyed. He died at the Leasowes, of a putrid fever, on the 11th of February 1763, and was buried by the side of his brother, in the churchyard of Hales-Owen.

In his private opinions, Shenstone adhered to no particular sect, and hated all religious disputes. Tenderness, in every sense of the word, was his peculiar characteristic; and his friends, domestics, and poor neighbours, daily experienced the effects of his benevolence. This virtue he carried to an excess that seemed to border upon weakness; yet if any of his friends treated him ungenerously, he was not easily reconciled. On such occasions, however, he used to say, "I never will be a revengeful enemy; but I cannot, it is not in my nature, to be half a friend." He was no economist; for the generosity of his temper prevented his paying a proper regard to the use of money, and therefore he exceeded the bounds of his paternal fortune. But if we consider the perfect paradise into which he had converted his estate, the hospitality with which he lived, his charities to the indigent, and all out of an estate that did not exceed L.300 a year, one should rather wonder that he left any thing behind him, than blame his want of economy. He yet left more than sufficient to pay all his debts, and by his will appropriated his whole estate to that purpose. Though he had a high opinion of many of the fair sex, he forbore to marry. A passion he entertained in his youth was with difficulty surmounted. The lady was the subject of that admirable pastoral, in four parts, which has been so universally read and admired, and which, one would have thought, must have softened the proudest and most obdurate heart. His works have been published by Mr Dodsley, in three volumes 8vo. The first volume contains his poetical works, which are particularly distinguished by an amiable elegance and beautiful simplicity; the second volume contains his prose works; the third his letters and other pieces.

SHEPOORY, a town of Hindustan, in the province of Agra, thirty-five miles north-west from Narwar. Long. 77. 10. E. Lat. 25. 25. N.

SHEPPERTON, a village of the county of Middlesex, in the hundred of Spelthorne. It stands on the banks of the Thames, eighteen miles from London. The course of the river having been changed, a small part of the parish is now in the county of Surrey. There is a bridge here over the river, near to which are a number of piles, called Cowey Stakes, said to have been driven into the stream by the Britons, to prevent the army of Cæsar from fording the river. It is commonly asserted that the learned Erasmus passed much of his time, when in England, at the parsonage-house, with the incumbent, who was his intimate friend. There are many fine and pleasantly situated houses looking on the river in this place. The population amounted in 1821 to 782, and in 1831 to 847.

SHEPPEY, Isle of, an island, being part of the county of Kent, situated at the mouth of the Thames and Medway, and separated from the mainland by an arm of the sea, called the Swale, which is navigable for vessels of 200 tons burden, extending about eleven miles in length. Nearly four fifths of the island consist of rich marsh and pasture land, and the rest of very productive corn and clover lands. The best wheat of England is grown on this island, the land being well manured by the large flocks of sheep on the uplands, and by the cows and oxen on the rich meadows. Though fertile, it is deemed unhealthy; and there is a scarcity of good water, though that has been of late partially remedied by a well sunk 330 feet.

The island is in none of the hundreds of Kent, but is a liberty of itself. It contains 18,340 acres of land, has within it the towns of Sheerness and Queenborough, four parishes, and, in 1831, a population of 9867, of whom 4833 were males, and 5034 were females.

SHEPTON-MALLET, a town of the county of Somerset, in the hundred of Whitestone, 116 miles from London. It is situated on the Mendip Hills, in a district abundantly supplied with coal, to which it is principally indebted for its prosperity. It is a place of considerable woollen manufacture, chiefly of broad cloths and cassimeres. The streets are narrow and ill built. It has a large parish church; and in the centre of the town a curious market-cross, erected in the year 1500, consisting of five arches, supported by that number of pentagonal columns. The manor of Shepton-Mallet is a portion of the duchy of Cornwall. There is a well-supplied market on Fridays. The population amounted in 1821 to 5021, and in 1831 to 5330.

SHER, a town in the Mahratta territories, in the province of Malwah, ninety miles north-east from Oojain. Long. 78. 55. E. Lat. 23. 58. N.

SHERBET, or Sherbit, a compound drink, first brought into England from Turkey and Persia, consisting of water, lemon-juice, and sugar, in which are dissolved perfumed cakes made of excellent Damascus fruit, containing an infusion of some drops of rose-water. Another kind of it is made of violets, honey, and juice of raisins.

SHERBORNE, a town in the hundred of its name, in the county of Dorset, 117 miles from London. It was formerly a city, the see of a bishop, removed to Salisbury in the eleventh century. It is situated at the foot of a hill, with narrow and ill-built streets, and has no striking object except the old cathedral, now the parish church, one of the finest in the west of England. The only branch of industry is the silk trade, the throwing of which is carried on by machinery. Adjoining to the town is the magnificent seat of the Earl of Digby, Sherborne Castle, which was once the residence of Sir Walter Raleigh. The town is supplied with water by the river Ivel. There are markets on Tuesday, Thursday, and Saturday. The population amounted in 1821 to 3622, and in 1831 to 4075.

SHERBURN, a town of the west riding of the county of York, in the wapentake of Barkston Ash. It is situated on the great road from Doncaster to York, 185 miles from London. It was once a place of more importance than it is at present, having been the seat of an archbishop, of whose palace no vestige now remains; but there is a fine old church. The place is celebrated for its cherry-orchards, and for a peculiar kind of plums. The population of the town amounted in 1821 to 1144, and in 1831 to 1155; but the parish extends over six other townships, whose aggregate population amounted in 1821 to 2916, and in 1831 to 3068.

SHEREGUR, a town of the Sikh territories, in the province of Mooltan, seventy miles south-south-west from Lahore. Long. 73. 24. E. Lat. 30. 55. N.

SHERIBON. See Cheribon.

SHERIDAN, Thomas, D.D., the intimate friend of Dean Swift, is said by Shield, in Cibber's Lives of the Poets, to have been born about 1684, in the county of Cavan, where, according to the same authority, his parents lived in no very elevated state. They are described as being unable to afford their son the advantages of a liberal education; but he, being observed to give early indications of genius, attracted the notice of a friend of his family, who sent him to the college of Dublin, and contributed towards his support while he remained there. He afterwards entered into orders, and set up a school in Dublin, which long maintained a very high reputation, as well for the attention bestowed on the morals of the scholars, as for their proficiency in literature. So great was the estimation which this seminary enjoyed, that it is asserted to have produced in some years the sum of L.1000. It does not appear that he had any considerable preferment; but his intimacy with Swift procured for him, in 1725, a living in the south of Ireland, worth about L.150 a year, which he went to take possession of, and, by an act of inadvertence, destroyed all his future expectations of rising in the church; for, being at Cork on the 1st of August, the anniversary of King George's birth-day, he preached a sermon which had for its text, "Sufficient for the day is the evil thereof." On this being known, he was struck out of the list of chaplains to the lord lieutenant, and forbidden the Castle.

This living Dr Sheridan afterwards changed for that of Dunboyne, which, by the knavery of the farmers, and the power of the gentlemen in the neighbourhood, fell so low as L.80 per annum. He gave it up for the free school of Cavan, where he might have lived well in so cheap a country on a salary of L.80 a year, besides his scholars; but the air being, as he said, too moist and unwholesome, and being disgusted with some persons who lived there, he sold the school for about L.400; and having soon spent the money, he fell into bad health, and died on the 10th of September 1738, in his fifty-fifth year.

Lord Cork has given the following character of him. "Dr Sheridan was a schoolmaster, and in many instances perfectly well adapted for that station. He was deeply versed in the Greek and Roman languages, and in their customs and antiquities. He had that kind of good nature which absence of mind, indolence of body, and carelessness of fortune, produce; and although not over strict in his own conduct, yet he took care of the morality of his scholars, whom he sent to the university remarkably well founded in all kinds of classical learning, and not ill instructed in the social duties of life. He was slovenly, indigent, and cheerful. He knew books much better than men; and he knew the value of money least of all. In this situation, and with this disposition, Swift fastened upon him as upon a prey with which he intended to regale himself whenever his appetite should prompt him." His lordship then mentions the event of the unlucky sermon, and adds, "This ill-starred, good-natured, improvident man returned to Dublin, unhinged from all favour at court, and even banished from the Castle. But still he remained a punster, a quibbler, a fiddler, and a wit. Not a day passed without a rebus, an anagram, or a madrigal."

One of the volumes of Swift's miscellanies consists almost entirely of letters between him and the dean. He published a prose translation of Persius; to which he added the best notes of former editors, together with many judicious ones of his own. This work was printed at London, 1739, in 12mo.

Sheridan, *Mrs Frances*, wife of Thomas Sheridan, A.M. was born in Ireland about the year 1724, but descended from a good English family which had removed thither. Her maiden name was Chamberlaine, and she was granddaughter of Sir Oliver Chamberlaine. The first literary performance by which she distinguished herself, was a little pamphlet at the time of a violent party-dispute relative to the theatre, in which Mr Sheridan had newly embarked his fortune. So well-timed a work exciting the attention of Mr Sheridan, he by an accident discovered his fair patroness, to whom he was soon afterwards married. She was a person of the most amiable character in every relation of life, with the most engaging manners. After lingering some years in a very weak state of health, she died at Blois, in the south of France, in the year 1767. Her Sidney Biddulph may be ranked with the first productions of that class in ours or in any other language. She also wrote a little romance, in one volume, called Nourjahad, in which there is a great deal of imagination, productive of an admirable moral. She was likewise the authoress of two comedies, The Discovery, and The Dupe.

Sheridan, *Richard Brinsley*, a distinguished dramatist and politician, was born at Dublin in the month of September 1757, and baptized in St Mary's Church on the fourth of the following month. His grandfather and father each attained a celebrity, by the friendship with which the former was honoured by Swift, and by the competition, and even rivalry, which the latter so long maintained with Garrick. His mother, too, was a woman of considerable talents. Her affecting novel, Sidney Biddulph, could boast amongst its panegyrists Mr Fox and Lord North; and in the tale of Nourjahad she employed the graces of oriental fiction to deceive her readers into a taste for true happiness and virtue.

At the age of seven years, Richard Brinsley Sheridan was, with his eldest brother Charles Francis, placed under the tuition of Mr Samuel Whyte of Grafton Street, Dublin; and after being little more than a year under his care, they were removed to England, where Mr and Mrs Sheridan had lately gone to reside. In the year 1762, Richard was sent to Harrow, Charles being kept at home as a fitter subject for the instructions of the father. At that time, Dr Sumner was at the head of the school, and Dr Parr, who to the massy erudition of a former age joined the free and enlightened intelligence of the present, was one of the under masters. Both he and Dr Sumner endeavoured, by all possible means, to awaken in Sheridan a consciousness of those powers which he manifestly possessed; but remonstrance and encouragement were equally thrown away upon the good-humoured indifference of their pupil. One of the most valuable acquisitions he derived from Harrow, however, was that friendship with Dr Parr, which lasted throughout his life, and which identity of political opinion tended not a little to invigorate.

On his leaving Harrow, where he continued until about his eighteenth year, he was brought home by his father, who, with the elder son, Charles, had lately returned from France, and taken a house in London. Here the two brothers for some time received private tuition from Mr Lewis Kerr, an Irish gentleman, who had formerly practised as a physician; and they also attended the fencing and riding schools of Mr Angelo, at the same time receiving from their father instructions in English grammar and oratory. Of this advantage, however, the elder son appears alone to have availed himself; and Richard, determined to owe all to nature, was found as impracticable a pupil at home as at school. But, however inattentive to his studies he may have been at Harrow, it is evident, from a letter of his school-fellow, Mr Halhed, that he had already distinguished himself in poetry, and, in conjunction with his friend, had translated the seventh Idyl, and many of the lesser poems of Theocritus. In the year 1770, when Halhed was at Oxford, and Sheridan with his father at Bath, they commenced a correspondence (of which Halhed's share only remains), and, with all the hope and spirit of young adventurers, began and prosecuted several works, of which none but their translation of Aristænetus ever saw the light.

In this copartnership of genius, their first joint production was a play in three acts, called *Jupiter*, written in imitation of the burletta of Midas. Of this piece Halhed, who had furnished the burlesque scenes, entertained great hopes; nor were those of Sheridan less earnest and sanguine; yet that habit of dilatoriness, which is too often attendant upon genius, and which, throughout life, was remarkable in the character of Mr Sheridan, prevailed so far, that though he received from his friend the sketch of this piece in 1770, it was not till May next year that the probability of the arrival of the manuscript was announced to Mr Foote. Another of their projects was a periodical miscellany, the idea of which originated with Sheridan. The title intended by him for this paper was Hernan's Miscellany, to which Halhed objected, and proposed The Reformer, as a newer and better name. But this paper, for want of auxiliaries, never proceeded beyond the first number, which was written by Sheridan. It is the characteristic of fools to be always beginning; and this is not the only point in which folly and genius resemble each other. Amongst the many literary works projected by Sheridan at this period, were a collection of Occasional Poems, and a volume of Crazy Tales, to the former of which Halhed suggests, that "the old things they did at Harrow, out of Theocritus," might form a useful contribution. But neither of these came to any thing; and the translation of Aristænetus was the only fruit of their literary alliance that, as we have already stated, ever arrived at sufficient maturity for publication.

The passion, however, that now began to take possession of his heart was little favourable to his advancement in serious studies. In the neighbourhood of Miss Linley, the arts and the sciences were suffered to fall asleep, and even the translation of Aristænetus itself proceeded but slowly. After various fortune, however, it at length made its appearance in August 1771, contrary to the advice of the bookseller, and, as it might have been expected, from the unpropitious season at which it appeared, complete failure was the consequence. The disappointment of the authors was no doubt proportioned to the sanguine expectations they had indulged. But as to Mr Sheridan, he sought for consolation in the society of Miss Linley, who had now become the star of his attraction, and the centre round which revolved all his hopes. This lady, indeed, notwithstanding the drawback of her profession as a singer, appears to have spread her gentle conquests to an extent almost unparalleled in the annals of beauty. "Her personal charms, the exquisiteness of her musical talents, and the full light of publicity which her profession threw upon both," says Mr Moore, "naturally attracted round her a crowd of admirers, in whom the sympathy of common pursuit soon kindled into rivalry, till she became at length an object of vanity as well as of love. Her extreme youth, too (for she was little more than sixteen when Sheridan first met her), must have removed, even from minds the most fastidious and delicate, that repugnance they might have justly felt to her profession, if she had lived much longer under its tarnishing influence, or lost, by frequent exhibitions before the public, that fine gloss of feminine modesty, for whose absence not all the talents and accomplishments of the whole sex can atone."

Even at this early age, she had been on the point of marriage with Mr Long, an old gentleman of considerable fortune in Wiltshire; but, on her secretly representing to him, that she never could be happy as his wife, he generously took upon himself the whole blame of breaking off the alliance, and even indemnified the father by settling L.3000 upon his daughter. Mr Sheridan, who owed to this liberality not only the possession of the woman he loved, but the means of supporting her during the first years of their marriage, uniformly spoke of Mr Long with all the kindness and respect which such a disinterested character merited. Meanwhile, in love, as in all besides, the power of a mind like Sheridan's made itself felt through all obstacles; and he won the entire affections of the Syren, though the number and wealth of his rivals, amongst whom were a brother and friend, the ambitious views of the father, and the temptations to which she was hourly exposed, kept his fears and jealousies continually on the watch. But, whilst this was the case, a new and unexpected difficulty awaited him.

Captain Mathews, a married man, and intimate with Miss Linley's family, had for some time harassed her with those discreditable addresses, which it is equally painful to disclose and intolerable to endure. To the threat of self-destruction, he is said to have added the still more unmanly menace of ruining her reputation, if he could not undermine her virtue. Terrified by his perseverance, she confided her distresses to Sheridan, who lost no time in expostulating with him upon the cruelty, libertinism, and hopelessness of his pursuit. Such a remonstrance, however, was but little calculated to conciliate the forbearance of this professed man of gallantry; so that, early in 1772, Miss Linley adopted the resolution of flying to France, and taking refuge in a convent. At this time Sheridan was little more than twenty, and Miss Linley just entering her eighteenth year. Landing at Dunkirk, they proceeded to Lisle, where they procured an apartment in a convent, with the intention of remaining there until Sheridan should have the means of supporting her as his wife. On the first discovery of the elopement, Mathews busied himself making inquiries into the affair. During the four or five weeks that the young couple were absent, he never ceased to haunt the Sheridan family with all sorts of exaggerated rumours; and at length, urged on by the restlessness of revenge, he inserted a violent and inflammatory advertisement in the Bath Chronicle, in which he publicly posted Mr Sheridan as a scoundrel and a liar. The consequences of this were such as might have been expected. The party now returned from the Continent, and, without loss of time, Sheridan called out Mathews. His second on the occasion was Mr Ewart, and the particulars of the duel, which was fought with swords, are stated by himself in a letter addressed to Captain Knight, the second of Mathews. From this it appears that Mathews, being worsted, was obliged to beg his life; after which he signed an ample apology, in which he retracted the expressions he had made use of, as "the effects of passion and misrepresentation," and begged pardon for his advertisement in the Bath Chronicle.

With the odour of this transaction fresh about him, Mr Mathews retired to his estate in Wales, and there found himself universally shunned. An apology may be, according to circumstances, either the noblest effort of manliness, or the last resource of fear; and, from the reception which this gentleman everywhere experienced, it is evident that to the latter class of cases his late retraction had been referred. In this crisis, a Mr Barnett, who had but lately come to reside in his neighbourhood, took upon himself the duty of urging a second meeting with Sheridan, as the only means of removing the stigma left by the first; offering, at the same time, to be the bearer of the challenge. This offer was accepted, and the parties met at Kingsdown, where a desperate encounter ensued, in which Mr Sheridan's sword was broken, and himself severely wounded. A narrative of this affair, drawn up by Mr Barnett, and sanctioned by the concurrence of Captain Paumier (Sheridan's friend) in the truth of its material facts, was soon afterwards published; whilst the comments which Sheridan thought it necessary to make have been found in an unfinished state amongst his papers. As soon as Sheridan was sufficiently recovered of his wounds, his father sent him to pass some months at Waltham Abbey, Essex, where he continued, with but a few short intervals of absence, from August or September 1772, till the spring of the following year.

During this period, he evinced considerable industry, particularly in an abstract which he made of the History of England, and in a collection of remarks on Sir William Temple's works, especially his essay on Popular Discontents, on which his observations are tasteful and just. Still his situation was at this time singularly perplexing. He had won the heart, and even the hand, of the woman he loved, yet saw his hopes of possessing her farther off than ever. He had twice risked his life against an unworthy antagonist, yet found the vindication of his honour incomplete. He felt within himself all the proud consciousness of genius, yet, thrown upon the world without a profession, he looked in vain for a channel through which to direct its energies. Even the precarious hope which his father's favour held out had been purchased by an act of duplicity, which his conscience condemned; for he not only had promised that he would instantly abandon the pursuit, but had even taken an oath that he would never marry Miss Linley. To a mind so young and so ardent, the pressure of these various anxieties must, of course, have been great; in fact they could only have been adequately described by him who felt them; and there still exist some letters, written by him during this time, which betray a sadness and despondency, sometimes breaking out into aspirings of ambition, sometimes rising even into a tone of cheerfulness, that ill concealed the melancholy underneath. But it was impossible that Sheridan could be always under a cloud. Misunderstandings there no doubt were, arising probably from those paroxysms of jealousy into which he must have been continually thrown; but reconcilement was with no great difficulty effected; and at length Mr Linley, convinced that it was impossible to keep them much longer asunder, consented to their union, which took place on the 13th of April 1773.

A few weeks previous to his marriage, Sheridan had been entered a student of the Middle Temple. It was not to be expected, however, that talents like his would submit to toil for the distant and dearly-earned emoluments which a life of labour in this profession might secure; nor, indeed, did his circumstances admit of any such patient speculation. A part of the sum which Mr Long had settled upon Miss Linley, and occasional assistance from her father, were now the only resources left him, besides his own talents. Mrs Sheridan's celebrity as a singer was a ready source of wealth, and offers of the most advantageous kind were pressed upon them by the managers of concerts, both in town and country. But her husband at once rejected all thoughts of allowing her to re-appear in public, and, instead of profiting by the display of his wife's talents, adopted the manlier resolution of seeking independence by his own. How decided his mind was upon the subject, appears by a letter written to Mr Linley about a month after the marriage. At East Burnham, whence this letter is dated, they were now living in a small cottage, to which they had retired immediately on their marriage; and to it they often looked back with a sigh, in after times, when they were more prosperous and less happy. Towards winter they went to lodge for a short time with Storace, the intimate friend of Mr Linley, and in the following year attained that first step towards independence, a house to themselves. During the summer of 1774, they passed some time at Mr Canning's and Lord Coventry's; but so little did these visits interfere with the literary industry of Mr Sheridan, that he had not only at that time finished his play of the Rivals, but was on the point of "sending a book to press."

On the 17th of January 1775, the comedy of the Rivals was brought out at Covent Garden. This play failed on its first representation, chiefly owing to the bad acting of Mr Lee in Sir Lucius O'Trigger. Another actor was, however, substituted in his stead, and the play being lightened of this and some other incumbrances, rose at once in public favour and patronage. The best comment on this lively play is to be found in the many smiling faces that are lighted up whenever it appears. With much less wit, it exhibits more humour than the School for Scandal, and the dialogue is more natural, as coming nearer the current of ordinary conversation. The characters, however, are not such as occur very commonly in the world, and for our knowledge of them we are indebted to their confessions rather than to their actions. Lydia Languish, in proclaiming the extravagance of her own romantic notions, prepares us for events much more ludicrous and eccentric than those in which she is concerned; in the composition of Sir Lucius O'Trigger, his love of fighting is the only characteristic strongly brought out; and the wayward, captious jealousy of Falkland, though so highly coloured in his own representation, is productive of nothing answerable to such an announcement. The character of Sir Anthony Absolute is perhaps the best sustained and most natural of any, and the scenes between him and Captain Absolute are genuinely dramatic. Mrs Malaprop's mistakes have often been objected as improbable from a woman in her rank of life; but though some of them are extravagant and farcical, they are almost all amusing; and the luckiness of her simile, "as headstrong as an *allegory* on the banks of the Nile," has been acknowledged by all whose taste is not too refined to be moved by the genuine comic.

Mr Sheridan now employed the summer recess in writing the Duenna, whilst his father-in-law, Mr Linley, assisted in selecting and composing the music for it. In hands so willing, the work made speedy progress, and, on the 21st November, the Duenna was performed at Covent Garden. The run of this opera has, we believe, no parallel in the annals of the drama. The Beggar's Opera had a career of sixty-three nights; but the Duenna, more fortunate, was acted no less than seventy-five times during the season, the only intermissions being a few days at Christmas, and the Fridays in every week. In order to counteract this great success of the rival house, Garrick found it necessary to bring forward all the weight of his best characters; and he had even recourse to the expedient of playing off the mother against the son, by reviving Mrs Frances Sheridan's comedy of the Discovery, and acting the leading character in it himself. The Duenna, in fact, is one of the very few operas in our language which combine the merits of legitimate comedy with the attractions of poetry and song. The "sovereign of the soul," as Gray calls music, always loses by being made exclusive sovereign; and the division of her empire with poetry and wit, as in the instance of the Duenna, doubles her real power. The intrigue of this piece is constructed and managed with considerable adroitness, having just material enough to form three acts, without being encumbered by too much intricacy, or weakened by too much extension. And as to the wit of the dialogue, except in one or two instances, it is of that accessible kind which lies near the surface, and which, as it is produced without effort, may be enjoyed without wonder.

Towards the close of the year 1775, Garrick intending to part with his moiety of the patent of Drury Lane theatre, and retire from the stage, Mr Sheridan made him an offer as purchaser, and eventually became patentee and manager. The progress of the negociation cannot be better related than in some of Sheridan's own letters, addressed to Mr Linley, which Mr Moore has printed. It appears, indeed, that the contract was perfected in June 1776; and in a paper drawn up by Mr Sheridan many years afterwards, the shares of the respective purchasers are thus stated, viz. Mr Sheridan, two fourteenths of the whole, L.10,000; Mr Linley, the same, L.10,000; and Dr Ford, three fourteenths, L.15,000. Whence Mr Sheridan's supply came, or to whom he was indebted for this seasonable aid, has never been known. Not even to Mr Linley, whilst entering into all other details, does he hint at the fountain-head from which it was to come; and, indeed, there was something mysterious about all his acquisitions, whether in love or in learning, in wit or in wealth. Finally, in reference to this subject, the first contribution which the new manager furnished to the stock of the theatre was an alteration of Vanburgh's comedy, the Relapse, which was brought out on the 24th of February 1777, under the title of a Trip to Scarborough.

Mr Sheridan was now approaching the summit of his dramatic fame. He had already produced the best opera in the language, and there now remained for him the glory of writing also the best comedy. As this is a species of composition which, more perhaps than any other, seems to require a knowledge of human nature and the world, it is not a little extraordinary that nearly all our first-rate comedies should have been the productions of very young men. Those of Congreve were all written before he was five-and-twenty. Farquhar produced the Constant Couple in his two-and-twentieth year, and died at thirty. Vanburgh was a young ensign when he sketched out the Relapse and the Provoked Wife; and Sheridan crowned his reputation with the School for Scandal at six-and-twenty. And it is still more remarkable to find, as in the instance before us, that works, which we might suppose to have been the offspring of a careless but vigorous fancy, should, on the contrary, have been the slow result of many doubtful experiments, gradually unfolding beauties unseen even by him who produced them, and at length arriving step by step at perfection. That the School for Scandal was produced by this tardy process, is evident from the sketches of its plan and dialogue which Mr Moore has produced, and which serve to throw a remarkable light on the first slow workings of genius, out of which its finest transmutations arise. The reader who may feel curious on this subject is referred to Mr Moore's clear and masterly exposition. Suffice it to mention, that there are two distinct sketches, in the second of which particularly, is shown the condensing process which his wit must have gone through before it attained its present proof and flavour. There appear also to have been originally two plots, which the author incorporated into one; yet, even in the details of the new plan, considerable alterations were subsequently made, entire scenes suppressed or transposed, and the dialogue of some completely rewritten.

This play was produced on the 8th of May 1777, and its success was decided and triumphant. Indeed, long after its first uninterrupted run, it continued to be played regularly two or three times a week; and on comparing the receipts of the first twelve nights with those of a later period, it will appear how little the attraction of the piece had abated by repetition. The beauties of this comedy are so universally known, that it cannot be necessary to dwell upon them. With but little interest in the plot, no very profound or ingenious development of character, and a group of personages, not one of whom has any legitimate claims upon either our affection or esteem, it yet, by the admirable skill with which its materials are managed, the happy contrivance of the situations, that perpetual play of wit which never tires, and a finish almost faultless, it unites the suffrages at once of the refined and the simple, and is not less successful in satisfying the tastes of the one, than in ministering to the enjoyment of the other. And this is the true triumph of genius in all the arts. In painting, sculpture, music, or literature, those works which have pleased the greatest number for the longest space of time, may be pronounced the best; for, however mediocrity may enshrine itself in the admiration of the few, the palm of excellence can only be awarded by the many. The defects of the School for Scandal, if they can be allowed to amount to defects, are in a great measure traceable to the amalgamation of two distinct plots, out of which the piece was formed. From this cause has devolved that excessive opulence with which the dialogue is almost overloaded, and which Sheridan himself used to mention as a fault which he was conscious of in his work. From beginning to end, it is a continued sparkling of point and polish; and the whole of the characters might be comprehended under one common designation of wits, even Trip, the servant, being as shining and brilliant as the rest. "In short," says Mr Moore, "the entire comedy is a sort of El Dorado of wit, where the precious metal is thrown about by all classes, as carelessly as if they had not the least idea of its value."

Soon after the appearance of this comedy, Sheridan made a further purchase of theatrical property, amounting to L.17,000; and amongst the visible signs of his increased influence in the affairs of the house, was the appointment, this year, of his father to be manager. At the beginning of the year 1779, Garrick died, and Sheridan, who had followed his body to the grave, wrote a monody to his memory, which was recited after the play in the month of March following. In the course of the same year he produced the entertainment of the Critic, which was his last legitimate offering at the shrine of the dramatic muse. In this incomparable farce, we have a striking instance of the privilege which genius assumes of taking up subjects that had passed through other hands, and giving them new value and currency. The plan of the Rehearsal was first adopted for the purpose of ridiculing Dryden; but although there is much laughable humour in some of the dialogue, the salt was not of a very conservative nature, and the piece continued to be served up to the public long after it had lost its relish. Fielding tried the same plan in a variety of productions, but without much success, except, perhaps, in the comedy of Pasquin. It was reserved for Sheridan to give vitality to this form of dramatic humour, and to invest even his satirical portraits with a generic, which, without weakening the particular resemblance, makes them representatives of the whole class to which the original belonged. Bayes, on the other hand, is a caricature made up of little more than personal peculiarities, but may amuse as long as reference may be had to the prototype, but fall lifeless the moment the individual that supplied them is no more.

Having terminated his dramatic career, in which he had been eminently successful, Sheridan now prepared to act a part in a widely different scene. His thoughts had been gradually drawn to the seducing subject of politics, on which he had tried his hand at some very fair remarks on absenteeism; he had also rendered some service to the party with which he had connected himself, by taking an active share in a periodical publication called the Englishman; and his first appearance before the public was made in conjunction with Mr Fox, at the beginning of 1780, when the Resolutions on the State of the Representation, together with a Report on the same subject, were laid before the public. The dissolution of parliament, which took place in the autumn of 1780, at length afforded the opportunity to which his ambition had so eagerly looked forward; and Stafford was destined to have the honour of first choosing him for its representative. It is not our intention, however, to investigate his political with the same minuteness as his literary life; and this is the less necessary, seeing that the amplest narrative would probably be the heaviest, and that the masterly pen of Lord Brougham has sketched an outline which must be fully sufficient to satisfy the inquiries of the most curious and inquisitive.

"His first effort," says Lord Brougham, "was unambitious, and it was unsuccessful. Aiming at but a low flight, he failed in that humble attempt. An experienced judge, Woodfall, told him it would never do; and counselled him to seek again the more congenial atmosphere of Drury Lane. But he was resolved that it should do; he had taken his part; and as he felt the matter was in him, he vowed not to desist till he had brought it out. What he wanted in acquired learning and natural quickness, he made up by indefatigable industry. Within given limits, towards a present object, no labour could daunt him; no man could work for a season with more steady and unwearied application. By constant practice in small matters, or before private committees, by diligent attendance upon all debates, by habitual intercourse with all dealers in political wares, from the chiefs of parties and their more refined coteries, to the providers of daily discussion for the public, and the chroniclers of parliamentary speeches, he trained himself to a facility of speaking, absolutely essential to all but first-rate genius, and all but necessary even to that; and he acquired what acquaintance with the science of politics he ever possessed, or his speeches ever betrayed. By these steps he rose to the rank of a first-rate speaker, and as great a debater as a want of readiness, and need for preparation, would permit.

"He had some qualities which led him to this rank, and which only required the habit of speech to bring them out into successful exhibition; a warm imagination, though more prone to repeat with variations the combinations of others, or to combine anew their creations, than to bring forth original productions; a fierce, dauntless spirit of attack; a familiarity, acquired from his dramatic studies, with the feelings of the heart and the ways to touch its chords; a facility of epigram and point, the yet more direct gift of the same theatrical apprenticeship; an excellent manner, not unconnected with that experience; and a depth of voice which perfectly suited the tone of his declamation, be it invective, or be it descriptive, or be it impassioned. His wit, derived from the same source, or sharpened by the same previous habits, was eminently brilliant, and almost always successful. It was, like all his speaking, exceedingly prepared, but it was skilfully introduced, and happily applied; and it was well mingled also with humour, occasionally descending to farce. How little it was the inspiration of the moment, all men were aware who knew his habits; but a singular proof of this was presented by Mr Moore when he came to write his life; for we there find given to the world, with a frankness which must almost have made the author shake in his grave, the secret note-books of this famous wit; and are thus enabled to trace his jokes, in embryo, with which he had so often made the walls of St Stephen's shake, in a merriment excited by the happy appearance of sudden unpremeditated effusion.

"The adroitness with which he turned to account sudden occasions of popular excitement, and often at the expense of the Whig party, generally too indifferent to such advantages, and too insensible to the damage they thus sustained in public estimation, is well known. On the mutiny in the fleet, he was beyond all question right; on the French invasion, and on the attacks upon Napoleon, he was almost as certainly wrong; but these appeals to the people, and to the national feelings of the House, tended to make the orator well received, if they added little to the statesman's reputation; and of the latter character he was not ambitious. His most celebrated speech was certainly the one upon the Begum charge, in the proceedings against Hastings; and nothing can exceed the accounts left us of

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its unprecedented success. Not only the practice then first began, which has gradually increased till it greets every good speech, of cheering, on the speaker resuming his seat, but the minister besought the House to adjourn the decision of the question, as being incapacitated from forming a just judgment under the influence of such powerful eloquence; whilst all men on all sides vied with each other in extolling so wonderful a performance. Nevertheless, the opinion has now become greatly prevalent, that a portion of this success was owing to the speech having so greatly surpassed all the speaker's former efforts, to the extreme interest of the topics which the subject naturally presented, and to the artist-like elaboration and beautiful delivery of certain fine passages, rather than to the merits of the whole. Certain it is, that the repetition of great part of it, presented in the short-hand notes of the speech on the same charge, in Westminster Hall, disppoints every reader who has heard of the success which attended the earlier effort. In truth, Mr Sheridan's taste was very far from being chaste, or even moderately correct. He delighted in gaudy figures; he was attracted by glare, and cared not whether the brilliancy came from tinsel or gold, from broken glass or pure diamond; he overlaid his thoughts with epigrammatic diction; he 'played to the galleries,' and indulged them, of course, with an endless succession of claptraps. His worst passages by far were those which he evidently preferred himself, full of imagery, often far-fetched, oftener gorgeous, and loaded with point that drew the attention of the hearer away from the thoughts to the words; and his best by far were those where he declaimed, with his deep clear voice, though somewhat thick utterance, with a fierce defiance of some adversary, or an unappeasable vengeance against some oppressive act; or reasoned rapidly, in the like tone, upon some plain matter of fact, or exposed as plainly to homely ridicule some puerile sophism; and in all this his admirable manner was aided by an eye singularly piercing,[1] and a countenance which, though coarse, and even in some features gross, was yet animated and expressive, and could easily assume the figure of both rage, and menace, and scorn. The few sentences with which he thrilled the House, on the liberty of the press, in 1810, were worth, perhaps, more than all his elaborated epigrams and forced flowers on the Begum charge, or all his denunciations of Napoleon, 'whose morning orisons and evening prayers are for the conquest of England, whether he bends to the God of Battles or worships the Goddess of Reason;' certainly far better than such pictures of his power, as his having 'thrones for his watchtowers, kings for his sentinels, and for the palisades of his castle sceptres stuck with crowns.' 'Give them,' said he in 1810, and in a far higher strain of eloquence, 'a corrupt House of Lords; give them a venal House of Commons; give them a tyrannical prince; give them a truckling court,—and let me but have an unfettered press; I will defy them to encroach a hair's breadth upon the liberties of England.' Of all his speeches, there can be little doubt that the most powerful, as the most chaste, was his reply, in 1805, upon the motion which he had made for repealing the Defence Act. Mr Pitt had unwarily thrown out a sneer at his support of Mr Addington, as though it was insidious. Such a stone, cast by a person whose house, on that aspect, was one pane of glass, could not fail to call down a shower of missiles; and they who witnessed the looks and gestures of the aggressor, under the pitiless pelting of the tempest which he had provoked, represent it as certain that there were moments when he intended to fasten a personal quarrel upon the vehement and implacable declaimer.

"When the just tribute of extraordinary admiration has been bestowed upon this great orator, the whole of his praise has been exhausted. As a statesman, he is without a place in any class, or of any rank; it would be incorrect and flattering to call him a bad, or a hurtful, or a shortsighted, or a middling statesman; he was no statesman at all. As a party man, his character stood lower than it deserved, chiefly from certain personal dislikes towards him; for, with the perhaps doubtful exception of his courting popularity at his party's expense, on the two occasions already mentioned, and the much more serious charge against him of betraying his party in the Carlton House negociation of 1812, followed by his extraordinary denial of the facts when he last appeared in parliament, there can nothing be laid to his charge as inconsistent with the rules of the strictest party duty and honour; although he made as large sacrifices as any unprofessional man ever did to the cause of a long and hopeless opposition, and was often treated with unmerited coldness and disrespect by his coadjutors. But as a man his character stood confessedly low. His intemperate habits, and his pecuniary embarrassments, did not merely tend to imprudent conduct, by which himself alone might be the sufferer; they involved his family in the same fate; and they also undermined those principles of honesty which are so seldom found to survive fallen fortunes, and hardly ever can continue the ornament and the stay of ruined circumstances, when the tastes and the propensities engendered in prosperous times survive through the ungenial season of adversity."

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Sheridan was indeed most unfortunate. Whilst death was fast gaining on him, the miseries of life were thickening around him; nor did the last corner where he now lay down to die, afford him any asylum from the clamours of his legal pursuers. Writs and executions came in rapid succession, and bailiffs at length got possession of the house. A sheriff's officer arrested the dying man in his bed, and was about to carry him off in his blankets to a spunging house, when he was prevented by an intimation of the responsibility he must incur, if, as was but too probable, his prisoner should expire on the way. In the mean time, the attention and sympathy of the public were awakened to the desolate condition of Sheridan, by an article which appeared in the Morning Post, written, it seems, by a gentleman who, though on no very cordial terms with him, forgot every other feeling in a generous pity for his fate, and in honest indignation against those who had deserted him. But it was now too late. Its effect, indeed, was soon visible in the calls made at Sheridan's door, amongst which the Duke of York and the Duke of Argyll appeared as visiters; but the spirit that these unavailing tributes might once have comforted was fast losing the consciousness of every thing earthly; and, after a succession of shivering fits, he fell into a state of exhaustion, which continued till his death. He expired on Sunday, the 7th of July 1816, in the sixty-fifth year of his age, and was buried on the Saturday following, many royal and noble persons crowding round his insensible clay, whose notice, had it been earlier, might have soothed and comforted his death-bed, and saved his heart from breaking. (A.)

SHERLOCK, William, a learned English divine in the seventeenth century, was born in 1641, and educated at Eton school, where he distinguished himself by the vigour of his genius and his application to study. From this he was removed to Cambridge, where he took his degrees. In 1669 he became rector of the parish of St George, Botolph Lane, in London; and in 1681 was collated to the prebend of Pancras, in the cathedral of St Paul's. He was likewise chosen master of the Temple, and had the rectory of Therfield, in Hertfordshire. After the Revolution he was suspended from his preferment, for refusing the oaths to William and Mary; but at last he took them, and publicly justified what he had done. In 1691 he was installed as dean of St Paul's. His Vindication of the Doctrine of the Trinity engaged him in a warm controversy with Dr South and others. Bishop Burnet tells us he was "a clear, a polite, and a strong writer; but apt to assume too much to himself, and to treat his adversaries with contempt." He died in 1707. His works are very numerous, among which are, 1. A Discourse concerning the Knowledge of Jesus Christ, against Dr Owen; 2. Several pieces against the Papists, the Socinians, and Dissenters; 3. A Practical Treatise on Death; 4. A Practical Discourse on Providence; 5. A Practical Discourse on the Future Judgment; and many other works.

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[1] It had the singularity of never winking.

Sherlock, *Dr Thomas*, bishop of London, was the son of the preceding, and was born in 1678. He was educated in Catharine Hall, Cambridge, where he took his degrees, and of which he became master. He was made master of the Temple when very young, on the resignation of his father; and it is remarkable, that this mastership was held by father and son successively for more than seventy years. He was at the head of the opposition against Dr Hoadley, bishop of Bangor, during which contest he published a great number of pieces. He attacked Collins's Grounds and Reasons of the Christian Religion, in a course of six sermons, preached at the Temple Church, which he entitled The Use and Intent of Prophecy in the Several Ages of the World. In 1728, Dr Sherlock was promoted to the bishopric of Bangor, and was translated to Salisbury in 1734. In 1747 he refused the archbishopric of Canterbury, on account of his ill state of health; but recovering in a good degree, he accepted the see of London the following year. On occasion of the earthquakes in 1750, he published an excellent Pastoral Letter to the clergy and inhabitants of London and Westminster, of which it is said there were printed, in quarto five thousand, in octavo twenty thousand, and in duodecimo about thirty thousand, besides pirated editions, of which not less than fifty thousand were supposed to have been sold. Under the weak state of body in which he lay for several years, he revised and published four volumes of Sermons, in octavo, which are particularly admired for their ingenuity and elegance. He died in 1762, worth L.150,000. "His learning," says Dr Nicholls, "was very extensive. God had given him a great and an understanding mind, a quick comprehension, and a solid judgment. These advantages of nature he improved by much industry and application. His skill in the civil and canon law was very considerable; to which he had added such a knowledge of the common law of England as few clergymen attain to. This it was that gave him that influence in all causes where the church was concerned, as knowing precisely what it had to claim from its constitutions and canons, and what from the common law of the land." Dr Nicholls then mentions his constant and exemplary piety, his warm and fervent zeal in preaching the duties and maintaining the doctrines of Christianity, and his large and diffusive munificence and charity; particularly by his having given large sums of money to the corporation of clergymen's sons, to several of the hospitals, and to the society for propagating the gospel in foreign parts, and also bequeathing to Catharine Hall, in Cambridge, the place of his education, his valuable library of books, and his donations for the founding a librarian's place and a scholarship, to the amount of several thousand pounds.

SHERON, a village of Persia, in Irak, fifteen miles east from Kermanshaw.

SHERRIFF of Mecca, the title of the descendants of Mahommed by Hassan Ibn Ali. These are divided into several branches, of which the family of Ali Bunemi, consisting at least of three hundred individuals, enjoy the sole right to the throne of Mecca. The Ali Bunemi are again subdivided into two subordinate branches, Darii Sajid and Darii Barkad, of whom sometimes the one, sometimes the other, have given sovereigns to Mecca and Medina, when these were separate states.

SHETLAND. See Zetland.

SHEVAGUNGA, a polygar town and district of Southern India, in the province of the Carnatic, and district of Little Marawar. This country, according to the custom of the Nairs, was ruled by females until about sixty years ago, when the government was usurped by two brothers of low caste. They were expelled by the nabob of Arcot, with the aid of the British troops, who afterwards reinstated them. They were again expelled, and being pursued and captured by the British, they were condemned and executed, and the country given to a relation of the former female sovereigns. Long. of the town 78. 30. E. Lat. 9. 54. N.

SHEVAGURRY, a town of the south of India, in the district of Tinnevelly, a hundred miles north from Cape Comorin. Long. 77. 32. E. Lat. 9. 23. N.

SHEVELPATORE, a town of the south of India, in the province of the Carnatic, 110 miles north from Cape Comorin. Long. 77. 43. E. Lat. 9. 31. N.

SHIELD, an ancient weapon of defence, in the form of a light buckler, borne on the arm to fend off lances, darts, and other weapons. The form of the shield is represented by the escutcheon in coats of arms. The shield was that part of the ancient armour on which the persons of distinction in the field of battle always had their arms painted; and most of the words used at this time to express the space that holds the arms of families are derived from the Latin word *scutum*. The French *escu* and *escussion*, and the English word *escutcheon* or *scutcheon*, are evidently from this origin; and the Italian *scudo* signifies both the shield of arms and that used in war. The Latin name *clypeus*, for the same thing, seems also to be derived from the Greek word *γλυφειν, to engrave;* and it had this name from the several figures engraved on it, as marks of distinction of the person who wore it.

The shield in war, among the Greeks and Romans, was not only useful in defence, but it was also a badge of honour to the wearer; and he who returned from battle without it was always treated afterwards with infamy. People have at all times thought this honourable piece of the armour the properest place to engrave or figure on the signs of dignity of the possessor of it; and hence, when arms came to be painted for families in aftertimes, the heralds always chose to represent them upon the figure of a shield, but with several exterior additions and ornaments, as the helmet, supporters, and the rest.

The form of the shield has not only been found different in various nations, but even the people of the same nation, at different times, have varied its form extremely; and among several nations there have been shields of several forms and sizes in use, at the same period of time, and suited to different occasions. The most ancient and universal form of shields, in the earlier ages, seems to have been the triangular. This we see instances of in all the monuments and gems of antiquity. Our own early monuments show it to have been the most antique shape also with us, and the heralds have found it the most convenient for their purposes, when they had any odd number of figures to represent; as if three, then two in the broad bottom part, and one in the narrow upper end, it held them very well; or if five, they stood as conveniently, as three below and two above. The other form of a shield, now universally used, is square, rounded, and pointed at the bottom. This is taken from the figure of the Samnitic shield used by the Romans, and since copied very generally by the English, French, and Germans.

The Spaniards and Portuguese have the like general form of shields, but they are round at the bottom, without the point; and the Germans, besides the Samnite shield, Shields, North.

have two others pretty much in use. These are, first, the bulging shield, distinguished by its swelling or bulging out at the flanks; and, secondly, the indented shield, or shield chancree, which has a number of notches and indentings all round its sides. The use of the ancient shield of this form was, that the notches served to rest the lance upon, that it might be firm while it gave the thrust; but this form being less proper for the receiving armorial figures, the two former have been much more used in the heraldry of that nation.

Besides this different form of the shields in heraldry, we find them also often distinguished by their different positions, some of them standing erect, and others slanting various ways and in different degrees. This the heralds express by the word *pendant*, "hanging," because they seem to be hung up, not by the centre, but by the right or left corner. The French call these *ecu pendant*, and the common antique triangular ones *ecu ancien*. The Italians call it *scuto pendente;* and the reason given for exhibiting the shield in these figures in heraldry is, that in the ancient tilts and tournaments, they who were to joust at these military exercises were obliged to hang their shields, with their armories, or coats of arms, on them, out at the windows and balconies of the houses near the place, or upon trees, pavilions, or the barriers of the ground, if the exercise was to be performed in the field.

Those who were to fight on foot, according to Columbier, had their shields hung up by the right corner, and those who were to fight on horseback had theirs hung up by the left. This position of the shields in heraldry is called *couche* by some writers, though by the generality *pendant.*

It was very frequent in all parts of Europe, in arms given between the eleventh and fourteenth centuries; but it is to be observed that the hanging by the left corner, as it was the token of the owner's being to fight on horseback, so it was esteemed the most honourable and noble situation; and all the pendant shields of the sons of the royal family of Scotland and England, and of our nobility, at the time, are represented thus hanging from the left corner. The hanging from this corner was a token of the owner's being of noble birth, and having fought in the tournaments before; but no sovereign ever had a shield pendant any way, but always erect, as they never formally entered the lists of the tournament.

The Italians generally have their shields of arms of an oval form. This seems to be done in imitation of those of the popes and other dignified clergy; but their herald, Petro Sancto, seems to regret the use of this figure of the shield, as an innovation brought in by the painters and engravers, as most convenient for holding the figures, but derogatory to the honour of the possessor, as not representing either antiquity or honours won in war, but rather the honours of some citizen or person of learning. Some have carried it so far as to say, that those who either have no ancient title to nobility, or who have sullied it by any unworthy action, cannot any longer wear their arms in shields properly figured, but are obliged to have them painted in an oval or round shield. In Flanders, where this author lived, the round and oval shields are in the disrepute he speaks of; but in Italy, besides the popes and dignified prelates, many of the first families of the laity have them.

The secular princes, in many other countries, also retain this form of the shield, as the most ancient and truly expressive of the Roman clypeus.

Shield, in *Heraldry*, the escutcheon or field on which the bearings of coats of arms are placed.

Shield Cape, a low point on the coast of New Holland, in the Gulf of Carpentaria, which projects six miles into the sea. Long. 136. 23. E. Lat. 13. 19. N.

SHIELDS, North, a township of the parish of Tynemouth, in the county of Northumberland, 233 miles from London and eight from Newcastle, situated on the north bank of the Tyne. It has gradually grown from a dirty fishing village to a town of great extent and wealth, from the coal trade. The population amounted in 1831 to 6744.

Shields, *South*, a township of the parish of Jarrow, in the county of Durham. It stands on the river Tyne, opposite to North Shields, and, like it, has risen chiefly from the coal trade, but has, besides, extensive salt-works. There are also large establishments for making glass, and for ship-building. It consists for the most part of one street, extending nearly two miles along the bank of the river. The population amounted in 1821 to 8885, and in 1831 to 9682.

SHIFFNAL, a town of the hundred of Brimstrey, in the county of Salop, 143 miles from London. It is a small place, of no trade except that arising from its being on the great post-road from London to Holyhead. There is a market on Friday. The population amounted in 1821 to 4411, and in 1831 to 4779.

SHIJASHROTAN, one of the Kurile Islands, at the eastern extremity of Asiatic Russia, in the ocean south of Kamtschatka. Long. 154. 39. E. Lat. 49. 15. N.

SHILLING, an English silver coin, equal to twelve pence, or the twentieth part of a pound.

Freherus derives the Saxon *scilling*, whence our shilling, from a corruption of *siliqua;* proving the derivation by several texts of law, and, among others, by the twenty-sixth law, *De annuis legatis*. Skinner deduces it from the Saxon *scild*, "shield," by reason of the escutcheon of arms which it has upon it.

Bishop Hooper derives it from the Arabic *scheele*, signifying *a weight;* but others, with greater probability, deduce it from the Latin *sicilicus*, which signified in that language a quarter of an ounce, or the forty-eighth part of a Roman pound. In confirmation of this etymology, it is alleged that the shilling kept its original signification, and bore the same proportion to the Saxon pound as sicilicus did to the Roman and the Greek, being exactly the forty-eighth part of the Saxon pound.

However, the Saxon law reckons the pound in the round number at fifty shillings, but they really coined out of it only forty-eight. The value of the shilling was fivepence, but it was reduced to fourpence above a century before the Conquest; for several of the Saxon laws, made in Athelstan's reign, oblige us to take this estimate. Thus it continued to the Norman times, as one of the Conqueror's laws sufficiently ascertains; and it seems to have been the common coin by which the English payments were adjusted. After the Conquest, the French *solidus* of twelvepence, which was in use among the Normans, was called by the English name of shilling; and the Saxon shilling of fourpence took a Norman name, and was called the *groat*, or great coin, because it was the largest English coin then known in England.

It was the opinion of Bishops Fleetwood and Gibson, and of the antiquaries in general, that, though the method of reckoning by pounds, marks, and shillings, as well as by pence and farthings, had been in constant use even from the Saxon times, long before the Norman conquest, there was never such a coin in England as either a pound or a mark, nor any shilling, till the year 1504 or 1505, when a few silver shillings or twelvepences were coined, which have long since been solely confined to the cabinets of collectors.

Mr Clarke combats this opinion, alleging that some coins mentioned by Mr Folkes, under Edward I. were probably Saxon shillings new minted, and that Archbishop Ælfric expressly says that the Saxons had three names for their money: mancuses, shillings, and pennies. He also urges the different value of the Saxon shilling at different times, and its uniform proportion to the pound, as an argument that their shilling was a coin; and the testimony of the Saxon gospels, in which the word we have translated *pieces of silver* is rendered *shillings*, which, he says, they would hardly have done if there had been no such coin as a shilling then in use. Accordingly the Saxons expressed their shilling in Latin by *siclus* and *argenteus*. He further adds, that the Saxon shilling was never expressed by *solidus* till after the Norman settlements in England; and howsoever it altered during the long period that elapsed from the Conquest to the time of Henry VII. it was the most constant denomination of money in all payments, though it was then only a species of account, or the twentieth part of the pound sterling; and when it was again revived as a coin, it lessened gradually as the pound sterling lessened, from the 28th of Edward III. to the 43d of Elizabeth.

In the year 1560 there was a peculiar sort of shilling struck in Ireland, of the value of ninepence English, which passed in Ireland for twelvepence. The motto on the reverse was, *posui Deum adjutorem meum*. Eighty-two of these shillings, according to Malynes, went to the pound. They weighed therefore twenty grains one fourth each, which is somewhat heavier in proportion than the English shilling of that time, sixty-two of which went to the pound, each weighing ninety-two grains seven eighths; and the Irish shilling being valued at the Tower at ninepence English, that is, one fourth part less than the English shilling, it should therefore proportionally weigh one fourth part less, and its full weight be somewhat more than sixty-two grains. But some of them found at this time, though much worn, weighed sixty-nine grains. In 1598, five different pieces of money of this kind were struck in England for the service of the kingdom of Ireland. These were shillings to be current in Ireland at twelvepence each, half shillings to be current at sixpence, and quarter shillings at threepence. Pennies and halfpennies were also struck of the same kind, and sent over for the payment of the army in Ireland. The money thus coined was of a very base mixture of copper and silver; and two years after there were more pieces of the same kinds struck for the same service, which were still worse; the former being three ounces of silver to nine ounces of copper, and the latter only two ounces eighteen pennyweights to nine ounces two pennyweights of the alloy.

The Dutch, Flemish, and Germans, have likewise their shilling, called *schelin*, *schilling*, and *scalin*; but these not being of the same weight or fineness with the English shilling, are not current at the same value. The English shilling is worth about twenty-three French sols; those of Holland and Germany about eleven sols and a half; those of Flanders about nine. The Dutch shillings are also called *sols de gros*, because equal to twelve gros. The Danes have copper shillings worth about one fourth of a farthing sterling.

SHILOH is a term famous among interpreters and commentators upon Scripture. It is found (Gen. xlix. 10) to denote the Messiah. The patriarch Jacob foretells his coming in these words: "The sceptre shall not depart from Judah, nor a lawgiver from between his feet, until Shiloh come; and unto him shall the gathering of the people be." The Hebrew text reads, ער בי יבא שלה, *until Shiloh come*. All Christian commentators agree that this word ought to be understood of the Messiah, or Jesus Christ; but all are not agreed about its literal and grammatical signification. St Jerome, who translates it by *Qui mittendus est*, manifestly reads *Shiloach* "sent," instead of *Shiloh*. The Septuagint have it 'Εως ἀν ἔλθη τα ἀποκειμενα ἀυτω; or Εὼς ἀν ἔλθη ὡ ἀποκειται, as if they had read שלן instead of שלה, that is, "Until the coming of him to whom it is reserved;" or "Till we see arrive that which is reserved for him."

It must be owned, that the signification of the Hebrew word Shiloh is not well known. Some translate, "the sceptre shall not depart from Judah, till he comes to whom it belongs;" שלה or שלי instead of לי אלן. Others render it, "till the coming of the peace-maker," or "the pacific;" or, "of prosperity," שלה, *prosperatus est*. Others, again, "till the birth of him who shall be born of a woman that shall conceive without the knowledge of a man," שיל or שליא *secundina, fluxus;* otherwise, "the sceptre shall not depart from Judah, till its end, its ruin; till the downfall of the kingdom of the Jews," שאל or שלה, *it has ceased, it has finished*. Some rabbin have taken the name Siloh or Shiloh as if it signified the city of this name in Palestine: "The sceptre shall not be taken away from Judah till it comes to Shiloh; till it shall be taken from him to be given to Saul at Shiloh." But in what part of Scripture is it said that Saul was acknowledged as king or consecrated at Shiloh? If we would understand it of Jeroboam the son of Nebat, the matter is still as uncertain. The Scripture mentions no assembly at Shiloh that admitted him as king. A more modern author derives Shiloh from שלה, *fatigare*, which sometimes signifies *to be weary*, or *to suffer;* "till his labours, his sufferings, his passion, shall happen."

But, not to amuse ourselves about seeking out the grammatical signification of Shiloh, it is sufficient for us to show, that the ancient Jews are in this matter agreed with the Christians. They acknowledge that this word stands for the *Messiah the King*. It is thus that the paraphrasts Onkelos and Jonathan, that the ancient Hebrew commentaries upon Genesis, and that the Talmudists themselves, explain it. If Jesus Christ and his apostles did not make use of this passage to prove the coming of the Messiah, it was because then the completion of this prophecy was not sufficiently manifest. The sceptre still continued among the Jews; they had still kings of their own nation in the persons of the Herods; but soon afterwards the sceptre was entirely taken away from them, and has never since been restored to them.

The Jews seek in vain to put forced meanings upon this prophecy of Jacob, saying, for example, that the sceptre intimates the dominion of strangers, to which they had been in subjection, or the hope of seeing one day the sceptre or supreme power settled again among themselves. It is easy to perceive that all this is contrived to deliver themselves out of perplexity. In vain, likewise, they take refuge in certain princes of the captivity, whom they pretend to have maintained beyond the Euphrates, exercising an authority over their nation little differing from absolute, and being of the race of David. This pretended succession of princes is perfectly chimerical; and though at certain times they could show a succession, it continued but a short time; and their authority was too obscure, and too much limited, to be the object of a prophecy so remarkable as this was.

SHINAAS, a small seaport on the Persian Gulf, situated between the town of Sinja and Cape Bastana.

SHINGLES, in building, small pieces of wood, or quartered oaken boards sawn to a certain scantling, or, as is more usual, cleft to about an inch thick at one end, and made like wedges, four or five inches in breadth and eight or nine inches in length.

Shingles are used instead of tiles or slates, especially for churches and steeples. This covering, however, is dear; yet, while tiles are very scarce, and a light covering is required, it is preferable to thatch; and where they are made of good oak, cleft, and not sawed, and well seasoned in water and the sun, they make a sure, light, and durable covering.

SHIP, a general name for all large vessels, particularly those equipped with three masts and a bowsprit; the masts being composed of a lower mast, top-mast, and top-gallant-mast, and each of these being provided with yards, sails, and the like. Ships, in general, are either employed for war or merchandise.

SHIP-BUILDING.

Introductory Observations.

Introduction.

Aphorism of Sir Walter Raleigh.

That profound thinker, Sir Walter Raleigh, has left this aphorism on record, "Whosoever commands the sea commands the trade; whosoever commands the trade of the world commands the riches of the world, and consequently the world itself." The time has passed by in which the command of the seas either can or ought to be maintained according to the spirit in which Sir Walter Raleigh framed this aphorism. Still the principle it is intended to enforce is as essential to the wellbeing of England now as it was then. We rejoice at the liberality of international communication, and of the political relations which distinguish the present age. We do more; we fervently hope that the same spirit may increase, even until all national distinctions and national divisions shall vanish before it. Yet we cannot but remember that it is with nations as with individuals. Interests may clash, quarrels may arise, and the friendships and the kindly feelings of to-day may be succeeded by the dissensions and the feuds of to-morrow; and therefore, even in the midst of a peace unexampled for its heartiness, and for the good faith which apparently pervades the councils of the nations of Europe, we cannot with wisdom neglect those means of defence which have hitherto preserved our land inviolate.

Continental naval policy.

The aphorism of Sir Walter Raleigh is of general application; but to an insular power, and which can only be reckoned of secondary rank in the scale of nations, in as far as size and population only are involved, naval pre-eminence is essential to its independence. An eminent statesman has lately most forcibly urged upon the continental nations of Europe this all-important fact, that the command of the seas, when vested in an insular power, gives her despotic authority over the nations of the earth, because she is herself invulnerable. He proceeds from this position to the conclusion, that the interest of Europe renders it imperative, that since the sceptre of the seas is at present held by an insular power, it should be wrested from her grasp, and bestowed on another, which, by being continental, must be vulnerable on her land frontier, and cannot therefore be despotic in her naval rule. Thus far does the continental writer pursue the argument, because thus far only are the interests of continental nations concerned; but for us there is yet another induction to be made; it is this: The same cause which invests an insular power with universal dominion as long as she can maintain the sovereignty of the seas, must divest her of all power when that sovereignty is lost; she falls at once from her high pre-eminence; first on the list of nations, to rank among the secondary powers; for the sea, her impregnable fortress in the one case, becomes a barrier to her enterprise in the other. It would be no difficult task to prove, from the history of Europe, that the influence of England among the nations has increased or diminished in proportion as her navy has been fostered or neglected.

It is strange, that with such a tremendous stake at issue as national independence, it should be possible to write, and to write with truth, that there have been periods in our history, during which the navy and the naval resources of this country have been suffered to decline. The naval sceptre has more than once trembled in our grasp: we trust the time is far distant in which we may again wield it in anger; but should that time ever arrive, the struggle must be desperate, because the powers of Europe have been taught that our naval pre-eminence places their destinies in our hands.

Introdu- tion.

England has few no scien fic treat on naval chitec

In connection with the occasional neglect of her naval resources, is another strange anomaly, namely, that England has less than any other maritime power encouraged the application of the exact sciences to naval architecture. She has not to this day one original truly scientific treatise on the subject in her language; and, passing by some few papers and tracts of modern times, she can only cite the writings of uneducated and unlearned men, as Mungo Murray, Hutchinson, and Stalkart, against those of such names as the Bernoullis, Euler, Chapman, Don Juan, Bouguer, Clairbois, Romme, and a host of others. The establishment of a school for naval architecture at Portsmouth has been directly and indirectly the means of diffusing much knowledge on this important subject, and the result has been a very considerable improvement in our ships of war, so that latterly they may perhaps fairly claim equality with those of other nations. It is perhaps principally in her merchant-shipping that England now suffers from this neglect of science.

It is a recognised principle that demand creates supply, and therefore we may presume that in England there has been no demand, such as would encourage men of science to furnish forth the supply. It is not irrelevant to the subject of this article to trace out the causes which have operated to this effect; they must be made known to be removed; and it is in vain to urge improvement if there be any insuperable bar to its progress in operation. And again, it cannot be irrelevant, in an article on a national subject, and in a national work, to pursue the inquiry to its end, the more so as we believe the task will lead us to the conclusion, that, however harmless hitherto this state of apathy to improvement may have been, the time has now arrived when its continuance will be dangerous to our naval pre-eminence; for through it, to quote again from Sir Walter Raleigh, we may lose "the command of the trade of the world, the command of the riches of the world, and consequently of the world itself."

English predilec tion for sea of e origin.

The predilection for the sea, and for a seafaring life, which is proverbially general throughout the population of England, may most probably be traced to an early period in our history, when, after the Norman conquest, for a long period of years, both shores of the narrow seas were under one rule, and the nobles of the land had possessions on either side of the Channel. This, and the constant intercourse kept up between England and her armies during the long subsequent wars, must have trained a hardy race of seamen, and have made passages by sea familiar to the entire population. The impression once given, the facilities afforded for maritime adventure, by the great comparative extent of our coast, and its numberless harbours, were quite sufficient to maintain it. Our insular situation will not alone account for our love of naval enterprise; otherwise a similar predisposition would be general with the inhabitants of islands, whereas we find a most remarkable instance to the contrary in Ireland, a country possessed of even more maritime advantages than England; with a more indented, and therefore a more favourable coast, with proportionally larger rivers, and with many lakes of great magnitude in the interior. This predilection of our population for the sea has hitherto enabled us most triumphantly to maintain our naval pre-eminence, even against the known and acknowledged advantages of superior ships; for it is universally admitted that the naval powers of the Continent have, throughout their struggles with us, been possessed of superior classes of vessels, in many respects, to those which we have employed against them.

It is a question for serious consideration, whether we are sure, throughout the future, to be able to contend with equal success should we labour under similar disadvantages; or whether there are causes now in operation which may render a favourable result questionable?

In pursuing our inquiry into the present state of the theory of ships, and particularly as it is applied to our mercantile navy, we shall arrive at an answer to this question. It certainly does not necessarily follow, that because our vessels of war have been inferior to those of other nations, our merchant-shipping should be in a similar position with respect to their mercantile navies.

The merchant princes of England, with their boundless wealth, proverbial generosity, and persevering enterprise, might surely have attracted the attention of men of science to the improvement of their argosies. That they have not done so is indisputable: the startling fact, that one ship and a half is the average daily loss registered on the books at Lloyd's, appears as a sad corroboration of the acknowledged truth, that the mercantile navy of England is the least speedy and the most unsafe that belongs to a civilized nation. Several causes have combined to produce this result, and to check any improvement in our merchant-ships. These it will be our object to explain.

During the late long war, when our fleets swept the commerce of the other nations from the seas, almost the whole traffic of the world was in our hands, and the carrying trade was shared only by the Americans, their neutrality obtaining for them the same advantages that we commanded by our power; but at the peace the seas were again free to the ships of all nations, and that which had been for a long series of years almost a monopoly, was thrown open to competition. It might naturally be inferred that this would operate injuriously to us; yet the question cannot but arise, why, with all the advantages of possession of the ground, of connection, and of stock, we have been, and still continue to be, supplanted by other maritime nations? We have not only lost much of the carrying trade for foreign merchants, but even English merchants find it for their interest, as individuals, to employ a great proportion of foreign shipping, to such an extent indeed, that nearly one half of the commerce on our western coast is carried on in American vessels. It may be urged against these statements, that the statistics of our mercantile navy show an increase in its numerical strength. This may be admitted, and the force of the argument remain the same; for it is not founded on its positive increase or decrease, but on its relative increase compared with that of the mercantile navies of other nations.

That there should have been a diminution in the demand for our shipping at the conclusion of the war, is a necessary consequence of the many causes of the employment of ships which belong only to a state of war; besides which, as in time of peace the delays occasioned by waiting for convoy are avoided, the time expended in the voyages is shorter, and therefore a less number of ships is required to perform the same quantity of work. We have, however, suffered more than the proportion due to these considerations, which, it should be remembered, must also, in a lesser degree, have operated to check the progress of the American mercantile navy; however, it is this navy which is principally supplanting ours. We cannot evade the conclusion, that the reason for this must be found in the inefficiency and inadequacy of the ships themselves, and that the absence of all improvement in our mercantile navy has placed it in this disadvantageous position.

During the war, almost the only colonial supplies which could reach the continental powers were those plundered by their privateers from the English merchant. The only safety to the English merchant-ship was in sailing in large convoys, in which the velocity of the whole fleet was necessarily regulated by that of the worst sailer. It was therefore of far more importance to the merchant who had few opportunities for adventure, to choose those ships which would carry a larger quantity than those which were possessed of a quality, velocity, of which they could not avail themselves. This operated as an effectual bar to all improvement in the forms of our mercantile shipping, for it caused the absurdities of the late law for tonnage to remain unnoticed for a series of years; and when at length their injurious tendency was perceived, it was not until they had become so completely identified in men's minds with ships themselves, that years more were suffered to elapse before it was clearly made manifest, that the cause of the inferiority of the shipping was the absurdity of the law. Years more must yet elapse before the mercantile navy of Britain can recover from the state to which these laws have reduced it.

Introduction.

Tonnage laws.

Their injurious operation.

American ships sailed singly.

While English merchant-ships were restricted to sailing in convoys, the neutrality of the Americans enabled their vessels to sail singly, and consequently it became immediately desirable to attain the greatest velocity which was consistent with a due portion of the other requisite qualities for a merchant-ship; there was therefore virtually a premium on improvement. Thus the peace found America in possession of an immense commercial navy, which, on an average, could perform its passages in one third less time than our own; and although this is necessarily attained by some sacrifice of capacity, the result has shown the sacrifice to have been judicious. The peace also found America in possession of ship-builders who had made the improvement of the qualities of ships their study. She therefore was not only in possession of a better mercantile navy, with which to compete with us, but she had also the vantage-ground of superior knowledge, and a far more extended experience, from which to start for the future competition. What wonder, then, that we have failed in the contest? The wonder should rather be, that we are not wholly driven from the field. Similar injurious causes operated against the English shipping in comparison with that of several of the maritime powers. Convoy was no safety to their ships of traffic, since their ships of war found no safety for themselves. The only chance for escaping our cruisers lay in sailing singly, as less likely to attract observation, and in trusting to their velocity if observed; besides which, the northern nations of Europe have long been possessed of a very superior class of mercantile shipping, the result partly of the advanced state of the knowledge of the science of naval architecture among them, and partly also of this custom of sailing singly on long voyages, even amidst all the dangers of war. It cannot be a matter of astonishment, therefore, that when the seas were once more open to ships of all nations, the foreign merchants, whom absence of commerce had impoverished, should choose those which would the soonest allow of a return of capital, and at the same time diminish the risk of its loss; for it must be remembered, that the safety of a ship is not only dependent on her powers as a sea-boat, but is in inverse proportion to the time she is exposed to the dangers of the seas. Again, if the foreign merchant thus preferred the foreign ship to the British, surely that competition, which is the very spirit of commercial enterprise, must of necessity have impelled the British merchant to pursue the same course; for it could not be a matter of indifference to him whether his goods should be the first in the market, or should arrive when that market was glutted.

Convoy no safety to foreign ships.

Present tonnage law.

The present modification of the tonnage laws is comparatively harmless, but the leaven of the old law remains. England possesses upwards of two millions and a half of tonnage in inferior shipping; and the merchant-builders of Britain, reared under the baneful influence of that law, are, with a few honourable exceptions, unequal to the task of competition with the more educated and more practised foreigner. The theory of ships is, even by those who are the most instructed in its principles, yet considered in its infancy; it

Difficulty of the study of the theory of ships.

can only be matured by a free and impartial encouragement of the application of the exact sciences to the improvement of naval architecture, and by the total abolition of all laws which can, directly or indirectly, limit the aspirings of the merchant-builders of England in their competition with foreigners. The writer of this article believes that England scarcely ever committed a greater error than when she first determined the existence of a law for levying duties according to tonnage.

Error in having restrictions on ship-building.

We may here advert to a most striking example of the effects of the removal of this check, in the matchless excellence of the yachts of England, and may therefore not unfairly presume, that the same skill which has already exalted one class of vessels beyond competition, might, under similar circumstances, attain the same comparative excellence for another, and that our merchant-ships may yet become as unrivalled as are our yachts. Be the law of tonnage founded on weight, on bulk, or on dimensions, in each and every case it operates as a check to the most important manufacture of the country. There is evidently nothing so essential to England as that she should possess a large maritime population; and this can only be insured by the preponderance of her mercantile navy, which, again, must in future be completely dependent on the qualities of the ships that compose it.

Ships to train seamen the paramount want of England.

It is obvious, that while the effects of a long, and solid, and, we believe, hearty peace, amongst the civilized nations of the world, are to increase the wealth of all other nations as well as our own, and with their wealth to increase their shipping, it becomes a serious national duty on the part of our rulers to frame such laws as may insure to us the vantage-ground we possessed when peace enabled all alike to start in the race of improvement. That we may have free exercise for our skill, capital, and enterprise, we must not be cramped by absurd laws as to the tonnage and sailing regulations of our ships. These impediments should evidently be removed, in order to place us at least upon equal terms with our competitors.

We do not pretend to arrogate to ourselves that command of the seas which was intended by Sir Walter Raleigh. The days when fleets were bound to lower topsails at the bidding of a single pennant have, happily for the wellbeing of mankind, long passed away. But we do say that the end and object of all British policy should be to insure such preponderance on the seas, that if, amidst the changes which we almost daily see occurring, and which make the possible advent of war no speculative imagining, one should arise to plunge Europe again into strife, England may not be found wanting in practised seamen. This, we believe, can only be assured by her possessing a mercantile navy, composed of ships the good qualities of which will insure for them a large proportionate share of the carrying trade of the world. In short, we believe, that, to insure for our military navy, in times of war, successes triumphant as heretofore over every sea, it is essential that our mercantile navy should, in these times of peace, crowd every port.

It is in order to advance this cause that we shall endeavour to set in a clear point of view the several difficulties which occur in the study of naval architecture; and we feel no doubt whatever, that if the principles of construction which we shall endeavour to explain be duly attended to, and the study followed up in earnest, the results will prove their correctness, and that the mercantile navy of England will become as unrivalled in its excellencies as are almost all the other productions of the skill, talent, and enterprise of this favoured land.

Rise and Progress of Naval Architecture among the Nations of Antiquity.

Charnock's chronological divisions.

In tracing the progress of naval architecture among the nations of antiquity, in order to connect it with its advance in more modern times, we shall cite the chronological divisions adopted by that indefatigable investigator Charnock, in his valuable History of Marine Architecture, because they present a very succinct idea of the probable rise, progress, decline, and revival of the art, and therefore offer a valuable guide for investigation. It would not be consistent with the purpose of this article to enter into the detail that would be necessary to ascertain the state of naval architecture during the periods embraced in each of the sections he has assigned to this subject. We shall confine ourselves to the statement of some few facts, collected from various authors, in illustration of the probable size and nature of the shipping of the ancient world. We shall also endeavour to trace what little is known of the rude vessels which, during the darkness of the middle ages, bore the marauders of the northern nations on their predatory excursions; in which they carried desolation and misery throughout the coasts of Europe, and, while they rooted out the last relics of ancient civilization, laid the foundations of empires which were destined, in their turn, to civilize the world. With Charnock's sixth section, inclusive perhaps of some few years at the close of his fifth, the naval history of Britain commences; and during the period embraced between that date and the present time we must gradually become more diffuse in our detail.

Charnock divides maritime history into seven sections. The first comprehends the time previous to the foundation of Rome, until which, he says, all history is founded on surmise. The second section comprises a period somewhat less obscure, in which the collateral testimony of various authors may be examined and compared; and therefore there certainly appears less difficulty in ascertaining facts. It extends from the foundation of Rome to the destruction of her rival Carthage. The termination of the third is at the conversion of the republic into an empire, an era when the want of naval enemies to contend with rendered the maintenance of a fleet, as connected with the prosperity and safety of the state, a consideration not only of secondary, but immaterial consequence. The death of Charlemagne ends the fourth epoch. The fifth extends from this period to the discovery of the mariner's compass. The sixth ends with the discovery of cannon; and their adaptation to naval warfare commences the seventh epoch.

Ancient shipping principally propelled by oars.

It will avoid much useless repetition if we premise our investigations on the state of ship-building among the nations of antiquity, by the observation that their fleets, whether for war or for commerce, appear to have consisted almost entirely of vessels whose principal mode of propulsion was by the use of oars. It would be foreign to the object of the present article to enter into the useless and perplexing, though most enticing question, as to how those oars were applied in the trireme, quadrireme, and quinquireme, nay, on the authority of Plutarch, even to the extent of fifty distinct banks of oars. It is possible to conceive many methods in which the benches of the biremes, and even of the triremes, may have been disposed, which would enable the oars to be plied with ease and advantage. But the vast combination implied by the fifty banks of the galley of Ptolemy Philopater has as yet received no solution, unless it may be that suggested by Mr Holwell in his Essay on the War Galleys of the Ancients, which we shall therefore, in the absence of all certain data, adopt. He imagines that the banks of oars must have been arranged obliquely up the sides of the vessel, as many oars in each bank as would admit of the highest being rowed with facility; then each additional bank would only require additional length in the vessel. Thus the galley of Ptolemy Philadelphus might have had forty, and that of Ptolemy Philopater fifty, of these oblique ascents of oars, and yet need not necessarily have been higher out of the water than the ordinary quinquireme. It should be stated, that the triremes seem to have been the limit of practical utility in the disposition of the oars, as they appear to have been most usually adopted for the purposes of war.

ojan r.

In tracing the records of the sizes of vessels, we find, on the authority of Thucydides, that the Grecian flotilla, at the siege of Troy, about 1184 years B. C., consisted of 1200 vessels, the largest of which contained not more than 120, the least fifty people. He also expressly says that they were without decks. These were therefore mere open row-boats or canoes.

rst naval ttle.

A great improvement on these must have been made in the fleets of the Corcyrians and Corinthians, between whom took place the first naval battle on record, and which occurred about 650 years before Christ; because at that time it appears the arrangement of the oars in banks had been introduced.

ils evi- ntly little ed.

We may perhaps infer, from a statement made by Thucydides, that these vessels were not adapted for carrying any large portion of sails, as they evidently had little if any ballast. He says (book i. chap. 50), "The Corinthians, when their enemies fled, staid not to fasten the hulls of the galleys they had sunk unto their own galleys, that so they might tow them after, but made after the men, rowing up and down to kill rather than to take alive." The vessels spoken of as sunk were evidently merely stove in and water-logged.

ventors the tri- mes and inqui- mes.

Herodotus, Thucydides, and Diodorus agree that Aminocles, the "shipwright of Corinth," was the inventor of the trireme, about forty years previous to this battle. The invention of the quinquireme is generally attributed to the Carthaginians.

lamis.

At the battle of Salamis, 480 years B. C., on the authority of Plutarch, the largest Grecian vessels carried only eighteen soldiers, exclusive of the rowers, and those employed in manœuvring the vessels.

eet of ardonius.

In the fleet of Mardonius, crowded as it must have been by a force collected for the purpose of invasion, we find that, on a comparison of the number of ships lost by tempest and the number of men drowned, the average is only sixty-six men to each vessel. This fleet consisted of 1200 galleys, and 2000 hulks (ὁλκαδες) of the "round manner of building."

ssels lf cked.

The whole of the Grecian vessels appear to have been only half-decked; the soldiers were stationed on platforms at each extremity, the middle or waist being left open for the rowers. Cimon, the celebrated Athenian commander, was apparently the first to join these two platforms with an intermediate flat, and thus to form a perfect deck, for the purpose of opposing a stronger armed force to the Persians.

cks in- duced Cimon.

This innovation took place preparatory to the battle of Eurymedon, B. C. 470. These decks were hatches to be removed at pleasure. The quinquiremes appear afterwards to have been always thus fitted, the quadriremes and biremes only occasionally; and all below these in size were open boats.

ips of ght build.

From the rapid preparation of armaments of most imposing force, in as far as numbers of shipping are concerned, and also from the fact of the ease with which the vessels were transported by land, we must infer that they were of but small dimensions, and of very fragile construction; and though occasionally we find that fabrics of large size were constructed, it was evidently, from the gorgeous descriptions which remain of them, more out of ostentation than from any anticipation of their utility.

eet of earchus.

The vessels composing the fleet of Alexander the Great in his Indian expedition, and in which Nearchus performed his celebrated voyage, were row-galleys of such moderate dimensions that, in the course of the voyage, they were frequently hauled on shore; and although we find, by collating the number of vessels and the number of men composing the expedition, that there could not have been more than fifty or sixty men on board each vessel, their accommodations were so poor that the journal takes notice of the inconvenience experienced by the crews from being obliged to remain for two consecutive nights on board. Purchas gives the detail of this voyage of Nearchus, on the authority of Arianus, lib. viii.

Carthaginians.

To pass to the Carthaginians, a people of great commercial enterprise and importance, and who inherited their nautical knowledge from their progenitors the Phœnicians, of whose commercial wealth history, both sacred and profane, gives repeated evidence: Ezekiel (chap. xxvii.) says of Tyre, It is situated at the entry of the sea, is a merchant for many isles; its ship-boards are of fir-trees of Senir, their masts of cedars, their oars of oak of Bashan, their benches of ivory, their sails of fine embroidered linen.

Voyage of Hanno.

We find that the Carthaginians must at a very early period of their history have possessed vessels of considerable magnitude; for in the journal of the much though unjustly disputed voyage of Hanno, which Clark, in his History of Maritime Discovery, places at 350 B. C., but which by some historians is said to have taken place as early as 1000 B. C., sixty ships afforded accommodation for 30,000 souls, including women and children, and this, too, with all the stores and requisites for colonization, which was the main purport of the enterprise. The little we know of the Carthaginians, we know through their implacable foes the Romans; and as the Roman fleets were built after a Carthaginian model, we may pass on to investigate the few certain particulars we can collect of the Roman shipping; though, in doing so, we must not assume that we are in possession of the extent of the state of naval science among the Carthaginians. All that the Romans adopted from them was their war-galley. Their commerce, and consequently their commercial vessels, were alike despised by this predatory state, which then lived almost solely by the sword.

Roman shipping.

Charnock, on the authority of Meibomius, has given the following as the dimensions of the Roman trireme and quadrireme. The triremes were 105 feet long and eleven feet broad. The quadriremes were 125 feet long and thirteen feet broad. The triremes, after the time of Julius Cæsar, were ninety feet long and ten feet broad. These dimensions have a much greater comparative length to breadth than the proportions adopted for the Neapolitan and Maltese galleys of more modern times. In them the length seldom exceeded seven breadths. According to Vossius, who is also one of the most voluminous writers on the subject of the shipping of the ancients, these Neapolitan galleys were capable of performing voyages by the oar of sixty leagues in twenty-four hours; and the distance from Naples to Palermo has been performed in seventeen hours.

Cæsar's account of the size of ships

Cæsar himself gives us a good criterion of the size of the Roman vessels employed by him in the invasion of Britain; for he says that they were so large that they could not approach near enough to the shore for the soldiers to disembark, but that they were obliged, encumbered as they were with their arms, to jump into the water, which was breast high; and that at last the galleys were ordered in between these larger vessels and the shore, to protect the disembarkation.

First Roman fleet.

When we consider the dimensions above quoted for the Roman navy, it does not appear that there is necessarily much exaggeration in the accounts given of the wonderful exertions made by that people to prepare their first maritime force. Sixty days after the axe was laid to the root of the tree, 160 galleys according to some accounts, 100 quinquiremes and twenty biremes according to others, rode at anchor in the sea; the quinquiremes each manned by 300 rowers and 200 soldiers. Polybius states the Roman fleet at the time of the first Punic war to have consisted of 330 ships, each containing 300 rowers and 120 soldiers. If we compare the small number of vessels which the might of Rome put forth at this time, when her very existence depended upon the success of her naval exertions, and then contemplate the enormous numerical force of the fleets of the petty Grecian states, we may form a very correct judgment of the necessarily comparative insignificance of the vessels which composed these more early navies.

Classes of Roman Shipping.

The Roman ships were divided into three classes: the *naves longæ*, or ships of war; the *naves onerariæ*, or ships of burthen; and the *naves liburnæ*, which were ships built expressly for great velocity, and may be supposed to have been used as despatch-boats, and for making passages with important personages. There is repeated evidence to prove that these vessels were invariably built of pine, cedar, or other light woods, excepting about the bows, which were of oak, strongly clamped and strengthened with iron or brass, in order to withstand the shock of opposing vessels; the tactics being comprised in the attempt to sink or damage the enemy's vessel, by violently propelling this armed bow against the weaker broadside of the enemy, or else endeavouring to break and cripple the oars. Oak was first applied to ship-building by the Veneti. This we have on the testimony of Cæsar in his treatise *De Bello Gallico*, lib. iii. cap. 13. Copper or brass was introduced for fastenings, in consequence of the quick corrosion of the iron, about the time of Nero. This is stated on the authority of Vegetius, and also of Athenæus; and Pliny mentions that flax was used for the purpose of caulking the seams of the plank.

Oak first used in ship-building.

Copper.

Caulking.

Exhumation of a Roman vessel.

The following quotation is from Locke's History of Navigation: "Sheathing of ships is a thing in appearance so absolutely new, that scarce any will doubt to assert it altogether a modern invention; yet how vain this notion is, will soon appear. Leo Baptisti Alberti, in his book of Architecture (lib. v. cap. 12), has these words: But Trajan's ship weighed out of the lake of Riccia at this time, while I was compiling this work, where it had lain sunk and neglected for above thirteen hundred years; I observed that the pine and cypress of it had lasted most remarkably. On the outside it was built with double planks, daubed over with Greek pitch, caulked with linen rags; and over all a sheet of lead fastened on with little copper nails. Raphael Volaterranus, in his Geography, says this ship was weighed by the order of Cardinal Prospero Colonna. Here we have caulking and sheathing together, above sixteen hundred years ago; for I suppose no man can doubt that the sheet of lead nailed over the outside with copper nails was sheathing, and that in great perfection, the copper nails being used rather than iron, which, when once rusted in the water, with the working of the ship, soon lose their hold and drop out."

Slight as this sketch may appear of the navies of antiquity, it embraces an outline of almost all that has descended to our times. No portion of ancient history is so imperfect as that which relates to the shipping, and in none necessarily has the historian derived less aid from remains. Even the monumental records here fail him, as the prow alone is sculptured on them.

Progress of Naval Architecture from the Downfall of Rome to the present Time.

Middle ages.

During the many centuries of utter stagnation in all improvement which succeeded the downfall of ancient civilization, it would appear vain to seek for records of the progress in naval architecture. "These were times," says Rymer, in the dedication of the third volume of the Fœdera, "of great struggle and disorder, all Europe over, and the darkest period of times." Although it may be useless to search for records of the improvement of the means of navigation during these ages, when thought appears to have been banished from the earth, and action to have been the only object of man's life, we may undoubtedly expect that, in the countries bordering on the seas, the spirit of naval enterprise would be peculiarly fostered, as congenial to man's habits, or essential to his preservation, during a period of universal aggression, confusion, and migration. The northern regions of the earth, regions which the civilization of the south had deemed uncongenial to man and unfit for his habitation, appear to have teemed, in all their wild and far-spreading districts, with a hardy and an adventurous population, horde after horde of whom poured down from the north-east in irresistible might, and spread desolation and misery throughout Southern and Western Europe; while from the north-west the same wide-spreading desolation swept away all trace of the incipient civilization of Britain and of Gaul. Every sea was ploughed by the fragile barks of the Scandinavian adventurers, and every shore was devastated by their incursions. Denmark, Norway, and Sweden sent their hardy sons to the coasts of the German Ocean, the Channel, the Bay of Biscay, and even to the Mediterranean on the west; while the barbarians of the Sclavonian nations poured down through the Danube and the Borysthenes on the east of Europe, the population of which, rendered feeble by the divisions and dissensions attendant upon the breaking up of the gigantic power of Rome, and enervated by the Sybaritc civilization of the latter days of that empire, perished beneath the arms or bent to the yoke of the hardy progeny of the north. The Saracens wrested from the descendants of the Cæsars the remnant which the Goth and Hun had spared; and Europe became repeopled throughout its limits with a young, a vigorous, and an enterprising population, while the maritime provinces had generally been the spoil of tribes inured to the dangers and delighting in the excitement of maritime adventure.

Northern nations.

Their enterprise.

We cannot but be astonished at the indomitable spirit of enterprise which characterized these rude times. But that, perhaps, which is the most extraordinary feature of the daring that distinguished this period, is to be traced by the results of its naval expeditions, which could not be believed, had they not been established on the most unquestionable evidence; and the whole history of the middle ages, with their revolutions, may be cited in corroboration of them. Still they had such important influence on the state of Western Europe, that, judging of causes by their effects, there must ever remain a doubt of our being in possession of correct information as to the means by which the results we speak of were accomplished. It is not difficult to suppose adventurous men trusting themselves to the mercies of the winds and the waves, and leaving the sterile north to plunder and colonize more favoured climates, of the existence of which their traditions might inform them. But this is not all: there is ample evidence to prove a recurrence of such enterprising voyages, their successful achievement, and the safe return of the adventurers, not only to Norway and the main land, but to Iceland; a remote spot, which might be left, but certainly could not be again repeatedly attained without more knowledge than we are willing to concede to so remote a period.

Their co parative difficulti

The navigator of the present day, accustomed to rely on the almost infallible aid of the compass, the chronometer, and the sextant, would pause ere he dared to commit himself to the boundless expanse of ocean, with no more sure pilotage over its trackless waters than he might chance to find from the appearance of the sun or stars and the flight of birds. And yet we have no record that these Scandinavian sea-kings knew of more certain guides than the sun by day, the stars by night, and such further aid as perchance might be wrested to their purpose, from the varied phenomena of nature; phenomena which may now be unobserved, because not needed.

Voyage Floke.

We read in Purchas's Pilgrims the following account of the voyage of Floke, a Norwegian pirate, made in the early part of the tenth century, from Shetland to Iceland; which he gives on the authority of Arngrim Jonas, an Icelandic

story.

historian. "There was yet no use of the marinrs compasse, wherefore Floco leaving Hietlandia, tooke certayne ravens unto him; and when hee thought hee had sayled a great way, he sent forth one raven, which flying aloft, went backe againe to Hietlandia, which she saw behind. Whereupon Floco perceiving that he was yet neerer to Heitlandia then other countryes, and therefore couragiously going forward, he sent forth another raven, which, because she could see no land, neither before nor behind, light unto the ship again. But, lastly, the third raven was sent forth by Floco, and having for the most part performed his voyage, through the sharpnesse of her quicke sight attayned the land, she speedily flew thither, whose direction Floco following, beheld first the eastern side of the iland."

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The vessels of the Saxon marauders are described by Charnock in the following terms: "The keel of their large flat-bottomed boats was framed of light timber, but the sides and upper works consisted only of wicker, with a covering of strong hides. The Saxon boats drew so little water, that they could easily proceed four score or an hundred miles up the great rivers; the weight was so inconsiderable, that they were transported on waggons from one river to another; and the pirates who had entered the mouth of the Seine or the Rhine might descend with the rapid stream of the Rhone into the Mediterranean."

This description of the skin-covered boats of the northern seas is founded on testimony which cannot be disputed. And, if they were used by the Northmen on their longer voyages, it was probably when they purposed incursions into the interior of the countries they were about to devastate; but that they must have had another and a far superior description of vessel, there can be no reason to doubt.

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The investigations of the Royal Society of Northern Antiquarians at Copenhagen have thrown considerable light on the subject of this early navigation, and of the discoveries of the Scandinavians in the west; and we can no longer suppose that it was in these coracles that frequent voyages were made to Newfoundland, and colonies established there, which it appears proved that there were even as early as the tenth century. But to recur to evidence which is familiar to us.

ulish
eti.

We have the description given by Cæsar of the ships of the Gaulish Veneti. "Their bottoms were somewhat flatter than ours, their prows were very high and erect, as likewise their sterns, to bear the hugeness of the billows and the violence of the tempests. The body of the vessel was entirely of oak. The benches of the rowers were made of strong beams about a foot in breadth, and fastened with iron nails an inch thick. Instead of cables, they secured their anchors with chains of iron; and made use of skins and a sort of thin pliant leather, by way of sails, probably because they imagined that canvass sails were not so proper to bear the violence of tempests, the rage and fury of the winds, and to govern ships of that bulk and burthen. ……Neither could our ships injure them with their beaks, so great was their strength and firmness, nor could we easily throw our darts, because of their height above us, which also was the reason that we found it extremely difficult to grapple the enemy and bring them to close fight." And again, speaking of the manner in which these ships were eventually taken possession of: "They," the Romans, "had provided themselves with long poles, armed with long scythes; with these they laid hold of the enemies' tackle, and drawing off the galley by the extreme force of oars, cut asunder the ropes that fastened the sailyards to the masts; these giving way, the sailyards came down, insomuch that as all the hopes and expectations of the Gauls depended entirely on their sails and rigging, by depriving them of this resource we at the same time rendered their vessels wholly unserviceable."

History.

The account proceeds to state, that many attempted to escape from this unforeseen means of aggression; but that the wind falling, and a perfect calm coming on, they were obliged to remain inactive on the water, and were taken possession of, one after the other, by the simultaneous attack of several Roman galleys. It would appear from this that they were vessels only intended for sailing, and that since oars were used, from the mention made of seats for the rowers, they could have been as very partial accessories to the sails, or probably even only for steering. Another fact is mentioned by Cæsar, that the Veneti sailed from their port to meet the Roman fleet, and several of the vessels escaped to their port from the fleet. This, though not conclusive of the fact of sailing on a wind, is worthy of notice.

Hengist and Horsa.

It is probable that it was ships such as these which brought Hengist and Horsa to England about the middle of the fifth century, since it is recorded that their force, which consisted of 1500 men, found accommodation in only three vessels. It is hardly to be imagined that the coracles or skin-boats of the northern nations were ever of sufficient dimensions to accommodate a force of 500 men, with arms and means of active aggression.

Danish invasions.

In the course of little more than a century from the first invasion of Hengist and Horsa, England became quietly subject to Saxon rule; and the prosperity incidental to a state of peace made her again a fit object of prey to new hordes of northern pirates, the Danes. But it is useless to dwell long on these times of historical doubt and inaccuracy. In the words of Milton, "These bickerings to record, what more worth is it than to chronicle the wars of kites or crows, flocking and fighting in the air."

Dawn of civilization.

At length order once more asserted her right to control men's actions, and out of order the arts and wants of civilization began again to dawn in the newly-formed states which had arisen from the wreck of the empires of antiquity. Man then saw that peace ministered to his comfort, and he turned his thoughts to commerce rather than to the sword, as a means of gratifying his newly-acquired cravings. Thus a long period did not elapse before those seas, which had for centuries been tracked only by the bark of the lawless marauder, bore on their surface the well-freighted craft of the peaceful and industrious merchant.

Rise of Venice.

The earlier irruptions of the northern barbarians into Italy had desolated the Roman province of Venetia, and driven a remnant of its inhabitants to the refuge afforded by the small marshy islands at the extremity of the Adriatic. There they are described by Cassiodorus, who assimilates them to water-fowl, as subsisting on fish, and steeped in poverty, their only manufacture and their only commerce being salt. From such humble beginnings arose the state destined to connect the old world with the new, and to lead the van of modern commercial and maritime enterprise. The mercantile prosperity of Venice diffused its influence throughout the shores of the Mediterranean, which thus became once again the nursery of civilization. For many centuries Venice was the great school for the arts connected with navigation, and her shipwrights and seamen were long the most instructed in Europe. While the northern seas were navigated by the Scandinavian sea-kings, in their rude and frail boats, in quest of plunder or of a home, ships floated on the waters of the Mediterranean bearing the banner of St Mark, which, it is said, were, even as early as the tenth century, of the burthen of 1200 up to 2000 tons. The vessels, however, generally adopted by the Mediterranean states, were either copies or modifications of the ancient galley.

Mediterranean galley.

It is a fact worth notice, that while the continuation of the use of this species of vessel in the comparatively tranquil waters of the Mediterranean fostered the arts of commerce and navigation, its introduction into the northern seas, to which it was ill adapted, appears to have checked, in a most remarkable degree, the maritime enterprise which had hitherto so characterized the population of their coasts. It is even probable that the barrier thus opposed to commerce entailed on the states of Northern and Western Europe centuries of comparative barbarism. Yet this was effected for a wise purpose, by one of the greatest ornaments of the middle ages, Alfred the Great.

Alfred. Alfred was the first ruler of England who clearly understood that the policy of Britain was rather to prevent than to resist invasion; and the by-gone history of his country told him plainly that its military strength was not only insufficient to awe invaders from its shores, but that all the military resources at his command were inadequate to preserve the liberties of his people. He therefore turned the energies of his mighty mind to the task of creating a naval force, which should be more powerful than that of his untiring persecutors the Danes. In this we find that he succeeded; and at length, under the protection of the fleets which his genius had created, he was enabled to establish that frame-work of internal policy and government, from the wisdom of which England has even to this day benefited. It is historically certain that Alfred himself superintended the formation of his fleet, and that he gave the design of vessels to be superior to those of the Danes.

His ships. We find that these vessels were galleys, generally rowed with forty oars, some even with sixty, on each side; and that they were twice as long, deeper, nimbler, and less "wavy" or rolling, than the ships of the Danes. The information on this subject is obtained by Selden, from a Saxon chronicle of the time of Alfred, which is in the Cottonian Library.

Reasons for their introduction. It should be remembered, that when Alfred thus introduced the Mediterranean galley into these northern seas, his object was not so much to form a vessel adapted for the purpose of navigating those seas, as to obtain one which would afford space for a large force of fighting men. For this the galley was admirably qualified; and indeed it maintained its place as the appropriate ship for the purposes of war, until the invention of cannon rendered other arrangements necessary.

Their success. The immunity which it insured from the attacks of the Danish marauders, caused its general adoption along the coasts hitherto open to their incursions, on all of which it thus superseded the sailing vessels that we have already described; and we shall find that voyages which, until its introduction, were boldly and successfully achieved, became of rare occurrence and of hazardous issue during the subsequent ages, until the galleys once again gave place to sailing vessels. It also gradually checked the enterprise of the Northmen, by the curb which it placed upon their successes.

Saxon rule. It is not our purpose to give more than a slight sketch of the naval history of Britain through the line of her Saxon princes; for we can discover little data on which to found any speculation even, as to the progress of naval architecture during these ages. We know that the galley of the Mediterranean continued to be used for the defence of the coasts; and the policy of Alfred appears to have been well understood by many of his successors,—that England only enjoyed peace from invasion when her fleets were powerful enough to repel it from her shores. We are also led to suppose that the use of sailing vessels was not wholly abandoned; for in the reign of Athelstan, the third in descent from Alfred, as we read in Hackluyt, it was decreed, that "if a marchant so thrived, that he passed thrise over the wide seas of his owne craft, he was thenceforth a Theins' right worthie."

Mercantile shipping. This establishes two rather interesting facts; one is, that at so early a period of our history there were merchants of importance enough to engage in such a traffic; and the other is, that from the richness of the reward held out to successful enterprise, we are enabled to estimate the difficulty of the task assigned. We may assume that these long voyages were made in ships more adapted for the purpose than galleys; in fact, in the vessels which the galleys had been intended to supersede. But the spirit of maritime enterprise had, as we have said, evidently received a check, since we see that one of the highest rewards in the power of the monarch to bestow was held out to the merchant, as an incitement to an adventure, which the vague hope of plunder would alone have been sufficient to induce that merchant's progenitors to attempt, and successfully perform. However, it is probable that at no time was the art of navigating vessels, which depended principally, although perhaps not wholly, upon their sails, lost in the northern seas. Gibbon says, that at the early crusades the vessels of the "Northmanni et Gothi" (the Norwegians and Danes) differed from those of the other powers, among all of whom the ships partook of the character of the Mediterranean galley. These northern crusaders are described by him as navigating "*navibus rotundis*, that is to say, ships infinitely shorter in proportion to their length than galleys." This was not later than the beginning of the twelfth century, and therefore not so far removed from the periods in question as to render the inference we wish to deduce from it erroneous, particularly when referring to times of such slow improvement as the middle ages.

Decline of naval enterprise.

Edgar. The "mighty" fleets maintained by Edgar afford no information on the subject of this article, excepting that the facts connected with that monarch's annual circumnavigation of his territories prove them to have consisted of row-galleys. They must however have formed comparatively a "mighty" fleet; for, from a grant of land made by Edgar to Worcester cathedral, we find that he assumed to himself the title of "Supreme Lord and Governor of the Ocean lying round about Britain." That they were but of slight construction, we may infer from the low state of the navy so shortly after the death of Edgar as the reign of Ethelred, who, in order to re-establish it, instituted a regular tax for providing and maintaining a navy. It was enacted, according to Selden, that whoever possessed "310 hides of land, was charged with the building of one ship or galley; and owners of more or less hides, or part of one hide, were rated proportionately;" the hide being, according to the best authorities, as much ground as a man could turn up with one plough in a year. But this tax appears to have been inadequate to the purpose of providing a sufficient fleet, for all the exertions of Ethelred could not preserve Britain from again being ravaged by the Danes; and we find, that after the short reign of his son Edmund Ironsides, England was ruled by Danish monarchs. From the known talent of Canute, the first of these princes, and from the crowns of Denmark, Norway, and Britain being united in his person, we may presume that the naval affairs of England were not suffered to retrograde. We have indeed a record of their advance during this second Danish rule. We may also infer it from the present which was made by Earl Godwin to Hardicanute, the third Danish sovereign, of a galley, sumptuously gilt, and rowed by fourscore men, each of whom wore on his arm a bracelet of gold weighing sixteen ounces; not that the mere gorgeousness of the gift would prove any advance in the art of ship-building, but we may suppose, from its nature, that naval affairs found favour in the sight of this monarch. Of this we have also other historical evidence, as Hardicanute raised eleven thousand and forty-eight pounds, in the first two years of his reign, for the purpose of building thirty-two ships; and the taxes he levied for the support of his navy were so grievous that, Florentius says, scarcely any man was able to pay them.

Ethelred.

Canute.

Norman conques The marine of England seems to have been maintained on a comparatively powerful footing up to the period of the Norman conquest; and from the naval resources at the command of Harold the Saxon, in comparison with the insignificance of the shipping which brought William and his

Normans across the channel, there can be no doubt that had Harold relied upon his naval strength, the conquest of England would never have been achieved. But, by some fatality, his fleet, which had been long stationed off the Isle of Wight, was dispersed, in consequence of a report that William had abandoned his enterprise.

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The flotilla of William the Conqueror is variously stated; by some at 900, by others at 3000 vessels. In either number we have a scale to estimate their insignificance, as the invading force consisted of about 60,000 troops, which would give in the one case about sixty-six men to each vessel, in the other twenty men only. Plate CCCCXLV. figs. 1 and 2.

The conquest of England being completed, the shores on either side of the narrow seas between England and Normandy were under the same rule. William therefore claimed sovereignty over them, which right was maintained by his successors. There can be no doubt that the constant intercourse between the two portions of the empire, which continued throughout the Norman sway, and indeed for a period of upwards of three centuries, must have done much towards fostering a maritime spirit among the population of England, and accustoming it to consider that fame and fortune were the rewards of nautical adventure.

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We have but slight evidence as to the state of naval architecture during the early period subsequent to the conquest. There are a few facts scattered among the records of these times, which may enable us to draw some vague conclusions as to the probable size and nature of the vessels used. When Prince William, son to Henry I., was drowned, by the loss of the vessel in which he was crossing from France to England, it is recorded that three hundred souls perished with him. As of this number a large portion, historians say one hundred and forty, were men of rank, and as there were many ladies, since the prince was accompanied by his sister, the vessel must have been of considerable burthen. A similar event, namely, a shipwreck, that occurred during the reign of Henry II., by which nearly the same number of persons perished, tends to prove that such was about the extent of the accommodation afforded by the shipping of this period. Galleys still continued to be used for the purposes of war; but as commerce began to be extended, it became necessary to recur to the use of sails, and we find that they were therefore gradually recovering their importance, and superseding oars. Indeed it is difficult to conceive commerce to be profitably engaged in, attended with the immense expense of the crews necessary to propel the larger galleys. We should imagine that this had an important influence in the improvement of navigation and of naval architecture, for the commercial intercourse between the portions of the empire on either side of the channel must have been considerable. There is constant reference in the early chronicles to the great extent of the wine trade, and of the commerce in wool and woollen cloths.

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The introduction of vessels propelled by sails for the purposes of commerce would necessarily cause a change in the constitution of the fleets assembled for the services of war; and this we find to have been the case.

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The expedition of Richard Cœur de Lion, in 1190, to join the crusade to the Holy Land, consisted of nine ships which are described as being of extraordinary size, 150 others of inferior dimensions, and only thirty-eight galleys. After the reduction of Cyprus, and the addition of the vessels captured there, with others which he had hired at Marseilles and in Sicily, his armament consisted of 254 "tall shippes, and about three score galliots." The increase was, therefore, almost wholly in the ships. This, together with the recorded fact, that he captured a Saracenic vessel of such size as to be capable of containing 1500 Saracens, and a large quantity of military stores, destined for the relief of Achon, tends to prove that the progress of naval architecture under the influence of the commercial powers of the Mediterranean, had been more rapid than in these northern seas, where the commerce was much more confined in its nature, and the nations bordering on which were in constant warfare with each other.

Sovereignty of the seas.

The Norman monarchs appear to have been very tenacious of their claim to the sovereignty of the narrow seas; and not only their claim, but their power to maintain their right, is admitted by the French historians. The Père Daniel sanctions the claim of Henry II. to this sovereignty.

John.

In the reign of John we find that the fleets of England were of such importance that the claim was extended; for it was then enacted, that if the masters of foreign ships should refuse to strike their colours, and thus pay homage to the English flag, such ships should be considered as lawful prizes. This monarch most carefully fostered the naval power of England; and it is in the records of the thirteenth year of this reign that we first read of any public naval establishment. There is in the close rolls published by the Record Commission, an order, which is dated the 29th of May 1212, from the king to the sheriff of the county of Southampton, in which he is directed without delay to cause the king's docks at Portsmouth to be enclosed by a good and strong wall, in order to protect the king's galleys and ships; and also to build storehouses against this wall for the preservation of the fittings and equipment of the said vessels; all of which works are to be performed under the direction of William, archdeacon of Taunton, and the greatest diligence is to be used, in order that the whole may be completed during the summer.

Early origin of Portsmouth dockyard.

Edward I.

The naval power of England appears to have continued sufficient to maintain the sovereignty assumed by John. For the occurrence of predatory excursions by some Genoese during the reign of Edward I. caused all the nations of Europe, bordering on the sea, to appeal to the kings of England, whom they acknowledged to be in peaceable possession of the "Sovereign Lordship and Dominion of the Seas of England, and Islands of the same;" which proves that their claim was generally acknowledged. This document, Evelyn says, was still extant in his time, in the archives of the Tower. The right to the absolute sovereignty of the seas was maintained up to the reign of James I. Queen Elizabeth insisted on and maintained her power to refuse or grant passage through the narrow seas, according to her pleasure. In 1634 Charles I. asserted his right to their sovereignty; and in 1654 the Dutch were compelled, after a severe struggle, to submit to it, and consent to "strike their flags and lower their top-sails on meeting any ship of the English navy in the British seas;" which homage the commanders of English men-of-war were instructed to exact from all foreign vessels until so lately as the close of the last war, when it was judiciously abandoned, for reasons which we shall give in the words of Sir John Barrow. In his Life of Howe, with reference to Trafalgar, he says, "That battle, moreover, having so completely humbled the naval powers of France and Spain, suggested to the consideration of the Board of Admiralty, with the approbation of the government, the omission of that arbitrary and offensive article which required naval officers to demand the striking of the flag and lowering of the top-sail from every foreign ship they might fall in with. That invidious assumption of a right, though submitted to generally by foreigners for some centuries, could not probably have been maintained much longer, except at the cannon's mouth; and it was considered, therefore, that the proper time had come when it might both morally and politically be spontaneously abandoned."

Error respecting the use of sailing vessels.

It is generally supposed, that ships intended only for sailing were first built by the Genoese, and that not until the beginning of the fourteenth century. We rather incline to the opinion, that in the Mediterranean they date from an earlier period than this; and that although the general adoption of the galley in Western Europe had much checked the art of navigation by means of sails, it had never been wholly lost, but that sailing vessels, though probably very few in number, and imperfect in their rig, had been constantly in use. If we may judge from the few hints handed down to us by history, they were probably luggers, and were adopted for mercantile purposes along the coast of the Channel and the Bay of Biscay. In the north of Europe sails had never been discontinued, although the more warlike galleys of England and France had gradually prevented the incursions of the northern nations into these more southern seas. The beginning of the fourteenth century is, however, decidedly an epoch in the histories both of navigation and of naval architecture, and from it may be dated the progress of navigation by means of sails. It is generally supposed, that the "large ships" mentioned in the enumeration of the fleets of this period, were ships built only for sailing, and intended for those long voyages which the invention of the compass by Flavio Gioia, a Neapolitan, about the year 1300, had rendered of comparatively easy performance.

Mariner's compass.

Edward III.

It has been surmised that the compass was brought to Europe from the East about forty years previous to this date, by Paulus Venetus. It is certain that the Portuguese found the knowledge of the magnetic needle generally and long diffused among the eastern navies. Evelyn says that "it was, near eighty years after its discovery, unknown in Britain." This is not improbable, for there does not remain much record of maritime affairs in the interval between the reigns of John and Edward III. This monarch's reign was, after a most severe struggle with France for supremacy on the seas, the era of a series of naval triumphs, and both navigation and naval architecture made most decided advances.

Naval battle.

In an engagement which took place in 1340, the French force amounted to four hundred vessels, of which a hundred and twenty were "large ships," these being principally Genoese mercenaries. Edward III. commanded the English fleet in person, which consisted of but two hundred and sixty sail. The French are variously reported to have lost twenty and thirty thousand men, and two hundred vessels are said to have been captured. The loss to the English was only four thousand men. Two facts are elicited by the accounts of this engagement; one is, that there is no mention of galleys as forming any part of the fleets; the other is, that in the James of Dieppe, which was captured by the Earl of Huntingdon, four hundred persons were found slain; consequently the size of the vessel must have been very considerable.

Royal fleet.

Use of cannon.

In 1344 Edward summoned commissioners from all the ports, to meet in the metropolis, provided with the state of their "navies." The roll of this fleet is inserted in the first volume of Hakluyt, from a copy in the Cottonian Library. The total numbers were 710 ships, and 14,151 mariners; and there were thirty-eight foreign ships, with eight hundred and fifteen mariners. From this roll we learn that galleys had ceased to be used by England, either in her wars or in her commerce, as neither among the king's ships, nor among those furnished by merchants, is there any mention of them. This fleet was that engaged in the celebrated siege of Calais, and it was probably at this time that cannon were first employed by the English. Camden in his Remains says, "Certain it is, that King Edward III. used them at the siege of Calais in 1347."

Sizes of Edward's ships.

Although from the fact of there being a royal dock-yard at Portsmouth so early as the reign of John, it is probable that the kings of England were possessed of a navy almost from the conquest; yet this roll of Edward's fleet contains the first enumeration of ships belonging to the sovereign, and employed in the service of the state, which occurs in English history; and, consequently, it is from the reign of Edward III. that we must date the formation of a royal navy. The king's ships were twenty-five in number, and were manned by 419 mariners. It appears that the vessels belonging to the sovereign were inferior in force to many of those which were supplied by subjects; for the average number of the crews of the king's ships was seventeen men to each vessel, while the average of the fleet was rather above twenty. Of course these numbers only include the mariners employed in navigating the vessels, and not the soldiers to be afterwards embarked on board them. If we consider the simplicity of the rig of these ships, in comparison to the wilderness of canvass and cordage covering the tall masts of a modern merchantman, we have more reason to be astonished at the large number of hands employed, than at the smallness of the averages seventeen and twenty. There is good reason to suppose that the addition of the bowsprit to the rig of ships dates no farther back than late in the reign of Edward III., which is alone quite sufficient to prove the very imperfect state of the navigation at that period, and also to excite astonishment that, with such apparently inadequate means, so much was effected; for history would almost lead us to suppose, that for all the purposes of war and commerce, fleets as proudly or as industriously ploughed the main then as now, "with all appliances and means to boot." Plate CCCCXLV. fig. 3.

Richard I
First navigation act

In the year 1381, the fourth of the reign of Richard II., the first navigation act was passed in England, for the encouragement of the naval interest, and the augmentation of our maritime power, by discountenancing the employment of foreign shipping. It enacted, "that for increasing the shipping of England, of late much diminished, none of the king's subjects shall hereafter ship any kind of merchandize, either outward or homeward, but only in ships of the king's subjects, on forfeiture of ships and merchandize, in which ships also the greater part of the crews shall be of the king's subjects." This act was not however enforced, permission being given to hire foreign shipping when there were no English ships in readiness.

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Henry I

Letter t
Henry V

We have said that the royal navy of England must date from the reign of Edward III. We have proof that it continued to be customary for the sovereign to possess ships; they were, however, used both for war and commerce. This practice, which does not at all militate against the existence of a royal navy, appears to have commenced when "large ships" were substituted for the galleys as vessels for war; and it long continued to be usual for merchants to hire shipping from the sovereign for commercial voyages. We learn from the proceedings of the privy council, which have been printed by the Record Commission, that in June of the year 1400, Henry IV. ordered his "new ship," together with such others as were in the port of London, to proceed against the enemy. There is also a letter in the Cottonian Library, which has been printed in Ellis's Collection of Letters, from John Alcetre to King Henry V. concerning a ship building for that monarch at Bayonne. The letter is of the date of 1419; and as it contains more minute details than might be expected to have descended to us from such an early period, we give the following extract. "At the makyng of this letter yt was in this estate, that ys, to wetyng xxxvj. strakys in hyth y bordyd, on the weche strakys hyth y layde xj. bemys; the mast beme ys yn leynthe xlvj. comyn fete, and the beme of the hameron afore ys in leynthe xxxix. fete, and the beme of the hameron by hynde is in leynthe xxxiij. fete; fro the onemost ende of the stemne in to the post by hynde ys in leynthe a hondryd iij$^{xx.}$ and vj. fete; and the stemne ys in hithe iiij$^{xx.}$ and xvj. fete; and the post xlviij. fete; and the kele ys in leynthe a hondryd and xij. fete; but he is y rotyt, and must be chaungyd."

We have also evidence of the existence of ships which belonged to the monarch, in contradistinction to ships which

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belonged to the "commons," in the quaint rhymes of an anonymous author of the year 1433, which have been preserved by Hackluyt, termed "The Prologue of the processe of the Libel of English policie, exhorting all England to keepe the sea, and namely, the narrowe sea, shewing what profite commeth thereof, and also what worship and saluation to England, and to all Englishmen."

> And if I should conclude all by the king
> Henrie the Fift, what was his purposing,
> Whan at Hampton he made the great dromons,
> Which passed other great ships of all the commons;
> The Trinitie, the Grace de Dieu, the Holy Ghost,
> And other moe, which as nowe bee lost.
> What hope ye was the king's great intent
> Of thoo shippes, and what in minde hee meant:
> It was not ellis; but that hee cast to be
> Lorde round about environ of the sea.

The term dromond is the corruption of a Levantine term, dromones, imported probably by the crusaders. The dromones were long row-galleys, but the adopted term dromond was applied generally to all large ships.

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There is a list of Henry's vessels in the fourth year of his reign, preserved in the proceedings of the privy council. His navy then consisted of three "large ships" or "grands niefs," three "carracks," eight barges, and ten balingers. In 1417 it was augmented to three "large ships," eight "carracks," six other ships, one barge, and nine balingers.

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Again, in a letter preserved among the Cottonian manuscripts, and printed in Ellis's collection, we find that the Spaniards offered Henry V. two carracks for sale, one of which is described as of a tonnage equal to 1400, and the other to 1000 butts. So energetical was Henry V. in all things relating to his navy, and the consequent increase in the number of the royal ships during his reign was so great, as to have led to the error that before his time the sovereigns of England were not possessed of vessels, but relied wholly upon the aid to be gathered from the different ports of England, or to be hired from foreigners. This is evidently incorrect.

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navy.

On the death of Henry V. a different line of policy appears to have been adopted; for in May 1423 the king's ships were all sold at Southampton, under a restriction that no foreigner could be a purchaser of them. But it appears that a long period did not elapse before the depressed state of the naval resources of the kingdom, consequent on this injudicious measure, attracted the attention of parliament. The following interesting quotation from the preface of the fifth volume of the Proceedings of the Privy Council, printed by the Record Commission, refers to this event. "In 1443 the attention of parliament was directed to this important part of the national defence (the naval force), and a highly curious ordinance was made for the safeguard of the sea. From February to November eight ships with forestages, or, as they were sometimes called then, as now, forecastles, armed with 150 men each, were to be constantly at sea. Every large ship was to be attended by a barge of eighty men, and a balinger of forty men. There were also to be 'awaiting and attendant upon them' four 'spynes' or 'spinaces,' with twenty-five men each. The whole number of men in these twenty-four ships was 2240."

There is also in the same preface an account of the various kinds of ships which formed the navies of this period, a part of which we shall quote, and by the addition of some further information of the same nature, derived from Froissart, Monstrelet, and other sources, the reader will be enabled to form a tolerably correct opinion as to the state of naval architecture in England previous to and during the fifteenth century. Plate CCCCXLVI.

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Ships. "The burthen of the largest ships at that period probably did not exceed 600 tons, though some of them were certainly very large" as, for instance, the vessel built at Bayonne for Henry V., already mentioned. "One which belonged to Hull was released from arrest" (she having been pressed into the king's service), "because she drew so much water that she could not approach within two miles of the coast of Guienne, where the Duke of Somerset's army intended to disembark;" and several notices occur of ships of 300 and 400 tons and upwards. Some had three and others only two masts, with short topmasts, and a "forestage" or "forecastle," consisting of a raised platform or stage, which obtained the name of castle from its containing soldiers, and probably from its having bulwarks. In this part of the ship it appears business was transacted; and in the reign of Edward III., if not afterwards, ships had sometimes one of these stages at each end, as ships "*ove chastiel devant et derere*" are then spoken of. (Plate CCCCXLVI. figs. 2, 3, 4, 5.) Lydgate, describing the fleet with which King Henry V. went to France after the battle of Agincourt, says,

> Fifteen hundred ships ready there be found,
> With rich sails and high topcastle.

This is a confusion of terms. The "topcastles" were not the forecastles, but were castellated enclosures at the mastheads, in which the pages to the officers were stationed during an engagement, in order to annoy the enemy with darts and other missiles; as is frequently mentioned in Froissart, and is represented in the illuminations to his work. Plate CCCCXLV. fig. 3.

Carracks.

Carracks "were vessels of considerable burthen, and were next in size to great ships, in which class they indeed were sometimes included. Their tonnage may be estimated by their being in some instances capable of carrying 1400 butts; and the sail of one afforded Chaucer a strange simile expressive of magnitude,

> And now hath Sathanas, saith he, a tayl
> Broder than of a carrike is the sayl.

Though occasionally armed and employed against the enemy, they were more generally used in foreign trade."

Charnock says that the first carrack which was built in England was built for a merchant, John Tavenier, of Hull, who was consequently honoured by Henry VI. with distinguished favour; and she was licensed in 1449 with particular privileges to trade through the Straits of Morocco. The king also ordered her to be called the Grace Dieu Carrack. The license states her to have been built "by the help of God and some of the king's subjects."

Barges.

Barges "were a smaller kind of vessel and of a different construction from ships, though, like them, they sometimes had forecastles. Those appointed to protect the seas in 1415 were of 100 tons burthen, and contained forty mariners, ten men-at-arms, and ten archers; whilst the ships employed on the same occasion were of 120 tons, and had forty-eight mariners, twenty-six men at arms, and twenty-six archers each. Four large barges and two balingers were capable of holding 120 men-at-arms and 480 archers and sailors."

Balingers.

Balingers "were still smaller than barges, had no forecastle, and sometimes contained about forty sailors, ten men-at-arms, and ten archers." Froissart makes frequent mention of "balniers," "balleniers," which he describes "as drawing little water, and being sent in advance to seek adventures, in the same manner as knights and squires, mounted on the fleetest horses, are ordered to scour in front of an enemy, to see if there be any ambuscades." Monstrelet speaks of one vessel that was employed by Louis XI. to abduct the Count de Charolais, by the two names ballenier and balayer. It is not improbable that the name is derived from the French word *baleine*, and that its origin was similar to that of our English name whaler. The whale-fishery in Biscay was of a very early date.

Galleys.

Galleys (Plate CCCCXLVI. fig. 1) "are frequently mentioned at a very early period; and in the 5th Rich. II. 1381, the Commons complained that no measures had been taken to resist the enemy, who had attacked the English at sea with their barges, galleys, and other vessels. In 1405 Henry IV. directed his council to apply to the king of Portugal to lend him his galleys to assist the English navy against the French."

In Sir Grenville Temple's Travels in Greece and Turkey, we find the following description of a Maltese galley, or, more correctly, galleas, made from an old model preserved there. "These galleys measured a hundred and sixty-nine feet one inch in length, and thirty-nine feet six inches in breadth. They had three masts with latine sails, and were propelled by forty-nine oars, each forty-four feet five inches long. Their armament consisted of one thirty-six pounder, two of twenty-four, and four of six, all on the forecastle, which in those days had in reality some appearance of a castle. On each side of the vessel, aft of the forecastle, were four six-pounders." The total crew, including galley-slaves, consisted of 549 persons.

Galleas.

The *Galleas* and the *Galleon* appear to have been successive improvements on the original galley, rendered necessary by the introduction of cannon into naval warfare. The artillery introduced on board the early galleys was placed either before or abaft the rowers, and to fire in the direction of the length. (Plate CCCCXLVII.) In the galleas, a description of vessel first used at the battle of Lepanto, guns were also placed between the rowers, to fire from the broadside. Evelyn describes the galleasses he saw at Venice (1645) as being "vessels to rowe of almost 150 foote long and thirty wide, not counting prow or poop, and contain twenty-eight banks of oares, each seven men, and to carry 1300 men, with three masts." In the galleon the oars ceased to be the principal means of propulsion, and if used at all, were only so as occasional aids. The galley and galleas had overhanging topsides for the accommodation of the oars. In the galleon, on the contrary, the topsides "tumbled home" to so extraordinary an extent, that the breadth at the water was twice that at the topside, a fashion which has continued, but in a much less degree, to the present time. Plate CCCCXLVIII.

Spynes or spynaces.

Spynes or *Spynaces*, "now called pinnaces, seem to have been large boats, capable of holding twenty-five men, and were probably used for swiftness. To these must be added crayers, hulks, gabarres or gabbars, a kind of flat-bottomed boat used in shallow rivers." The French still continue to apply the term "gabarre" to store-ships.

Playtes and smaller vessels.

"Playtes, cogships, whence perhaps cogs and coggles are derived; farecrofts, passagers, which were perhaps boats used between England and France; and cock-boats, a small boat which attended upon all kinds of ships. The whole of these vessels were employed in conveying goods or passengers, and most of them on rivers or in the coasting trade. The ships, carracks, barges, balingers, and galleys, were employed equally for commerce or for war. When sent against the enemy, soldiers were put on board of them; and it is most likely they were at all times partly manned by soldiers. In foreign voyages they usually sailed in convoys; and it was a very ancient custom for the masters and sailors to elect their own admiral."

Foists or foysts.

In Burchett's account of the unfortunate action in the Bay of Conquet in 1513, in which the Lord High Admiral, Sir Edward Howard, lost his life, four *foists* are mentioned as forming a part of the French force. They were probably vessels of a similar character with the galley, but smaller in size. About the beginning of the seventeenth century, "carracks," "galleons," and "tall shippes" appear to have become synonymous terms. Plate CCCCXLVIII.

Hulks.

The term hulk originally was applied in a different sense from that which is stated in the part of the foregoing remarks which we have quoted from the preface to the proceedings of the privy council. Frequent allusion is made to hulks in documents of the fifteenth and sixteenth centuries. In a letter from Sir Thomas Seymour to the privy council, dated the 13th of November 1544, when in command of the "shipes whyche was a poyntede to kepe the Narrow Sees," vindicating himself for putting back on account of a storm, there is the following passage, from which we might almost infer that hulk was a general name synonymous with ships. "Thre holkes that come after me colde nott gett syght thereof (the 'Eylle of Wyght),' tyll they warre in a bay on the est syde of the Eylle, of the whyche Mr Strowd, Bramston, and Battersebe of the garde, God rest their sowles, was in on of them, whyche holke brake all her ankeres and cabelles, and she brake all to peses on the shorr, and but 41 of 300 saved a lyve. The other two rode out the storme, whyche lasted all that nyght and the next day. My brother (Sir Hy Seymour) and John Roberds of the garde, tryde the sees all the furst nyght, and the next day cam into Dartemouth haven, wharre my brothers holke strake on a roke and brest all to peses; but God be praysede, all the men warre savede, savying thre; and a nother new holke that tryde the sees that nyght brake thre of her bemes, and with moche ado came into the Wyght."

Again, in a letter from Lord Viscount Lisle, Baron Malpas, the Lord High Admiral of England, to Henry VIII., we have an announcement, that "their is cum into the Downes 30 sayle of hulkses, whereof sum be tall shipes." And again, in a letter from the same to the Lord Chamberlain, Lord St John, he speaks of having detained "3 grate hulkes bound, as they say, for Lusshborne, the leste of y^{m} 500 tunnes." And again, from the same to the same, he speaks of his former letter and the "goodly hulkes," and says, "sithens that tyme I have stayed other too, which in beautye and well appoynting are beyond the others. That I have last stayed ys a shipe of 600 at the least, and hath 5 toppes, and she ys of the town of Dansick, and ladon in Flanders for Lusshbourne."

State of mercanti shipping. Willian Canynge

The importance of the mercantile shipping of England during the fifteenth century must have been considerable. About the middle of it flourished the celebrated William Canynge, a merchant of Bristol, who built the church of St Mary's, Redcliff, in that city, in which church he was buried in 1474. This man appears to have been much in advance of the rude times in which he lived. His mercantile transactions were on so extensive a scale, and carried on in vessels of such large size, that they must have had an important influence in improving the navies of the period. It is therefore not only as a fact of much historical interest, but as one which is intimately connected with and most probably materially affecting our subject, that we shall dwell on the information which has descended to us respecting him. He was a great patron of the arts, a friend and protector of genius, and eminent for his virtue and piety. From an inscription upon his tomb, a tradition has become current, that Edward IV. took 2470 tons of shipping from him, he having "forfeited the king's peace;" and for the obtaining of which again, it is stated that Edward accepted these ships instead of a fine of 3000 marks. The Itinerary of William of Worcester, preserved in the library of Bennett College, Cambridge, gives the names of Canynge's vessels, among which are the Mary and John of 900 tons, Mary Redcliff of 500 tons, and Mary Canynge of 400 tons. The same authority gives the names and tonnage of other large ships belonging to Bristol merchants, among which are the John, of 511 tons, and the Mary Grace, of 300 tons. If there be any truth in the tradition of the confiscation of the shipping, it is probable that the inscription on the tomb may refer to some act of Canynge's in favour of the house of Lancaster, as he appears to have enjoyed the favourable opinion of Henry VI. Another account, which, it is said, is authenticated by the original instrument in the Exchequer, states that this Canynge assisted Edward IV. with a loan, and received in return a license to have 2470 tons of shipping free

story.

of imposts. In Corry's History of Bristol it is said, "the commerce and manufactures of Bristol appear to have made considerable progress during the fifteenth century, about the middle of which flourished the celebrated Canynge. This extraordinary man employed 2853 tons of shipping and 800 mariners during eight years. Two recommendatory letters were written by Henry VI. in 1449, one to the master-general of Prussia, and the other to the magistrates of Dantzic, in which the king styles Canynge his beloved eminent merchant of Bristol."

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Some doubt must always remain as to the actual size of the shipping of this remote period, as we cannot ascertain the bulk that was then considered as equivalent to a ton. It is probable that the tonnage was estimated according to the number of butts of wine that a vessel could carry. For we find references to ships sometimes by tonnage, and sometimes by the "portage" of so many butts.

ry VII.

This, however, is only a question as to exactness of size. In whatever way measured, Canynge's ships must have been of very considerable dimensions. It is rather extraordinary, that at the unsettled period in question Bristol should have enjoyed such a state of commercial prosperity as the ownership of such shipping as that enumerated by William of Worcester necessarily involves. Bristol, for many centuries, was only second in mercantile importance to London; but the civil wars which distracted the kingdom during a great part of the fifteenth century must have much retarded the increase both of the military and the mercantile navy of England; and only when order was again re-established by the accession of Henry VII. to the throne in 1485, ought we to expect men's minds to revert from the internal excitement of party strife to external affairs.

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In this interval, in which England was torn by the wars of the houses of York and Lancaster, naval science had made more rapid strides than in any previous period of similar duration. The compass was not only known, but was generally adopted. Navigators could take observations by the use of an instrument called the astrolabe, invented by the Portuguese. The Spaniards and Portuguese were sufficiently advanced in the art of navigation to sail on a wind, and their smaller vessels, at least, were adapted for this manœuvre. New maritime states had started into existence. The Netherlands, until then scarcely known, was under the Duke of Burgundy, the most formidable naval power in the north of Europe. "His navy," says Philip de Commines, "was so mighty and strong, that no man durst stir in those narrow seas for fear of it, making war upon the king of France's subjects, and threatening them everywhere; his navy being stronger than that of France and the Earl of Warwick joined together." Venice, in 1420, according to Denina in his Revolutions of Italy, supported 3000 merchant-ships, on board of which were 17,000 seamen. They employed 300 sail of superior force, manned by 8000 seamen; had forty-five carracks, with 11,000 men to navigate them; and her arsenals employed 16,000 carpenters. Portugal had pushed her discoveries round the Cape, and Spain had added America to the world.

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The progress of discovery by the Portuguese to the south and east, and by the Spaniards to the west, with the consequent rapid increase in the importance of these two powers, and the influence of their discoveries on the state of Europe, renders the fifteenth century probably the most important of modern history. In it was given the death-blow to the increase of the Saracenic power, and to that of the Mediterranean states. The Turk, the Venetian, and the Genoese, had hitherto been the monopolizers of the commerce of the east. The discovery of the passage round the Cape of Good Hope opened this trade to all nations. The commercial sceptre, and consequently the military sceptre, hitherto shared by the Turk, passed wholly from the infidel to the believer. The crescent sank before the cross.

History.

Its influence on naval architecture.

There can be no doubt, also, that the "*tormentas*" of the "*grão Cabo de boa Esperaça,*" were a means of great improvement in naval architecture; for we find, that in consequence of the representations of Bartholomew Diaz, John II. of Portugal ordered ships to be constructed for the especial purpose of contending with the stormy seas of the Cape of Good Hope. The ships were built to form the squadron of Vasco de Gama, and were of small tonnage, from the very proper idea that small vessels were more adapted to prosecute researches in unknown seas than those of a large size, and consequent increased draught of water.

Squadron of Vasco de Gama.

The squadron of Vasco de Gama consisted of three ships and a caravella. One of the ships was of the burthen of two hundred tons, another one hundred and twenty, and the third one hundred; the caravella was of fifty tons. The largest of the ships was a victualler; the smallest was intended to prosecute discovery up creeks and shallows; and the other was for a display of force. As it is evident that it was not increase of dimensions which was to be the object in designing new vessels, the direction of improvement must have been towards perfecting their forms, strengthening their frames, and adding to the efficiency of their *materiel.* Portugal by these means became the most advanced state of Europe, in knowledge of the art of ship-building; for we find that it was long supposed that the passage to India required ships such as the Portuguese alone could build. Spain, in her career of discovery, conquest, and colonization across the mighty waters of the Atlantic, as if to assimilate the means to the vastness of her achievements, rapidly acquired the art of constructing ships of very large dimensions; and as long as she possessed a marine, her ships maintained this superiority.

State of naval affairs in England.

We have a curious instance of the light in which naval enterprises were considered in England at this time, notwithstanding the earnest desire of the monarch to re-establish his navy, which had necessarily suffered from the long civil wars. There is a letter from Henry VII. to the pope, preserved in the Cottonian Library, excusing himself from sending succour against the Turk, from which the following is a quotation. "The Galees commying from Vennes to England be commonly vij. monethes sailying, and sometimes more;" and again, "it should be May or they should be ready to saill, and it shall be the last end of Septembr or the said shippes shuld passe the Streits of Marrok; and grete difficultie to fynde any Maryners hable to take the rule and governance of the said shippes sailying into so jeopardous and ferre parties."

Henri Grace Dieu.

There is a drawing (Plate CCCCXLIX.) extant in the Pepysian Library in Magdalen College, Cambridge, of the Henri Grace à Dieu, built by the order of Henry VII., which Charnock has engraved in his History of Marine Architecture, and argues as to the general authenticity of the representation. He says, "this vessel may be termed the parent of the British navy. This celebrated structure, the existence of which is recorded in many of the ancient chronicles, cost the king, by report, nearly 14,000 pounds."

Early origin of naval terms.

From this drawing may be traced the derivation of one or two names which have been preserved even to the present hour; as, for instance, the "yard-arm," no doubt from the ends of the yards being armed with an iron hook. The castellated work from which we have the term "forecastle" is earlier than this; and the buckler-ports are most probably derived from a yet earlier period, when the bucklers of the knights were ranged along the sides of the ship, as they are represented in the illustrations of Froissart, and of the early chroniclers, and even in the Bayeux Tapestry. Plate CCCCXLV.

"The masts were five in number, inclusive of the bowsprit, an usage which continued in the first-rates without alteration till nearly the end of the reign of King Charles I.; they were without division, in conformity with those which had been in unimproved use from the earliest ages. This

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inconvenience it was very soon found indispensably necessary to remedy, by the introduction of separate joints, or top-masts, which could be lowered in case of need."

The drawing shows two tiers of ports. The introduction of port-holes is said to be an improvement due to a French ship-builder of Brest, named Descharges, in the reign of Louis XII., and about the year 1500. If the drawing be authentic, the correctness of this appropriation of the merit of the introduction of port-holes may be questionable.

Again, if the drawing be a correct representation of the vessel, she would have been in danger of upsetting, excepting in calm weather, and when her course was with the wind. In fact, as yet the large ships of war of England were not at all adapted to sail on a wind, and were very ill provided with such sails as would enable them to do so; they had therefore nothing to fear from the result of a measure which could not be put into execution. The fleets of war of which we have hitherto written seldom ventured out of port excepting in the summer months, and then only when the wind was favourable to their intended course. But very shortly after the date of the building of the Henri Grace à Dieu, we shall find that great improvement took place, and that in the reign of Henry VIII. there is evidence to prove that sailing on a wind formed one of the qualities of the vessels composing his fleets. This fact appears to throw some doubt upon the correctness of the drawing, for it must have required ships widely different from any of which that would at all give an idea, to have performed the evolution of tacking or wearing; and as the Henri Grace à Dieu was in all probability the same ship that on the accession of Henry VIII. was called the Regent, she must have formed one in fleets which were capable of performing these manœuvres. It is true that she may have been altered to adapt her to these new requirements of an improved system of seamanship; and it must also be said, that she was burned in an action with the French fleet, which occurred as early as the fourth year of the reign of Henry VIII.

Henry VIII. Sailing on a wind.

Though it is out of the question that ships with the enormous top-hamper which, on the evidence of all the drawings extant, still continued to be the fashion, could have made much progress in sailing on a wind, the letters of the time extant corroborate the statement we have made; for they begin to contain references to this improvement in navigation. In a letter from Sir Edward Howard, "Lord Admiral," to King Henry VIII., upon the state of the fleet, A. D. 1513, preserved in the Cottonian Library, and published in Ellis's collection, we find the following passage: "Ye commanded me to send your grace word how every shipp dyd sail; and this same was the best tryall that cowd be, for we went both slakyng and by a bowlyn, and a cool acros and abouet in such wyse that few shippes lakkyd no water in over the lee wales." The Lord High Admiral Lisle, in one of his letters (1545), says the small vessels of his fleet could "lye best by a wynde;" and in 1567 we have conclusive proof that there were "fore and aft," indeed "cutter-rigged" vessels, on the British seas; as in a map of Ireland of that date, published in the state-papers, two such vessels are represented, for the purpose, apparently, of indicating regular packets from England to Ireland.

It has been very generally supposed, on the authority of Sir Walter Raleigh, that the "knowledge of the bowline" was a discovery in navigation made shortly before his time; but we think it is probable that there were, even from the time of the Northmen, craft so rigged as to be capable of sailing on a wind. Froissart mentions, in several instances, "a vessel called a Lin, which sails with all winds, and without danger;" and again, "a vessel called a Lin, which keeps nearer the wind than any other." Boats with a rig adapted for this manœuvre are also represented in engravings of a very early date. In the plates of Breydenbach's Voyage to Palestine, which was published in 1483, boats and small vessels are represented with lateen sails; and in Braun's *Civitates Orbis Terrarum*, published in 1572, sprit-sails are met with. It is quite certain, however, that sailing on a wind was by no means a general quality possessed by the ships of war, or to any extent even by the greater portion of the larger shipping, until about the reign of Henry VIII. We shall adduce one other instance, in the account of the loss of the Mari Rose, a ship of the "portage of 500 tons," not so much to corroborate the fact of sailing on a wind, as to show that the two innovations, the introduction of port-holes, and the "knowledge of the bowline," were, as we have just said, in advance of the qualities of the large ships of war of the time. Sir Walter Raleigh says that "in King Henry VIII.'s time, at Portsmouth, the Mari Rose, by a little sway of the ship in casting about, her ports being within sixteen inches of the water, was overset and lost."

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The loss of this ship has been the means of giving us another interesting insight into the comparatively low state of nautical skill in England at this period, namely, the middle of the sixteenth century. In a letter among the state-papers published under the direction of the Record Commission, addressed by the Duke of Suffolk to Sir William Pagett, "chief secretary to the kinge's highnes," dated the 23d of July 1545, and containing a schedule of things necessary to be had for the raising of the Mari Rose, one item is "fifty Venyzian maryners and one Venyzian carpenter;" the next item is "sixty Englisshe maryners to attende upon them." It would also appear that the attempt was to be made under the direction of an Italian, as the conclusion of the schedule is, "Item, Symond, petrone and master in the Foyst, doth aggrie that all thyngs must be had for the purpose aforesaid." The attempts however all failed; the wreck of the Mari Rose remains to this day at Spithead, and so lately as August 1836, several of her brass cannon, of most exquisite workmanship, were recovered from the sea by the enterprise and ability of an Englishman of the name of Deane.

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period.

We may obtain some idea of the detail of ship-building rather before this period, from an account of a vessel built by James IV. of Scotland, at the close of the fifteenth or the beginning of the sixteenth century. The extract is from Charnock, but he has not mentioned his authority. "The king of Scotland rigged a great ship, called the Great Michael, which was the largest and of superior strength to any that had sailed from England or France; for this ship was of so great stature, and took so much timber, that, except Falkland, she wasted all the woods in Fife which were oakwood, with all timber that was gotten out of Norway; for she was so strong, and of so great length and breadth, all the wrights of Scotland, yea, and many other strangers, were at her device by the king's command, who wrought very busily in her; but it was a year and a day ere she was completed. To wit, she was twelve score foot of length, and thirty-six foot within the sides; she was ten foot thick in the wall and boards, on every side so slack and so thick that no cannon could go through her. This great ship cumbred Scotland to get her to sea. From that time that she was afloat, and her masts and sails complete, with anchors offering thereto, she was counted to the king to be thirty thousand pounds expense, by her artillery, which was very great and costly to the king, by all the rest of her orders. To wit, she bare many cannon, six on every side, with three great bassils, two behind in her dock and one before, with three hundred shot of small artillery, that is to say, myand and batterd falcon, and quarter falcon, flings, pestilent serpentens, and double dogs, with hagtor and culvering, corsbows and handbows. She had three hundred mariners to sail her, she had six score of gunners to use her artillery, and had a thousand men of war, by her captains, shippers, and quarter-masters."

Several of the writers of this period mention the fact of a ory.

Swe- ip.

Swedish ship of extraordinary dimensions built in the middle of the sixteenth century, and which was burned in an action between the Swedes and Danes in 1564. Chapman has given an estimate of the dimensions of this vessel. She was called the Makalos (by Charnock, Megala). According to Chapman, she was 168 English feet in length and forty-three English feet in breadth, an immense vessel for that period. Her armament was 173 guns, sixty-seven only of which could be considered as cannon, the remainder being merely swivels.

ards.

We find that Henry VIII., deeply sensible of the necessity of a permanent and powerful naval force, established the navy-office, and also several dock-yards for building and repairing the ships of the royal navy. Among these were Woolwich, Deptford, and Chatham. He also greatly added to and improved the dock-yard at Portsmouth. He invited from foreign countries, particularly from Italy, the commercial cities of which were still in advance of the rest of Europe in the maritime arts, as many skilful foreigners as he could allure, either by the hope of gain, or by the honours and distinguished countenance he paid to them. The following extract is from a report made to James I. in the year 1618, and published in the Archæologia. It was made in answer to a commission issued by that monarch to the several master-builders. The date of the report is rather in advance of our history; but we insert it here because the information it contains is of the time on which we are writing; as, while it confirms the statement we have just made, it informs us on the force of the royal navy during the reigns of Edward and of Mary, the period at which we have now arrived.

ard VI.

The minority of Edward VI., and the civil and religious strife which distracted the kingdom during the reign of Mary, depressed the resources of the state, and evidently much checked the progress of its maritime strength. The report says, "In former times our kings have enlarged their dominions rather by land than sea forces, whereat even strangers have marvelled, considering the many advantages of a navy; but since the change of weapons and fight, Henry VIII., making use of Italian shipwrights, and encouraging his own people to build strong ships of war, to carry great ordnance, by that means established a puissant navy, which in the end of his reign consisted of seventy vessels, whereof thirty were ships of burthen, and contained in all 10,550 tons, and two galleys. The rest were small barks and row-barges, from eighty tons downwards to fifteen tons, which served in rivers and for landing of men. Edward VI., in the sixth year of his reign, had but fifty-three ships, containing in all 11,005 tons, with 7995 men, whereof only twenty-eight vessels were above eighty tons each. Queen Mary had but forty-six of all sorts."

ects of hips of period.

There is one peculiarity about the fleets of this time, which exemplifies the defects of their design in a very remarkable feature. It is, that the ships built for the royal navy appear only to have been adapted for the lodgment of the soldiers and mariners, with their implements of war, and the necessary stores for navigation. The provisions were carried in an attendant vessel, called a "victualler," of which there was one attached to each of the large ships of war in the fleet, or to several of the smaller size. The hold appears to have been principally occupied by the "cook-room," the inconvenience of which arrangement, though much complained of, was general when Sir Walter Raleigh, in his Discourse on the Royal Navy and Sea-Service, recommended that it should be removed to the forecastle; and even so lately as 1715, several men of war had "cook-rooms" in their holds. There is also no doubt that the enormous quantity of ballast which was rendered necessary by the immense top-hamper of these ships, and the space which it occupied from being shingle, left but little room for the stowage of any quantity of provisions. In the ships built for commerce, this defect does not appear to have existed, as in fleets composed of the king's and of private shipping, those ships only which belonged to the royal navy had these attendant victuallers. We also know that the cook-rooms in the merchant-shipping were under the forecastle; and they had less top-hamper, as less accommodation was required for officers.

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Epoch in naval architecture.

Although we may comment on the comparative inefficiency of the vessels, we cannot but perceive that we have entered that period in the history of naval architecture and of navigation, in which, though still in their infancy, these arts may be considered as perfect in all but the maturity to be acquired by the experience of years. The mariner's compass was known; the theory of taking observations was understood, and the practice of it in the course of being perfected; and therefore the longest voyages could be undertaken with comparative certainty and safety. Besides this, the ships, though still imperfect, were becoming gradually manageable machines, and had ceased to be the cumbrous masses of the preceding ages, which, with few exceptions, were capable of little more than of being driven before the wind.

Three epochs in the maritime history of England.

If we consider the contents of the foregoing pages, there will appear to be three epochs in the maritime history of England; the first commencing with the introduction of galleys by Alfred, and ending with the reign of Edward III., before whose time these galleys and vessels propelled by oars were the chief instruments of navigation; the second ending with the reign of Henry VII., during which period, though sailing vessels were used for the purposes both of war and commerce, they were comparatively at the mercy of the winds, and, speaking generally, could sail only when they blew both fairly and gently; the third epoch we have already noticed. And henceforward we find the sister arts of navigation and naval architecture, if not always making rapid progress towards their present improved state, at least with no existing impediment to their advance towards that comparative perfection.

Elizabeth. Action with Spanish Armada.

We have seen, from the extract of the report of the builders, the state of the navy during the reigns of Edward VI. and of Mary. We know, therefore, that when Elizabeth ascended the throne, the marine of England, both military and mercantile, was in a very depressed state. The successful enterprise of Drake, and the fear of the Spanish Armada, aroused the energies of the country, and the force collected to resist the invasion amounted to 197 vessels of various descriptions, of the aggregate burthen of nearly 30,000 tons; thirty-four of which, measuring together 12,600 tons, composed the royal navy. It is true, that by far the larger portion were of small force. One only, the Triumph, was of 1100 tons; another, the White Bear, was of 1000 tons; two were of 800 tons, three of 600, six of 500, and five of 400; sixty-six were under 100 tons; and fifteen were victuallers, of which the tonnage is not mentioned. There are also seven other vessels included in the 197, which have no tonnage assigned them; but they must have been of small size, the number of mariners on board the whole seven being only 474. We have very conclusive means of comparing the Spanish with the English ships, and also of judging how very little naval arrangements were then understood, from their imperfect state even on board a fleet which had occupied the whole attention of the Spanish authorities for a space of three years, exemplified in the following anecdote; Burchett, in his account of the action of the 23d of July 1588, says, "The great guns on both sides thundered with extraordinary fury, but the shot from the high-built Spanish ships flew over the heads of the English without doing any execution; one Mr Cock being the only Englishman who fell, while he was bravely fighting against the enemy in a small vessel of his own."

Three-decked ships.

The Spaniards appear to have been the first to introduce a third tier of guns, the earliest mention of a three-decker being the Philip, a Spanish ship engaged in the action

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off the Azores in 1591, with the Revenge, commanded by Sir Richard Greenvil. The following armament of the Philip is extracted from a most spirit-stirring account of this tremendous action, which was written by Sir Walter Raleigh, and has been preserved by Hackluyt. "The Philip carried three tire of ordnance on a side, and eleven pieces in euerie tire. She shot eight forth right out of her chase, besides those of her stern portes."

We do not appear to have followed the example set by the Spaniards; for, during the long reign of Elizabeth, the ships of the royal navy were not much, if at all, increased in their dimensions, which was probably owing to the triumphant successes of her fleets, though, as we have seen, they were composed of ships generally much smaller in size than those opposed to them. We find from the list of the royal navy at the time of her death, in 1603, given by Sir William Monson in his tracts, that of forty-two ships composing the navy, there were then only two ships of 1000 tons, three of 900, three of 800, two of 700, four of 600, four of 500, and there were eight under 100 tons burthen. Two of these ships, the Triumph and the White Bear, are rated in this list each at 100 tons less burthen than in the list of the fleet in the year 1588, which we have already noticed.

James I.
Report of commission.

Shortly after the accession of James to the throne, several commissions were appointed to inquire into the state of the navy. From that of the year 1618, a very voluminous report emanated, of which the following is an extract, that affords an example of the state of knowledge on naval architecture at that time. "The next consideration is the manner of building, which in shipps of warr is of greatest importance, because therein consists both their sayling and force. The shipps that can saile best can take or leave (as they say), and use all advantages the winds and seas does afford; and their mould, in the judgment of men of best skill, both dead and alive, should have the length treble to the breadth, and breadth in like proportion to the depth, but not to draw above sixteen foote water, because deeper shipps are seldom good saylers, and ever unsafe for our rivers, and for the shallow harbours, and all coasts of ours, or other seas. Besides, they must bee somewhat snugg built, without double gallarys, and too lofty upper workes, which overcharge many shipps, and make them coome faire, but not worke well at sea.

"And for the strengthening the shipps, wee subscribe to the manner of building approved by the late worthy prince, the lord admll., and the officers of the navy (as wee are informed), on those points.

"1. In makeing 3 orlopes, whereof the lowest being placed 2 foote under water, both strengtheneth the shipp, and though her sides bee shott through, keepeth it from bildgeing by shott, and giveth easier meanes to finde and stopp the leakes.

"2. In carrying their orlopes whole floored throughout from end to end, without fall or cutting off y^e wast, which only to make faire cabbins, hath decayed many shipps.

"3. In laying the second orlope at such convenient height that the portes may beare out the whole fire of ordinance in all seas and weathers.

"4. In placeing the cooke roomes in the forecastle, as otherr war shipps doe, because being in the midshipps, and in the hold, the smoake and heate soe search every corner and seame, that they make the okam spew out, and the shipps leaky, and soone decay; besides, the best roome for stowage of victualling is thereby soe taken up, that transporters must be hyred for every voyage of any time; and, which is worst, when all the weight must bee cast before and abaft, and the shipps are left empty and light in the midst, it makes them apt to sway in the back, as the Guardland and divers others have done."

This commission was followed by several others during this and the succeeding reign, and from their reports arose many regulations tending much to the improvement of the navy, although the expenses incurred were, ostensibly at least, in part the means of causing the subsequent revolution.

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In the early part of the reign of James I. the mercantile navy of England was reduced to a very low state, most of the commerce being carried on in foreign bottoms. The incitement offered by the advantageous trade which the Dutch had long engaged in to India at length aroused the nation, and the formation of the East India Company, which was the act of James, was followed by the building of the largest ship that had yet been constructed for the purposes of commerce, at least in England. The king dined on board of her, and gave her the name of the Trade's Increase. She is reported to have been of the burthen of 1200 tons. The impetus once given, before the end of the reign of James an important mercantile navy was owned by British merchants.

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Another interesting fact connected with this reign is the founding of the Shipwrights' Company, in the year 1605, and which was incorporated by a charter granted to the "Master, Warden, and Commonality, of the Art or Mystery of Shipwrights," in May 1612. Mr Phineas Pett, of whom we shall presently speak, was the first master. The draughts for the ships of the royal navy were subsequently ordered to be submitted to this company for approval previously to being built from. They also had jurisdiction over all builders, whether of the royal navy or of merchant shipping.

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In 1610 the Royal Prince was launched; she was the largest ship which at that time had been built in England, and was also a most decided improvement in naval architecture. The great projection of the prow, a remnant of the old galley, was for the first time discontinued, and the stern and quarters assimilated more to those of a modern ship than to any which had preceded her. She is thus described in Stow's Chronicles: "A most goodly ship for warre, the keel whereof was 114 feet in length, and the cross beam was 44 feet in length; she will carry 64 pieces of ordnance, and is of the burthen of 1400 tons. The great workmaster in building this ship was Master Phineas Pett, Gentleman, some time master of arts at Emanuel College, Cambridge."

Phinea
Pett.

The same gentleman, Mr Phineas Pett, continued the principal engineer of the navy during the reign of Charles. The family of the Petts were the great instruments in the improvement of the navy, and, if the term may be allowed, of modernizing it, by divesting the ships of much of the cumbrous top-hamper entailed on them from the castellated defences which had been necessary in, and which yet remained from, the hand-to-hand encounters of the middle ages; and it is probable that, but for the taste for gorgeous decoration which prevailed during the seventeenth century, this ingenious family would have been able to effect much more; as it was, they decidedly rendered England pre-eminently the school for naval architecture during the time they constructed its fleets. This family can be traced as principal engineers for the navy from about the middle of the fifteenth century to the end of the reign of William III.

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gate.

Evelyn, in his Diary, relating a conversation, says, "Sir Anthony Deane mentioned what exceeding advantage we of this nation had by being the first who built frigates, the first of which ever built was that vessell which was afterwards called the Constant Warwick (built in 1646), and was the work of Pet of Chatham, for a trial of making a vessell that would sail swiftly. It was built with low decks, the guns lying near the water, and was so light and swift of sailing, that in a short time she had, ere the Dutch war was ended, taken as much money from privateers as would have laden her." The dimensions of this vessel are given in Pepys's Miscellanies as follows: Length of the keel eighty-five feet, breadth twenty-six feet five inches, depth thirteen feet two inches, and 315 tons burthen; her "highest number of guns" thirty-two, and of crew 140.

Peter

Peter Pett, who built the Constant Warwick, was the son of Phineas Pett. He caused the fact of his being the inventor of the frigate to be recorded on his tomb. He was also the builder of the Sovereign of the Seas, in 1637, which was the first three-decker built in England. Her length over all is stated to have been 232 feet, her length of keel 128 feet, her main breadth forty-eight feet, and her tonnage 1637. Heywood describes her in the following terms: "She hath three flush deckes and a forecastle, an halfe decke, a quarter decke, and a round-house. Her lower tyre hath thirty ports, which are to be furnished with demi-cannon and whole cannon throughout, being able to beare them. Her middle tyre hath also thirty ports for demi-culverin and whole culverin. Her third tyre hath twentie-sixe ports for other ordnance. Her forecastle hath twelve ports, and her halfe decke hath fourteene ports. She hath thirteene or foureteene ports more within board for murdering peeces, besides a great many loope-holes out of the cabins for musket shot. She carrieth, moreover, ten peeces of chase ordnance in her right forward, and ten right aff; that is, according to land service, in the front and the reare. She carrieth eleaven anchors, one of them weighing foure thousand foure hundred, &c.; and according to these are her cables, mastes, sayles, cordage, which, considered together, seeing Majesty is at this infinite charge, both for the honour of his nation, and the security of his kingdome, it should bee a spur and encouragement to all his faithful and loving subjects to bee liberall and willing contributaries towards the ship money." Plate CCCCXLIX.

Of this ship, Fuller, in his Worthies, says, "The Great Sovereign, built at Woolwich, a leiger ship for state, is the greatest ship our island ever saw; but great medals are made for some grand solemnity, while lesser coin are more current and passable in payment." She was afterwards cut down one deck, and remained in the service, with the character of the best man-of-war in the world, until the year 1696, when she was accidentally burnt at Chatham.

About this time, 1650, appeared the first work connected with naval improvement ever written in this country, and by no less celebrated an author than Sir Walter Raleigh. It is very probable that his two discourses, the one on the Invention of Shipping, the other Concerning the Royal Navy and Sea-Service, had great influence in creating the interest which was evidently taken about this period in the improvement of the navy. Sir Walter says, "Whosoever were the inventors, we find that every age had added somewhat to ships and to all things else. And in my owne time the shape of our English ships hath been greatly bettered. It is not long since the striking of the top-mast (a wonderfully great case to great ships both at sea and harbour) hath been devised. Together with the chaine-pumpe, which takes up twice as much water as the ordinary did, we have lately added the bonnett and the drabler. To the courses we have devised studding-sayles, top-gallant-sayles, sprit-sayles, topsayles. The weighing of anchors by the capstane is also new. We have fallen into consideration of the length of cables, and by it we resist the malice of the greatest winds that can blow; witnesse our small Milbroke men of Cornewall, that ride it out at anchor half seas over betweene England and Ireland all the winter quarter; and witnesse the Hollanders that were wont to ride before Dunkirke with the wind at north-west, making a lee-shore in all weathers; for true it is that the length of the cable is the life of the ship in all extremities; and the reason is, because it makes so many bendings and waves as the ship riding at that length is not able to stretch it, and nothing breaks that is not stretched. In extremity, we carry our ordnance better than we were wont, because our nether-overloops are raised commonly from the water, to wit, betweene the lower part of the port and the sea. We have also raised our second decks, and given more vent thereby to our ordnance, tying in our nether-overloope.

"We have added crosse pillars in our royall ships to strengthen them, which being fastened from the kelson to the beams of the second decke, keepe them from setling or from giving away in all distresses.

"We have given longer floares to our ships than in elder times, and better bearing under water, whereby they never fall into the sea after the head, and shake the whole body, nor sinck sterne, nor stoope upon a wind, by which the breaking loose of our ordnance, or the not use of them, with many other discommodities, are avoided. And to say the truth, a miserable shame and dishonour it were for our shipwrights, if they did not exceed all other in the setting up of our royall ships, the errors of other nations being farre more excusable than ours. For the kings of England have for many years been at the charge to build and furnish a navy of powerfull ships for their owne defence, and for the wars only; whereas the French, the Spainards, the Portugalls, and the Hollanders (till of late), have had no proper fleete belonging to their princes or states.

"Only the Venetians for a long time have maintained their arsenal of gallyes, and the kings of Denmark and Sweden have had good ships for these last fifty years. I say, that the forenamed kings, especially the Spainards and Portugalls, have ships of great bulke, but fitter for the merchant than the man of warre, for burthen then for battaile. ...Although we have not at this time 135 ships belonging to the subjects of 500 tuns each ship, as it is said we had in the 24th yeare of Queen Elizabeth, at which time also, upon a generall view and muster there were found in England, of all men fit to beare arms, eleaven hundred and seventy-two thousand; yet are our merchants' ships now farre more warlike and better appointed than they were, and the royal navy double as strong as then it was.... We have not therefore lesse force than we had, the fashion and furnishing of our ships considered; for there are in England at this time 400 saile of merchants fit for the wars, which the Spainards would call gallions; to which we may add 200 saile of crumsters or hoyes, of Newcastle, which each of them will bear six demi-culverins, and foure sakers, needing no other addition of building than a slight spar-decke fore and afte, as the seamen call it, which is a slight decke throughout. The 200 which may be chosen out of 400, by reason of their ready staying and turning, by reason of their windwardnesse, and by reason of their drawing of little water, and they are of extreame vantage neere the shoare, and in all bayes and rivers to turn in and out; these, I say, alone, well manned and well conducted, would trouble the greatest prince in Europe to encounter in our seas; for they stay and turn so readily, as, ordering them into small squadrons, three of them at once may give their broad-sides upon any one great ship, or upon any angle or side of an enemy's fleet. They shall be able to continue a perpetuall volley of demi-culverins without intermission, and either sink or slaughter the men, or utterly disorder any fleete of crosse sailes with which they encounter.

"I say, then, if a vanguard be ordained of these hoyes, who will easily recover the wind of any other ships, with a battaile of 400 other warlike ships, and a reare of thirty of his majestie's ships to sustaine, relieve, and countenance the rest (if God beat them not), I know not what strength can be gathered in all Europe to beat them. And if it be objected that the states can furnish a farre greater number, I answer, that his majestie's forty ships, added to 600 before named, are of incomparable greater force than all that Holland and Zeeland can furnish for wars."

Ships of royal navy inferior to merchant-ships.

In the foregoing extract, we have strong evidence that the ships of the royal navy were generally inferior to those employed by the merchant-service, in the essential qualifications of being weatherly. This is exactly the conclusion that might be arrived at from the consideration, that a private individual would dispense with all that superabundance of top-hamper which was entailed on the ships of the royal navy, by the accommodation required for the numerous officers and gentlemen generally embarked on board them, and also by the mania for gorgeous decorations. This mania is well exemplified by the fact, that of the Sovereign of the Seas it is stated, " she beareth five lanthornes, the biggest of which will hold ten persons to stand upright, and without shouldring one another."

Sir Walter Raleigh, in his Discourse on the Royal Navy and Sea-Service, adverts to the same subject. He says, " We find by experience, that the greatest ships are lesse serviceable, goe very deep to water, and of marvellous charge and fearfull cumber, our channells decaying every yeare. Besides, they are lesse nimble, lesse maineable, and very seldome imployed. *Grande navio, grande fatica*, saith the Spainard; a ship of 600 tons will carry as good ordnance as a ship of 1200 tons; and though the greater have double the number, the lesser will turne her broad sides twice before the greater can wend once; and so no advantage in that overplus of ordnance. And in the building of all ships, these six things are principally required. 1. First, that she be strong built; 2. Secondly, that she be swift; 3. Thirdly, that she be stout sided; 4. Fourthly, that she carry out her guns all weather; 5. Fifthly, that she hull and try well, which we call a good sea ship; 6. Sixthly, that she stay well when bourding and turning on a wind is required.

" 1. To make her strong, consisteth in the truth of the workeman and the care of the officers.

" 2. To make her sayle well, is to give a long run forward, and so afterward done by art and just proportion. For, as in laying out of her bows before, and quarters behind, she neither sinck into nor hang in the water, but lye cleare off and above it; and that the shipwrights be not deceived herein (as for the most part they have ever been), they must be sure that the ship sinck no deeper into the water than they promise, for otherwise the bow and quarter will utterly spoile her sayling.

" 3. That she be stout, the same is provided and performed by a long bearing floore, and by sharing off above water even from the lower edge of the ports.

" 4. To carry out her ordnance all weather, this long bearing floore, and sharing off from above the ports, is a chiefe cause, provided alwayes that your lowest tyre of ordnance must lye foure foot cleare above water when all loading is in, or else those your best pieces will be of small use at the same in any growne weather that makes the billoe to rise, for then you shall be enforced to take in all your lower ports, or else hazard the ship.

" 5. To make her a good sea ship, that is, to hull and trye well, there are two things specially to be observed; the one that she have a good draught of water, the other that she be not overcharged, which commonly the king's ships are, and therefore in them we are forced to lye at trye with our maine course and missen, which, with a deep keel and standing streake, she will performe.

" 6. The hindrance to stay well is the extreame length of a ship, especially if she be floaty and want sharpnesse of way forwards; and it is most true, that those over-long ships are fitter for our seas than for the ocean; but one hundred foot long, and five and thirty foot broad, is a good proportion for a great ship. It is a speciall observation, that all ships sharpe before, that want a long floore, will fall roughly into the sea, and take in water over head and ears.

" So will all narrow quartered ships sinck after the tayle. The high charging of ships is it that brings them all ill qualities, makes them extreame leeward, makes them sinck deep into the water, makes them labour, and makes them overset. Men may not expect the ease of many cabbins, and safety at once, in sea-service. Two decks and a half is sufficient to yield shelter and lodging for men and mariners, and no more charging at all higher, but only one low cabbin for the master. But our marriners will say, that a ship will beare more charging aloft for cabbins, and that is true, if none but ordinary marryners were to serve in them, who are able to endure, and are used to, the tumbling and rowling of ships from side to side when the sea is never so little growne; but men of better sort and better breeding would be glad to find more steadinesse and lesse tottering cadge work. And albeit, the marriners doe covet store of cabbins, yet indeed they are but sluttish dens, that bread sicknesse in peace, serving to cover stealths, and in fight are dangerous to teare men with their splinters."

In Fuller's Worthies, we have also a short summary of the comparative qualities of the ships of different nations in the middle of the seventeenth century. It is as follows: " First, for the Portugal, his carvils and caracts, whereof few now remain (the charges of maintaining them far exceeding the profit they bring in); they were the veriest drones on the sea, the rather because formerly their seeling was dam'd up with a certain kind of morter to dead the shot, a fashion now by them disused.

" The French, however dexterous in land-battles, are left-handed in sea-fights, whose best ships are of Dutch building. The Dutch build their ships so floaty and buoyant, they have little hold in the water in comparison to ours, which keep the better winde, and so outsail them.

" The Spanish pride hath infected their ships with loftiness, which makes them but the fairer markes to our shot. Besides, the winde hath so much power of them in bad weather, so that it drives them two leagues for one of ours to the leeward, which is very dangerous upon a lee shore.

" Indeed the Turkish frigots, especially some thirty-six of Algier, formed and built much nearer the English mode, and manned by renegadoes, many of them English, being already too nimble heel'd for the Dutch, may hereafter prove mischievous to us, if not seasonably prevented."

During the early part of the seventeenth century, the Dutch navy rapidly increased in importance. Their success in having wrested from the Portuguese a share of the commerce of the east, emboldened them, in the then depressed state of the Spanish marine, to make a similar attempt on the west, and endeavour to establish settlements in South America.

The wars with Spain, in which they were consequently engaged, had such an important effect in establishing their maritime power, that in 1650 their navy consisted of 120 vessels fitted for war, seventy of which had two tiers of guns; and their fleet was in all respects the most efficient in Europe.

Evelyn, in his tract on Navigation and Commerce, speaking of the fisheries, says, " Holland and Zeeland alone should, from a few despicable boats, be able to set forth above 20,000 vessels of all sorts, fit for the rude seas, of which more than 7000 are yearly employed upon this occasion. 'Tis evident that by this particular trade they are able to breed above 40,000 fishermen and 116,000 mariners, as the census (1639) has been accurately calculated."

The tremendous struggle in which they were enabled by these means to engage with us shortly after this period, in consequence of the injurious operation of the navigation act on their commerce, had a most influential effect on the improvement of our navy, which at the commencement of the contest was very unequal to that of the Dutch; and it is probable that this war was the means of enabling us to contend triumphantly against the immense and unexpected attempts of Louis XIV. to wrest the sceptre of the seas from our grasp.

The sovereigns of the house of Stuart, without exception, appear to have devoted much attention to the improvement of the navy. Charles I. may be almost said to have lost both crown and life in consequence of these efforts; nor would it be doing justice to Cromwell to omit mention

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of the energy with which he took advantage of the all but despotic power which he possessed to increase his naval force. For this purpose not only many ships were built during the protectorate, but numbers of merchant-vessels were bought for the service of the state.

les II. perso- atten- to build- and al af- s.

After the restoration, Charles II. paid great personal attention even to the minutiæ of his navy, as we find by the following curious extract from a letter of his to Prince Rupert, preserved in the state-papers, and also by continual references to his naval predilections in Evelyn's and Pepys's Memoirs and writings. The letter is dated 4th August 1673. It says, "I am very glad the Charles does so well; a gerdeling this winter when she comes in will make her the best ship in England; next summer, I believe, if you try the two sloops that were builte at Woolidge that have my invention in them, they will outsail any of the French sloops. Sir Samuel Mooreland has now another fancy about weighing anchors; and the resident of Venice has made a model also to the same purpose. We have not yet consulted them with Mr Tippet nor Mr Deane; but hope when they are well considered, we may find one out of them that will be good."

Antho- Deane.

In Pepys's Diary, 19th May 1666, we find the following notice relating to one of the gentlemen mentioned in the above letter: "Mr Deane and I did discourse about his ship the Rupert, which succeeds so well, as he has got great honor by it, and I some by recommending him. The king, duke, and every body, say it is the best ship that was ever built. And then he fell to explain to me his manner of casting the draught of water which a ship will draw beforehand, which is a secret the king and all admire in him; and he is the first that hath come to any certainty beforehand of foretelling the draught of water of a ship before she be launched." This gentleman appears therefore to have been the first who applied mathematical science to naval architecture in this country. Pepys also says, "another great step and improvement to our navy, put in practice by Sir Anthony Deane," was effected in the Warspight and Defiance, which were "to carry six months' provisions, and their guns to lie 4½ feet from the water." This was in 1665.

t ap- ation of hema- l calcu- on to al ar- ecture.

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Sir Robert Slingeby.

We have hitherto in our historical sketch several times adverted to the probability that the merchant-shipping of England were superior in their sea-going qualities to those composing the royal navy. In a "Discourse touching the Past and Present State of the Navy," by Sir Robert Slingeby, knight-baronet, and comptroller of the navy, dated 1669, we have the following interesting statement, which points to a reason why this superiority of the merchant-shipping may have existed. "But since these late distractions began at home" (the Commonwealth), "forraigne trade decayed, and merchants so discouraged from building, that there hath been scarce one good merchant-ship built these twenty years past; and of what were then in being, either by decayes or accident, there are very few or none remaining. The merchants have found their private conveniences in being convoyed att the publick charge; they take noe care of making defence for themselves if a warr should happen." Yet he says in the time of Charles I. "the merchants continued their trade during the wars with France and Spain, if there could but two or three consort together, not careing who they met," they being little inferior in strength or burthen to the ships of the royal navy. The Discourse expresses much regret at this decay in the importance of the mercantile shipping, and recommends that measures should be taken to check the evil.

Decay of mercantile navy.

Sir Richard Haddock.

First analysis of the royal navy.

About 1684 Sir Richard Haddock, comptroller of the navy, adopted the example already set by Mr, afterwards Sir Anthony Deane, and directed an inquiry to be made as to "the number of cube feet that are contained in the bodyes of several draughts to their main water-line, when all materialls are on board fitt for saileing." The result of this inquiry was a very voluminous statement of the weights which made up the whole displacement of the fourth, fifth, and sixth rate ships, including minute details of their masts, yards, armament, &c. accompanied by perfect drawings of each ship. The original document is now in the possession of the writer of this article, having successively belonged to Sir Jacob Ackworth, Sir Jacob Wheate, and Mr Edward Hunt. The following table contains the dimensions and displacements, &c. of each class.

Table of Dimensions, from a Manuscript dated 1684.

	A First Fourth-rate near the largest dimensions.	A Second Fourth-rate near the dimensions of the Adventure.	A Fifth-rate of the largest dimensions.	A First Sixth-rate.	A Second Sixth-rate.	A Sixth-rate of the largest dimensions.	A Sixth-rate of the old fashion.
	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.
Length on the gun-deck from the rabbitt of the stem to the rabbitt of the post	124 6	116 6	103 9	87 8	70 0	92 6	93 0
Maine breadth to the outside of the outboard planke	35 0	32 9	28 8	23 6	21 6	23 6	22 9
Depth in hold from the seeling to the upper side of the beame	14 0	13 2	11 4	10 9	9 10	11 9	10 0
Breadth at the afte side of the maine transome	21 0	18 4	18 0	14 0	13 0	14 0	15 0
Height on the gun-deck from planke to planke, afore	5 9	6 0	5 9	5 7	5 6	...	...
midships	6 0	6 0	6 0	...	...	...	...
abafte	6 6	6 3	6 7	6 3	6 2	...	...
The center of the fore mast from the rabbitt of the stern	13 6	12 9	9 10	7 6	6 6	10 0	9 6
maine	69 0	62 0	54 6	45 0	36 0	50 0	49 6
mizion	102 0	96 9	84 0	71 0	57 0	73 0	74 0
Draft of water, afore	14 6	13 6	12 0	9 8	8 6	10 0	8 0
abaft	15 10	15 0	13 0	10 8	9 6	11 0	9 0
Number of tuns, tunage	885	580	362	...	...	230	220
Number of men (in warr)	260	180	135	85	70	90	90
Number of guns	50	44	34	24	18	22	24
Cube feet in the several draughts to their main water-line	29,814	22,346	13,195	8906	6790	...	...
	Ts. et. qr. lb.	Ts. ct. qr. lb.	Ts. et. qr. lb.	Ts. et. qr. lb.	Ts. et. qr. lb.	Ts.	Ts.
Weight of each ship's hull, and all manner of materials on board	851 16 2 8	638 9 0 16	377 0 0 3	254 9 0 16	194 0 0 0	...	...
Each ship's hull at first launching	418 0 0 0	314 0 0 0	160 0 0 0	120 0 0 0	98 0 0 0	...	...
Burthen in tuns, what she will really carry	433 16 2 8	324 9 0 16	216 0 0 0	134 9 0 16	...	135	130
No. of months' provisions and water	4	3	3	2	2	...	...

James II.

James II., from having so long and so gloriously filled the office of Lord High Admiral while Duke of York, was perfectly aware of the requirements of the navy; and during his short reign he paid great attention to increasing its efficiency. He also especially directed inquiries into the question of the durability of timber for the construction of it, and carefully accumulated both materials and stores for its maintenance. It is not a little curious that it was probably the attention which the monarchs of the line of Stuart had bestowed on the naval service, which enabled it so triumphantly to resist the persevering attempts of Louis XIV. to recover for them the throne of their ancestors.

The Revolution.

Though England was at the Revolution possessed of an efficient fleet, manned by experienced seamen, who had all the confidence arising from a series of naval triumphs, it must be remembered that for a long period no opposition to her naval superiority had been anticipated from any other power than Holland; and consequently the fleets of England were composed of ships which had many of them been built to adapt them to this service, for which small dimensions and light draughts of water were essential qualifications, on account of the shoalness of the Dutch coast.

William III.

William was too cautious a monarch to have neglected so important a means of national defence, as was the navy when engaged with such an ambitious and energetic opponent as Louis XIV.; and we find that the naval force was considerably increased, both numerically and in dimensions, during his reign. But the triumphs of our armies under Marlborough having for a time diverted the attention of the nation from naval affairs, it fell into decay during the reign of his successor.

Louis XIV.

When Louis XIV. determined to dispute with England for the sovereignty of the seas, he was not only without a navy, but without the means of forming one. The military and commercial marine of France had ceased to exist.

Rise of French naval power.

The sanguine temperament of the monarch, and the wisdom of his minister Colbert, removed all obstacles; commerce began to flourish on the quays, merchant-vessels to crowd the ports; dock-yards, harbours, and shipping appeared simultaneously to start into existence; and the nation, which almost for centuries had been essentially military, felt constrained to turn its energies to commerce and to the sea. A navy which in 1661 consisted of some four or five small vessels, in little more than ten years bearded and baffled the combined fleets of Holland and of Spain, and asserted the sovereignty of the Mediterranean. In 1681 her fleets consisted of 115 line-of-battle ships, manned by 36,440 men, with 179 smaller ships, the crews of which amounted to 3037 men; and in 1690 a fleet of eighty-four vessels of war, out of which three were of a hundred guns and upwards, and ten others were above eighty-four guns, with twenty-two fire-ships, was cruizing in the British seas. It is true that these mighty armaments failed in fulfilling the ambitious designs of Louis. But the severity of the struggle, which at length ended in the annihilation of his hopes, and in our triumphant assertion of our naval superiority, must always serve as an example of the danger we may incur by too great confidence in that superiority.

Comparison between English and French ships.

We have the following comparison between the French and British ships of about this period, from an official contemporary paper, by a gentleman of the name of Gibson: "Our guns being for the most part shorter, are made to carry more shott than a French gunn of like weight, therefore the French guns reach further, and ours make a bigger hole. By this the French has the advantage to fight at a distance, and wee yard-arm to yard-arm. The like advantage wee have over them in shipping; although they are broader and carry a better saile, our sides are thicker, and better able to receive their shott; by this they are more subject to be sunk by gunn shott than wee."

Injudicious management of royal navy.

The paper also complains much of the injudicious management of our shipping, by which it says, "many a fast sayling shipp have come to loose that property, by being over-masted, over-rigged, over-gunned (as the Constant Warwick, from twenty-six gunns, and an incomparable sayler, to forty-six gunns and a slugg), over-manned (vide all the old shipps built in the parliament time now left), over-built (vide the Ruby and Assurance), and haveing great tafferills, gallarys, &c., to the making many formerly a stiff, now a tender-sided shipp, bringing thereby their head and tuck to lye too low in the water, and by it takeing away their former good property in steering, sayling, &c. The French by this defect of ours make warr with the sword (by sending no small shipps of warr to sea, but clean), and wee, by cruseing in fleetes, or single shipps foule, with bare threates."

Charnoc opinions and paral lels.

Charnock draws some curious parallels between the state of the two navies of France and England during the earlier half of the eighteenth century, which may be summed up in a few words. That when the French took an English ship, it was seldom admitted into their navy; or, if admitted, it was only at a much lower rating, as, for instance, the Pembroke, a sixty-four in our service, became a fifty-gun ship in theirs. That in cases when an English fleet was in chase of a French fleet, it was ships which were British built which fell into our possession; but that almost on every occasion the French ships could evade ours. That the losses sustained in the French navy by foundering at sea, or by wrecks, were principally those ships which had been taken from us. That, on the contrary, the favourite ships in our fleets were those which had been taken from the French, and the instances in which French ships in our service were ever recovered possession of by them were extremely rare; we as far excelling them in all that related to the manœuvres and management of ships as they did us in designing them.

In consequence of the little attention bestowed upon the navy during the land-triumphs of Marlborough, it was found absolutely necessary, at the commencement of the reign of George I. that vigorous measures should be taken to re-establish it. Much pains were bestowed during this and the succeeding reign of George II. to improve its efficiency. The dimensions and the armament of the ships composing it underwent frequent revisals, and many valuable accessory improvements were made. Still it was evident that the perfect seamanship of the officers, and the undaunted valour of their crews, were frequently rendered nugatory by the superior qualities of the ships of their opponents, and the nation reaped little more than empty honour from the contests in which she engaged; the heavy sailers of England being unable to prevent her colonies and her commerce from suffering severely from the attacks of the light squadrons of her enemies. The naval commanders of England were constant in their complaints of the comparative inferiority in speed, in stability, and in readiness of manœuvring, of the ships under their command.

Lord R ney.

In a letter from Sir George (afterwards Lord) Rodney, dated the 31st May 1780, to Mr Stephens, the secretary of the Admiralty, is a passage which proves in a remarkable degree the truth of the above statement. "Nothing could induce them (the French fleet), to risk a general action, though it was in their power daily. They made, at different times, motions which indicated a desire of engaging, but their resolution failed them when they drew near; and as they sailed far better than his majesty's fleet, they with ease could gain what distance they pleased to windward."

Cause inferior of Engl ships.

One great cause of the inferiority of our ships arose from the practice which prevailed during the first half of the eighteenth century, through a mistaken idea of economy, of "rebuilding" old ships, so that, in fact, the forms and dimensions of the previous century passed down in many

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instances nearly to the end of this; and, with little stretch of the imagination, we may suppose, that under a continuation of the same ill-judged system, we should have had the representations of the carracks and galleons of the reign of Elizabeth in the fleets of the present day!

The French system of improvement was followed by the Spaniards, and the capture of the Princessa in 1740, of seventy guns, 165 feet in length and forty-nine feet eight inches in breadth, when our ships of the same force then building were only 151 feet long and forty-three feet six inches broad, caused an appeal to be made by the Admiralty to Admiral Sir John Norris, the then "naval oracle" of England. The consequence of the inquiries was, that the several master-shipwrights were directed to send in proposals for the future established dimensions of the navy; and in 1745 the Admiralty issued a new establishment for the dimensions of the several ratings of ships. The following table, taken from Derrick's Memoirs of the Royal Navy, contains the various established alterations from the reign of Charles II. to this of 1745, which was the last. Since then there has been considerable improvement, but there have been no fixed tables as established dimensions, at least none involving all the ratings.

The ships built after the establishment of 1745 are reported to have been stiff, and to have carried their guns well, but were still inferior to those of the French; and, consequently, about ten years afterwards an alteration was made in the draughts for the several ratings, and the dimensions were also slightly increased. It may not be uninteresting to remark, that the proportional breadths in the establishment of 1745 considerably exceeded those of more modern ships. Their breadth varied from $\frac{100}{349}$ to $\frac{100}{355}$ of their lengths; while, at the present time, with the exception of those built after the designs of the present surveyor of the navy, the breadths of most of our line-of-battle ships are within the limits of $\frac{100}{361}$ and $\frac{100}{383}$ of their lengths. We merely state this as a historical fact, not as advocating an undue increase of breadth. The question of the relative proportions of the dimensions of ships belongs to another portion of this article.

An Account showing the Dimensions established, or proposed to be established, at different times, for Building of Ships. Extracted from Derrick's Memoirs of the Royal Navy.

	Establishment of								Proposed in				Establishment of 1745.	
	1677.		1691.		1706.		1719.		1733.		1741.			
Ships of 100 Guns.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In-	Ft.	In.	Ft.	In.	Ft.	In.
Length on the gun-deck	165	0	...		...		174	0	174	0	175	0	178	0
Length of the keel, for tonnage	137	8	...		...		140	7	140	7	142	4	144	6½
Breadth, extreme	46	0	...		...		50	0	50	0	50	0	51	0
Depth in hold	19	2	...		...		20	0	20	6	21	0	21	6
Burthen in tons	1550		...		...		1869		1869		1892		2000	
90.														
Length on the gun-deck	158	0	...		162	0	164	0	166	0	168	0	170	0
Length of the keel, for tonnage	...		...		132	0	132	5	134	1	137	0	138	4
Breadth, extreme	44	0	...		47	0	47	2	47	9	48	0	48	6
Depth in hold	18	2	...		18	6	18	10	19	6	20	2	20	6
Burthen in tons	1307		...		1551		1566		1623		1679		1730	
80.														
Length on the gun-deck	...		156	0	156	0	158	0	158	0	161	0	165	0
Length of the keel, for tonnage	...		...		127	6	128	2	127	8	130	10	134	10¾
Breadth, extreme	...		41	0	43	6	44	6	45	5	46	0	47	0
Depth in hold	...		17	4	17	8	18	2	18	7	19	4	20	0
Burthen in tons	...		1100		1283		1350		1400		1472		1585	
70.														
Length on the gun-deck	150	0	...		150	0	151	0	151	0	154	0	160	0
Length of the keel, for tonnage	...		...		122	0	123	2	122	0	125	5	131	4
Breadth, extreme	39	8	...		41	0	41	6	43	5	44	0	45	0
Depth in hold	17	0	...		17	4	17	4	17	9	18	11	19	4
Burthen in tons	1013		...		1069		1128		1224		1291		1414	
60.														
Length on the gun-deck	...		144	0	144	0	144	0	144	0	147	0	150	0
Length of the keel, for tonnage	...		...		119	0	117	7	116	4	119	9	123	0½
Breadth, extreme	...		37	6	38	0	39	0	41	5	42	0	42	8
Depth in hold	...		15	8	15	8	16	5	16	11	18	1	18	6
Burthen in tons	...		900		914		951		1068		1123		1191	
50.														
Length on the gun-deck	..		...		130	0	134	0	134	0	140	0	144	0
Length of the keel, for tonnage	...		...		108	0	109	8	108	3	113	9	117	8½
Breadth, extreme	...		...		35	0	36	0	38	6	40	0	41	0
Depth in hold	...		...		14	0	15	2	15	9	17	2½	17	8
Burthen in tons	...		...		704		755		853		968		1052	
40.														
Length on the gun-deck	...		...		118	0	124	0	124	0	126	0	133	0
Length of the keel, for tonnage	...		...		97	6	101	8	100	3	102	6	108	10
Breadth, extreme	...		...		32	0	33	2	35	8	36	0	37	6
Depth in hold	...		...		13	6	14	0	14	6	15	5½	16	0
Burthen in tons	...		...		531		594		678		706		814	
20.														
Length on the gun-deck	...		...		...		106	0	106	0	112	0	113	0
Length of the keel, for tonnage	...		...		...		87	9	85	8	91	6	93	4
Breadth, extreme	...		...		...		28	4	30	6	32	0	32	0
Depth in hold	...		...		...		9	2	9	5	11	0	11	0
Burthen in tons	...		...		...		374		429		498		508	

The Royal George was the first ship built on the increased dimensions, which were the result of the before-mentioned inquiry. She was laid down in 1746, and launched in 1756; and rather more than ten years afterwards, that is, in 1758, Triumph and Valiant.

the Triumph and Valiant of seventy-four guns were built on the lines of the Invincible, a French seventy-four-gun ship, captured in 1747.

We give the dimensions of these ships, as they were manifestations of an improved system, which, however, was not persevered in; for, with the exception of occasionally building after a French or Spanish model, the English ships were scarcely altered from those built at the commencement of the century.

	Royal George.	Triumph and Valiant.
	Feet. In.	Feet. In.
Length on the gun-deck..........	178 0	171 3
Length of the keel, for tonnage...	143 5½	138 8
Breadth, extreme....................	51 9½	49 9
Depth in hold........................	21 6	21 3
Burthen in tons......................	2047	1826

Grand distinction between English and foreign navies.

There was still a very essential distinction between the navy of England and that of either France or Spain, which was this; that until after 1763 neither of these nations had any three-deckers in their fleets. Their largest armament appears to have been eighty-four guns on two decks, while we had third-rates which were three-deckers, as the Cambridge and Princess Amelia, launched in 1754 and 1757, and carrying only eighty-four guns. The capture of the Foudroyant, a French eighty-four on two decks, in 1758, caused a change in this respect, by furnishing the English with a model for a very superior class of men-of-war, which was adopted. Derrick, in his Memoirs of the Royal Navy, says, that "no eighty-gun ship with three decks was built after the year 1757, no seventy-gun ship after 1766, nor any sixty-gun ship after 1759."

French-built thr deckers.

During the peace that preceded the war with America, which commenced in the year 1768, the French had introduced three-deckers into their fleets, having found their eighty-fours on two decks to be no match for the more powerful of our three-deckers. Their first-rates were at this time generally of a hundred and ten guns on three decks. The Bretagne, one of these ships, was, according to Charnock, a hundred and ninety-six feet three inches long on the water line; and her moulded breadth was fifty-three feet four inches. Her displacement, it is stated in Sewell's Collection of Papers on Naval Architecture, was 4640 English tons. This can hardly be correct.

Establis ment of French fleets.

In 1786 the establishment of the French fleet was fixed by an ordinance, as according to the following table, which we extract from Charnock.

	Ships of 120 Guns.	Ships of 110 Guns.	Ships of 80 Guns.	Ships of 74 Guns.	Ships of 64 Guns.	Frigates carrying 18 Pounders.	Frigates carrying 12 Pounders.	Corvettes of 20 Guns.	Advice-boats, carrying four 4 Pounders.
	Feet. In.	Feet.	Feet.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.	Feet. In.
Length from head to stern......	196 6	186—185	184—180	170 0	156 0	144 0	136 0	112 0	80 0
Breadth from outside to outside of the frame............	50 0	49 6 in.	48 0 in.	44 6	41 0	36 6	34 6	28 4	24 0
Depth in hold......................	25 0	24 6	23 9	22 0	20 0	18 0	17 6	14 4	12 0
Draught of water abaft when light..........................	17 6	17 4	17 0	15 8	14 6	12 6	11 3	9 6	8 4
Draught of water forward when light..................	14 0	13 8	12 0	10 10	11 1	8 7	8 6	8 5	8 0
Draught of water abaft when laden........................	25 0	24 8	22 6	21 6	19 9	16 0	15 4	13 3	11 6
Draught of water forward when laden..................	22 8	22 2	21 0	19 10	18 9	15 2	13 9	11 9	10 0
Total weight of the ship and stores when victualled and furnished for a six months' cruise........................	Tons. 5246	Tons. 4910	Tons. 3825	Tons. 3548½	Tons. 2300	Tons. 1479	Tons. 1162	Tons. 546	Tons. 266
Weight of the hull and masts...	2500	2400	1804	1437	1120	665	583	266	141

George III. and George IV.

The ships of England continued throughout the wars of the reigns of George III. and George IV. notoriously inferior to those of France and Spain. The skill of our commanders, and the indomitable courage of our seamen, eventually succeeded in these, as in all former contests, in annihilating opposition, and in triumphantly asserting our naval supremacy. It cannot be denied that their task would have been comparatively easy, accompanied with less loss of life and expenditure of treasure, had their ships been more upon a par with those of their opponents.

Reasons for the continued inferiority of British shipping.

Although so much attention appears to have been directed at various times to the improvement of the navy, not only by the servants of the crown officially connected with it, but by the sovereigns themselves, we have seen that this continued inferiority of our ships to those of our opponents has been repeatedly asserted on undoubted testimony. The reason that all the attention thus bestowed failed in producing a corresponding beneficial effect was simply this; that in England the speculative ideas of men, undoubtedly of sense and judgment, as may be seen from the quotations of their opinions which we have made, but men uninformed as to principles, were taken as the rules for guidance. In France, on the contrary, the aid of science was called in, and some of the greatest mathematicians of the time turned their attention to the improvement of the shipping of that country; and it is a most astonishing fact, that the experience of more than a century of acknowledged inferiority to France, also with the admission that her superiority was caused by the researches of her mathematicians, should have still left it a question in England, whether our ships shall be designed on speculative opinions, or from scientific deductions. Colbert employed an engineer of the name of Rénau d'Elisagaray, a protégé of the Count de Vermandois, whose first essay was in the adaptation of ships to carry bombs, to be used in the then projected armament against the piratical states of the Mediterranean. Under the enlightened direction of Colbert, the French ships, which, by the ordinance of 1688, were much restricted in dimensions, were increased nearly one fourth in size, and every means taken which the then state of knowledge could suggest to insure a corresponding increase in good qualities. Rénau was, we believe, the first French author who wrote on the theory of ships. He was followed by the Bernoullis, by Père La Hoste, by Bouguer, Euler, Don Jorje Juan, Romme, and a host of others, the effects of whose writings we have traced in the progress of the improvements they introduced into the navies of France and Spain, and forced the navy of England to imitate. The only English treatise on ship-building that can lay any claim to a scientific character was published by Mungo Murray in 1754; and he, though his conduct was irreproachable, lived and died a working shipwright in Deptford dock-yard.

ance of rance.

A most palpable instance of the ignorance of all the principles of naval architecture among the authorities who were charged with designing our royal navy, even up to the close of the last century, may be quoted from an article in a recent periodical publication, the Papers on Naval Architecture, which was devoted to the advancement of this science, and which was for some years conducted by two gentlemen who were educated at the School of Naval Architecture at Portsmouth. The article in question was written by Mr Wilson of the late Navy Office, now Admiralty, a gentleman whose judgment, talents, and sound professional knowledge as a naval architect, contrasted with the humbleness of his situation, that of draughtsman to the surveyor of the navy, may also be cited as affording an instance of the mistaken policy of the successive naval administrations of England, as to the encouraging the application of science to naval architecture.

ee of Anson.

Mr Wilson, speaking of the cutting down of the Anson, a sixty-four-gun ship, to a frigate of thirty-eight guns, says, "she was cut down in the year 1794; and although in all other maritime states the science of naval construction was well understood, yet so culpably ignorant were the English constructors, that this operation, so well calculated, when properly conducted, to produce a good ship, was a complete failure. Seven feet of the upper part of the top-sides, together with a deck and guns, making about 160 tons, were removed, by which her stability was greatly increased; but, by a complete absurdity, the sails were reduced one sixth in area. In her first voyage the rolling was so excessive that she sprung several sets of top-masts. To mitigate this evil, in 1795 her masts and yards were increased to their original size; but as there was no decrease of ballast, she was still a very uneasy ship, and, as a necessary result, her wear and tear were excessive.

"Other sixty-fours were cut down, masted, and ballasted in exactly the same manner, and, it need scarcely be added, experienced similar misfortunes; and although they were improved by enlarging their masts and yards, they were still bad ships. Had their transformations been scientifically conducted, a class of frigates would have been continued in the navy, capable, from their size, of coping with the large American frigates; and thus the disasters we experienced in the late war, from the superior force of that nation, would, without doubt, have been not merely avoided, but turned into occurrences of a quite opposite character."

ety for Im- rement Naval hitec-

Several attempts have been made in England to alter this state of things, and to establish a system of scientific improvement in our ships. One was the formation of a Society, in 1791, for the Improvement of Naval Architecture, which numbered among its members the late sovereign, then Duke of Clarence, and many noblemen and gentlemen of rank, influence, and talent. This society arose out of the patriotic exertions of a bookseller of the name of Sewell, the proprietor of the European Magazine, who in an excursion to one of our seaports, heard such universal complaints as to the inferiority of the British ships compared with those to which they were opposed, that he devoted the covers of his magazine to correspondence on naval architecture, and gave a room in his house for discussion on the same subject, and for the reception of plans and models connected with it, which were always open to public inspection. The papers that were by these means collected were republished in two volumes; and, among much trash, there are several valuable articles contained in them. The society conducted a course of experiments on resistances of fluids, in the Greenland docks, on which they appear to have exhausted their resources and their energies, and that too without deducing any results which added to the previous knowledge on that subject. We are not aware that more than the first year's Report of their proceedings was ever published. Of this we have only met with one copy; and in consequence of the probability that the results of the society's experiments might be completely lost, they were republished in the Papers on Naval Architecture. They have been since republished in a most splendid form, and in a most patriotic spirit, solely for gratuitous distribution to scientific societies and individuals, by Mr Beaufoy, the son of the late Colonel Beaufoy, the gentleman to whom the task of conducting them was intrusted by the society, and on whom, it appears, a great portion of the expenses devolved.

Colonel Beaufoy.

School of Naval Architecture.

Another effort to improve the scientific knowledge of naval architecture in this kingdom was the establishment, in 1811, of a School for Naval Architecture in her majesty's dock-yard at Portsmouth. This was in consequence of the statements and recommendations contained in the Report of a Commission of Naval Revision appointed in 1806. These recommendations were founded on an inquiry into the education and attainments of the shipwright officers then in the dock-yards, "from their first entry as apprentices, to their elevation to the rank of surveyor of the navy." The Report stated as follows:—"In the whole course we have described, no opportunity will be found of acquiring even the common education given to men of their rank in life; and they rise to the complete direction of the construction of the ships on which the safety of the empire depends, without any care or provision having been taken, on the part of the public, that they should have any instruction in mathematics, mechanics, or in the science or theory of marine architecture."

Report of the Commission of Naval Revision.

The Report stated it to be among the most important parts of the duty of the Commission to endeavour "to put an end to that want of foresight and due consideration, which may finally lead to so much danger to the country; and to bring into our dock-yards apprentices of more liberal education than has hitherto been required."

The Commissioners recommended the establishment of two classes of apprentices. They proposed the arrangments necessary for putting their recommendations into practice, and also laid down a system of education for the first class. These proposals were directed to be carried into effect, by an order in Council of the 20th of September 1809, which was complied with in the establishment of the School of Naval Architecture on the first of January 1811.

School of Naval Architecture established.

The arrangements of the school were modified by a second order in Council on the 30th of January 1816, in consequence of a building for the reception of the students having been completed. By this order the establishment was incorporated with the Royal Naval College, and the number of students limited to twenty-four, that number being considered as "sufficient to supply the place of officers who may die or be removed," and therefore to fulfil the intentions of the Board of Naval Revision. This second order in Council stated, that the object of the institution was to introduce "a better and more skilful description of shipwright officers in his majesty's royal dock-yards;" and the "regulations established relative to the admission of students into the School of Naval Architecture," for the information of the candidates, stated that, "on the expiration of the apprenticeship, the students will be eligible to all situations in the ship-building department of his majesty's service; and in the event of there being no vacancy in any of his majesty's yards, they shall be employed as supernumeraries in the yards, until vacancies do occur," "provided the apprentice shall, at the expiration of the time above mentioned, have completed the plan of education, and shall be certified by the professor to be properly qualified."

History.

Number of students.

Forty-two gentlemen have been educated at this establishment, and twenty-two still remain in the ship-building department of her majesty's service, of whom many, bound to the service under heavy penalties, were, for eight or ten years after leaving the school, employed as supernumeraries in the dock-yards, awaiting their first appointments as foremen, although vacancies were during the interval continually occurring. Three only have been promoted to the step next above that of foreman; and, out of the last fourteen appointments to situations superior to that of foreman, only one has been conferred upon a member of the School of Naval Architecture.

The attempt has therefore most signally failed. For, from the comparative ages of the gentlemen of this establishment, and those of the officers who have been placed in these vacancies, there can be no rational hope that the expectations of the Commissioners of Naval Revision, or of the members of the Councils of State, can be fulfilled; and it may therefore now be said (in 1839), with as much truth as by the Report of the Board of Naval Revision in 1806, "nothing certainly can be more surprising than that, in a nation so enlightened as this is, and whose power, importance, and even safety, depend on its naval superiority, matters so essential to the preservation of that superiority should so long have been neglected."

Abolition of the school. Reasons of its failure.

The School of Naval Architecture was abolished in 1832; and we cannot write of the failure of this establishment without endeavouring to trace its causes, and to account for the strong prejudice which has existed against its members from the moment the first student's name was recorded on its books; a prejudice which has baffled them in every endeavour to obtain just attention to their claims from each successive naval administration, and which has virtually deprived the nation of the advantages anticipated by the Board of Naval Revision. That it is not in the failure of the students themselves to fulfil the conditions required of them, is evident, since the sole condition was that which we have quoted from the regulations, that they should complete the plan of education, "and be certified by the professor to be properly qualified." This the professor has officially complied with in the strongest terms. Nor is it that they are individually unfit to fill the situations which were guaranteed to them; for many of them are possessed of the most flattering testimonials of efficiency, as thorough practical officers, men of business, and gentlemen of principle. We believe it to arise solely from this, that the foundation of the establishment was accompanied by the most mortifying and humiliating reflections on the officers then filling the situations in the dock-yards, and, consequently, on all who rose to such situations from the working class of the yards. From these officers, to all of whom the very existence of the School of Naval Architecture has been a reproach, and a constant source of mortification, and to many of whom the advance of its members would operate as a bar to promotion, successive Admiralties have been contented to derive their information as to the success of that establishment, and the efficiency of its members. It surely would be expecting more than can be hoped from human nature in its most exalted state, to suppose such information could be given devoid of party feeling and of prejudice, or that men would voluntarily admit their own inefficiency, and concede to those whom they must regard as their rivals for the favours of the Admiralty; a merit equal, nay, on the very principle of the foundation of the establishment, superior, to that which they themselves possess. The First Lord of the Admiralty, therefore, for the time being, acting on information thus derived, annually asserts in his place in parliament, and believes his assertion to be correct, that these "young men" (men between forty and fifty years of age) "though gentlemen and men of education, yet want experience, and therefore cannot be promoted."

History.

It has bee productiv of much good.

The institution has however not been unattended with benefit to the service. The correct principles of naval architecture have become known and generally diffused; and though the members of the establishment may not reap the reward, the merit is undoubtedly theirs, for it has been through their instrumentality and from their works. It cannot, either, be denied that the officers of the dock-yards of the old school have had their energies aroused, and have risen in the scale of educated society, from their rivalry with the members of the new. On an inquiry into their competency to fill the situations in which they have been placed, though there would be many instances fully to warrant as great animadversion as was passed by the Board of Revision on their predecessors, there would also be found among them gentlemen, men of talent, and of considerable acquirements.

Sir William Symonds.

In 1830, Captain, now Sir William Symonds, was appointed to the office of surveyor of the navy, in consequence of having constructed a corvette, the Columbine, for her majesty's service, which was reported most favourably of after a trial cruize with other corvettes built from designs furnished by Sir Robert Seppings and the late Admiral Hayes.

The appointment of a naval officer to fill the solitary situation in the civil service of the navy which may be said to offer any great inducement to the exertions of the naval architect, was certainly of questionable policy. There are few clerks in the public offices of this country who do not early attain to salaries and retirements far exceeding those doled out to the highest offices in the engineering department of the navy, with this one exception; and to deprive the naval architect of this sole incitement to exertion, cannot but operate injuriously to the service, besides the evil resulting from having the head of a department, who must be presumed to be not only totally unacquainted with the detail of the duties of his subordinates, but also necessarily to be unqualified to perform a great portion of the duties connected with his own situation, and therefore to be dependent upon those from whom he is obliged to seek for guidance.

The office of surveyor of the navy, be it remembered, is an office of active operation rather than an office of supervision, and therefore essentially requires to be filled by a professional naval architect.

Sir William Symonds is the first constructor of the English navy who has been left unrestricted as to dimensions; and he has consequently been enabled to introduce into the service, ships which undoubtedly bear very high characters in some very decided points of efficiency as men of war. He has also practically demonstrated the possibility of ships of war obtaining sufficient stability without the aid of ballast, which is a very important advantage, and one which will yet be productive of essential benefit. But at the same time, being in error as to the true principles on which the stability of floating bodies is dependent, he has not obtained these advantages without, in many instances, incurring a compensating disadvantage, from uneasiness of motion, and which appears to be a very general complaint against the ships of his construction, some of them being most marked examples of the uneasiness attendant on a stability which depends almost wholly on breadth at the load-water section, to the neglect of the form of the solids of immersion and emersion.

His writings.

The opinions on which Sir William Symonds founds his system of construction have been explained by him, first in a brochure, printed, we believe, for private distribution, and then in an article, communicated by himself, in the United Service Journal for July 1832. To that therefore we refer our readers for information as to the principles upon which the fleets of England are now constructed. The following tables contain the dimensions of the various classes of ships which Sir William Symonds has introduced into the British navy; also the dimensions according to which the ships of

History.

the French navy are now being built, and the dimensions of one or two other modern ships about which considerable interest has been excited. The dimensions of the vessels designed by Sir William Symonds are obtained from Edye's Scales of Displacements, and from a list which was published in the United Service Gazette, and which we have endeavoured to verify; we therefore believe them to be correct. The dimensions of the French ships were procured in the French dock-yards during the summer of 1837, and are certainly correct. The London and Castor are obtained from Edye's Scales of Displacements; the Sapphire and Orestes from Morgan and Creuze's Papers on Naval Architecture; and the other dimensions are from the best available authorities.

Dimensions of Modern English Ships of War.

	Names, &c.	Guns.	Length of Gun-Deck.		Length of Keel for Tonnage.		Extreme Breadth.		Depth in Hold.		Burden in Tons.
			Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	
Designs of Sir William Symonds.	First Rate.										
	Royal Frederick, now Queen	110 on 3 decks	204	0	166	5	60	0	23	9	3099
	Second Rate.										
	Vanguard	82 on 2 decks.	190	0	155	3	56	9	23	4	2589
	Third Rate.										
	Boscawen	70 on 2 decks.	180	0	146	8	54	0	22	4	2212
	Fourth Rate.										
	Vernon	50	176	0	144	6½	52	8½	17	1	2082
	Fifth Rate.										
	Pique	36	160	0	131	0	48	8	14	6	1622
	Sixth Rate.										
	Vestal	26	130	0	105	9	40	7½	10	6	913
	Carysfort	26	130	0	106	10	40	0	10	6	911
	Corvettes.										
	Rover	18	113	0	90	1¾	35	5	16	9	590
	Calypso	18	120	0	99	5½	37	6	18	0	731
	Brigs.										
	Columbine	16	105	0½	84	0	33	6¼	7	11	492
	Serpent	16	102	5	79	10	32	3	15	0	434
	Racer	16	100	8	78	9½	32	4¾	14	10	431
	Pantaloon	16	91	10	71	4	29	4	12	8	323
Sir Robert Seppings	London	92 on 2 decks.	205	6	170	4	54	4	23	2	2598
	Castor	36	159	0	133	7	43	0	13	6	1283
	Inconstant, Admiral Hayes	36	166	6	133	5⅝	45	5	13	7	1422
	Modeste, Admiral Hon. G. Elliot	18	120	0	98	7	32	9	7	11	562
Professor Inman	Sapphire	28	119	0	100	7½	33	8	8	0	605
	Orestes	18	109	11	92	10⅛	30	6	7	6	459

Dimensions of Ships composing the French Royal Navy.

	Line-of-Battle.						Frigates.				Corvettes.			
Number of Guns	120		100		90		60		52		32		24	
	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.
Length on gun-deck between rabbets	209	5	205	0½	198	6	178	1½	172	1	138	7½	125	4
Moulded breadth	55	3¾	54	11½	53	5¾	47	7	45	2½	36	0¼	32	7¼
Draught of water, forward	24	11¾	23	10¾	23	4	19	11½	...		14	9	13	6½
Draught of water, aft	26	8¾	26	0½	25	4	21	3½	...		16	3	14	10
Draught of water, mean	25	10¼	24	11½	24	4	20	7½	20	8	15	6	14	2¼
Load, displacement in tons	4940		4393		4013		2542		2267		999		738	

Description of the manner of performing the Calculations incidental to designing a Ship, with Investigations of some of the principal Elements of the Design.

The labours of the numerous men of science who have devoted either the whole or a portion of their attention to the various problems embraced in the theory of ships, have left but few of its abstract principles uninvestigated; most of the properties of a ship have been examined, and the laws on which they depend clearly defined, either by the aid of mathematical demonstration, or by experimental induction. There are however some questions, which, though solved in theory, still depend on the results of physical experiment for perfecting their practical application.

Elementary principles may be classed in two divisions.

The elements of naval construction, a term very generally applied to the theory of ships, may be classed in two divisions; those which are solely dependent on known laws of nature, and those of which the solution involves laws of nature which are yet imperfectly developed.

The first division embraces by far the greater part of those

Of one the principles are established.

Practice apparently contradicts this assertion.

principles on which the most essential properties of ships depend; and it may now be said that the principal difficulties of these are surmounted, and are familiar to the instructed naval architect. These are alone sufficient to insure the attainment of a certain and considerable degree of excellency in a ship, to give it a preponderance of any peculiar property, to discover the causes of any bad quality, and to obviate its tendency by an appropriate remedy. In fact, they are enough, quoting from an article in an American Review, to "direct and limit the variations that may safely be made in the models at present in use, and guide us in the draught of new ones, suited to those changes in the force and magnitude of the several rates of vessels, which are continually making in the strife between the nations of the civilized world." Should the science of naval architecture never make further progress than it is thus described as having attained, it is evident that it is so far perfect as to be available for, and capable of being made to keep pace with, the wants of mankind. It may be objected, that the American writer assumes too high a standard, and that, so far from changes in the rate and magnitude of ships being made with the certainty attributed, each deviation from the beaten track seems but an isolated, baseless, and aimless venture, instead of forming one step in the progress of improvement. But, in justice to naval architecture, it should be remembered that the American spoke of the existing knowledge, and of the application of that knowledge in France, and in countries where its importance is recognised and its principles are known and cultivated, not in England, where its very claim to the rank of a science has been derided.

Second division embraces elements dependent on undeveloped laws of nature.

Mr Russel's researches on resistances.

Such knowledge not indispensable to the naval architect.

Propor- tions of t body, th positions and rake masts, pr portion an shape of sails, ma be deter mined by induction.

Danger of erroneous deductions unless made wit aid of scientific knowledge

The elements which may be classed in the second division, as those of which the solution resolves itself into a dependence on laws of nature which are as yet imperfectly developed, consist almost entirely of such as are dependent, in a greater or less degree, on a knowledge of the nature and laws of elastic and non-elastic fluids. This is a subject which has hitherto baffled alike the researches of the mathematician and the experimentalist; but, from the analogy of discoveries in other sciences, we may safely assert, that even its difficulties must be eventually surmounted by the patience and labour of the inductive philosopher. We are possibly on the eve of an important era, in so far as the laws of the resistances of fluids are involved. The researches of Mr Russel will apparently do much towards unravelling their mysteries, perhaps more than has as yet resulted from the labour of all preceding ages. Not that the perfect solution of these problems is really of such vital importance to the progress of improvement in naval architecture as it is often asserted to be, and which the apparent intimate connection of that science with the knowledge of fluids and of their laws would appear to sanction. Of those elements of naval construction which seem wholly to depend on such knowledge, some are restricted by considerations which are adverse to its application; and although it may be a desideratum in the determination of certain of the elements, the difficulties which arise from the want of it only require to be fully known and understood, to be, if not absolutely theoretically removed, at least, from the collection of facts, from experiment, and from analogy, so far overcome as to leave nothing to be desired on the score of practical utility. The form of a ship's body need not necessarily remain imperfect because the curve of the solid of least resistance is unknown, since enough has resulted from the consideration of the nature of that solid to prove that, however it might probably be applicable to the navigation of smooth waters, the perfect solution of the problem of its form could only be generally desirable to the naval architect, as contributing to the theoretic perfection of the science, and would add but little to its practical utility in its application to vessels which must encounter the tremendous powers of the elements in the open seas. Experience has proved, that a ship constructed with the bow and of the form which are recognised as at least nearly approximating to the solid of least resistance, would be unable to withstand the violence of the shocks of the motion of pitching, and of the waves; or, could she do so, would necessarily lose, by the additional resistance resulting from increased immersion, every advantage which might otherwise be anticipated. Neither can the exact position of the greatest section be a question of theoretic niceties, when the great capacity and the adjustments of form necessary to the exigencies of modern warfare and the advanced state of navigation are considered, which not only require a ship to be effective in all the *matériel*, and for all the purposes of war, when first from the hands of the builder, but to be equally so after long periods have elapsed and extended seas have been navigated. On the other hand, the comparative fulness of the fore and after bodies, the positions, rakes, and proportions of the masts, the adjustment and the shape of the sails, the bracing of the yards, and many other questions intimately connected with the resistance of fluids, may, and will eventually, be correctly determined by comparison, experiment, and induction, guided by the knowledge of those principles of science which are involved in them; and, without such knowledge to enable us to test and to establish the correctness of the conclusions which may be drawn, both experiment and comparison must be as useless in this, as, under similar circumstances, they would prove to any other branch of art. It has been most wisely said, that there are more false facts in the world than false theories. The reason is evident; the correctness of a fact is totally dependent on the competency of the observer; and how very few, even among those whose minds have been trained to habits of thought, are competent to the task of discriminating fact from fallacy. If there be few among such men, how much fewer in proportion must that number be among men of nncultivated minds, who can be capable either of observing facts, or of forming correct conclusions from those which they may have casually observed; and to such, almost without exception, has been confided the task of establishing the facts, and drawing the conclusions, upon which to found the theory of ships. as far as the development of that theory has been attempted in England.

Error in doing this

How it has arisen.

A most unphilosophic mode of reasoning is very generally applied to the question of the application of the exact sciences to naval architecture; and because chance on some few occasions, inductions from a tedious experience of failures on others, but far more frequently the results of observations on ships built by men of science, may have produced good ships, the question is often hastily decided, and the conclusion assumed, that since ships possessing more than an average of good qualities have been produced without abstract scientific study, therefore the exact sciences cannot be available to the advancement of naval architecture; the fact being placed quite out of the consideration, that the results of observations on ships designed by men of science are really the results of science, and that if the observations were made by persons competent to the task, these results would be onward steps in the progress of improvement.

The aid of induction cannot yet be dispensed with;

The time certainly has not yet arrived when the naval architect can effect with precision and confidence the synthetical composition of a perfect ship; but we have already asserted that he may, by the application of principles already established, proceed in the full confidence of producing one with a preponderance of good qualities.

for the theory of ships is yet imperfect.

The mistake is in the assumption that the theory of ships is already perfected, instead of merely being capable of being perfected by a rigid analysis of facts which daily experience would elicit were the abstract sciences applied to the task of analysing, collating, and registering them. It should always be remembered, that generally in every science a ory.

perfect theory is the result of the perfection of the science, rather than that the perfection of the science results from the theory. To argue against this principle, would be to retrograde from the nineteenth to the sixteenth century, and to affirm that Bacon has lived in vain.

We shall, in as concise a manner as is consistent with clearness of explanation, detail the method of performing the calculations necessary to determine the essential elements of the design of a ship's body, in the course of preparing the original draught or drawing.

A dy at re on a flu dis- pla s its we t.

A body floating at rest, upon a fluid also at rest, displaces as much of the fluid as is equal to the weight of the body. The truth of this proposition will appear from the consideration that the equilibrium between the body and the fluid is maintained by precisely the same upward pressure as supported the fluid which the body has displaced; and as the same pressure must support the same weight when there is an equilibrium, the weight of the floating body must be equal to that of a quantity of fluid equal in bulk to that part of the body which is immersed. It follows that the weight of the water displaced by a ship floating on it at rest, is equal to the weight of the ship and all its contents.

Di ace- me syno- ny us wit he we t.

It is usual to call the weight of the quantity of water which a ship displaces when she is floating at rest, her displacement; or, in other words, according to the foregoing proposition, the term displacement applied to a ship is synonymous with her weight.

To tain the eight of a ip.

To obtain, therefore, the total weight of a ship, it is only necessary to ascertain the weight of the volume of water which she displaces when floating at rest. This is found by calculating the number of cubic feet contained in a homogeneous solid equal in bulk to that part of the body below the surface of the water, and then multiplying this number by the specific gravity of the water, that is, by the weight of one cubic foot: the result will be the weight of the water displaced, and consequently also that of the ship.

Firs uide to d en- sion

That a ship of war may be able to carry and to maintain effective, in ordinary circumstances of weather, a determined armament, or a merchant-ship a certain lading, it is evident that the weight of the ship, and all that she is destined to contain, must be in such proportion to her bulk that she shall not be so far immersed in the water as to render her armament inefficient under circumstances in which its efficiency may be required; or her lading oppressive to her, if lading be the purport of her construction. The bulk of a ship is in proportion to her length, her breadth, and her depth. This, when the naval architect has ascertained the displacement necessary for his ship to possess, is his first guide to proportion her dimensions, so as to insure that displacement without undue immersion.

Gre st tran rse secti

The next step is to determine the form and area of a transverse vertical section at the largest part of the ship's body, which generally extends from the middle of the length for some distance towards each extremity. This section is called the midship section, and on its area is principally dependent the direct resistance which the vessel will experience, while the stability or resistance to inclination, and the easiness or uneasiness of her motions, are greatly dependent on its form.

Grea t hori al secti

Having to a certain extent fixed upon the midship section, the next consideration is to determine the area and form of a horizontal section at the surface of the water. This section is called the load water-section, or sometimes the "plane of flotation." On this section also the stability of the ship, in proportion to her dimensions, is very greatly dependent, as will be seen when we more fully explain that quality.

Dept n water nd differ e of dra ht of wat Bow a quarte section

The depth in the water, and the shape of the vertical section through the longitudinal axis of the ship, should next be determined; and then transverse vertical sections of the body between the midship section and either extremity of the vessel, generally at those parts where the body is intended to alter materially from the form of its midship section to that of the more sudden curvature at the extremities. An important consideration is involved in the forms of these sections, considerably influencing the easiness of the ship's motions. At present it will be enough to mention them as the next progressive step in the design;

Displacement.

after which the constructor has data sufficient to determine whether the dimensions he has chosen will enable him to obtain adequate displacement for the services required of his vessel. If so, he may proceed to trace in intermediate sections, and thus gradually, letting his design keep pace with his calculations, complete his drawing by the aid of processes which will be fully explained in a subsequent portion of this article, and which we therefore shall wholly omit here, as the limits of our space will not admit of repetition. Also, we can hardly describe the method of proceeding with the drawing until the principles which ought to guide us in forming the design have been investigated.

Diagonal, bow, and buttock lines. Inclined water-lines.

As we are totally unacquainted with the course of the fluid along the bottom of a vessel, it is essential that the curves bounding diagonal sections, called diagonal lines, and the curves bounding vertical sections, called buttock and bow lines, should be attentively considered, and also the curves bounding the inclined water-sections, that they may be such as, by comparison with other and acknowledged fast ships, may be presumed to be conducive to velocity. It must constantly be remembered, that naval architecture is a science of comparisons and of analogies; and no pains must be spared in rendering them subservient, not only to the design in progress, but to the eventual perfection of the science.

Alteration of seat in water from consumption of stores.

An important consideration connected with the forming the design of a ship is involved in the gradual alteration of the vessel's seat in the water from the consumption of stores. It is not only essential that a ship should be possessed of stability combined with easiness of motion, be weatherly and quick in manœuvring when she is stored and completed for foreign service as a ship of war, or fully laden as a merchant-ship; but it is equally essential that she should be possessed of these qualities towards the expiration of her cruize, or on her return light from her voyage. Designs for ships to be as perfect as the present state of knowledge can make them, must be made with reference to several water-lines.

Merchant-ships more uncertain in qualities than ships of war,

We see, therefore, that there are difficulties opposed to the improvement of the forms of merchant-ships, which do not exist to the same extent in opposition to the improvement of the forms of ships of war.

because of greater variation of seat in water,

In the designing of ships of war, the nature of the service in which they will be employed is known, and the lading, in comparison with that of a merchant-ship, is a constant quantity: it is therefore only necessary to endeavour to obtain a maximum of good qualities in relation to these circumstances. But in a merchant-ship the lading is of such a variable nature, both as to quantity and species, that the ship is at different times under very different circumstances; yet she is subjected to the same trials. Thus an East Indiaman, on her outward voyage, is two feet more immersed than on her homeward; and the draught of water of a collier is reduced, at different times, four, five, or six feet, by which the stability is generally very much diminished; and even with the same draught of water the stability may vary very considerably, owing to the difference in the nature and disposition of the lading, and the consequent effect produced on the centre of gravity of the ship; and yet, under these different circumstances, the ships are exposed to the same winds and seas. It is evident that if, when at their proper draught of water and stowage, they are only equal to the trials to which they are subject, they must be very inadequate to the contest with such a deduction from their powers as this would produce; particularly if their design be not made with a due consideration of this circumstance.

Theory.

The loss of stability which results from the diminution of draught of water cannot be compensated by a proportionate arrangement of sail, without incurring other evil consequences. If the quantity of sail, which at all times is comparatively small in a merchant-ship, be lessened, the wind on the increased hull might so counterbalance its effect, that she would be utterly unable to beat off a lee shore, or make any way on a wind.

causing diminution of stability, and increased uneasiness.

A ship is not only subject to a loss in stability when lightened, but becomes laboursome, on account of top-hamper: her rolling motion is more violent as her diminished depth in the water decreases the resistance which is opposed to the inclination, and she also generally becomes more leewardly, owing to the difference made in the resultant of the resistance, the diminution of the lateral resistance, and of her power of carrying sail.

That these effects are to be dreaded, is proved by the enormous loss of lives and property in light merchantmen, and especially light colliers.

Thus, for a ship which is intended for the various purposes of commerce, to be at all equal to a ship destined only to sail with a constant lading, more art is required in the design. But though this is a difficulty which opposes itself, it is no bar to progressive improvement, which is evident, as we are now suffering under the effects of such improvement, made, under all the same obstacles, by foreign powers.

Sacrifice of burthen necessary,

That the forms of merchant-ships may at all be benefited by the application of that knowledge which is possessed of the principles of naval architecture to their construction, a sacrifice in part must be made of those qualities which have hitherto been considered too exclusively at the expense of others. These are great capacity under small dimensions, and few men to navigate them.

by increased dimensions in proportion to displacement.

To enable them to sail and work well, their resistance must be diminished and their stability improved by an increase of dimensions in comparison with the displacement, by which they would gain in velocity, easiness of motion, power to carry sail, and consequently safety. But this would require a proportionally greater quantity of sail, and of course a larger crew to manage it; yet as other nations possess better ships than ourselves, and have therefore subjected themselves to this inconvenience of larger crews, that must not be considered as an insurmountable obstacle.

As the body of a ship is not generally any regular figure, the rules which determine the contents of regular solids will give only approximations when applied to finding its content; but the error arising from the application of the best methods now used for calculating displacements is so small as to be utterly insignificant in practice.

Atwood's rules for areas of curvilinear spaces.

The rules most applicable, and at present most generally applied, to the measuring of curvilinear spaces, by naval architects, are those published by Atwood in the Philosophical Transactions of the Royal Society for 1798. "They are founded on Sir Isaac Newton's discovery of a theorem, by which, from having given any number of points situated in the same plane, he could ascertain the equation to the curve which would pass through them all; and by means of this equation was enabled to express the ordinate in the curve corresponding to an abscissa of any given length, as well as the area intercepted between any two of the ordinates."

In order to determine the area of any curvilinear space by these rules, parabolic curves are supposed to pass through the extremities of a certain number of equidistant ordinates, dependent on the order of the parabola; for a conic parabola three ordinates, for a parabola of the third order four ordinates, and so on. It is evident that the correctness of the approximation of the parabolic area to the area of the required curvilinear space, is dependent on the distance between the ordinates; as on that depends the nearer or the more remote coincidence of the parabolic curve with the curve bounding the area required. An almost mathematical accuracy is attained in naval architectural calculations by assuming the ordinates to be one foot apart, even in those portions of the curvilinear areas in which the alterations of the ordinates are the most rapid, as in the fore, after, and lower parts of the body. But spaces considerably longer than this will be found to give results of great correctness.

Theo

Two on in use.

Atwood gives eight theorems for measuring curvilinear spaces, two only of which are necessary for the purposes of the naval architect. The first of these is applicable when the number of equidistant ordinates is odd. It is founded on the assumption, that each portion of the curve which passes through the extremities of three successive ordinates is a part of a conic parabola, and that the first of the three ordinates of each succeeding portion is the last of the three ordinates of the preceding portion. It is not necessary in this article to prove the correctness of these rules; it is sufficient to describe their application to the subject of the article.

First ru Numbe ordinat odd.

The first rule is as follows: Measure the lengths of all the equidistant ordinates. Take the sum of the extreme ordinates, then take the sum of the second, fourth, sixth, or even ordinates, and multiply it by four; and then take the sum of the remaining odd ordinates, or the third, fifth, &c., and multiply it by two. To the sum of these two products add the sum of the extreme ordinates, and multiply this sum by one third of the common interval between the ordinates; the result will be the approximate area required.

Second rule. Nu ber of or nates exceeds by unity a m tiple of 3.

The second rule, which is frequently useful, is applicable when the number of ordinates is one greater than a multiple of three. It is founded on the assumption that each portion of the curve which passes through the extremities of four successive ordinates is a part of a cubic parabola, and that the first of the four ordinates of each succeeding portion of the curve is the last of the four ordinates of the preceding portion.

This rule is as follows: Measure the lengths of all the equidistant ordinates. Take the sum of the extreme ordinates, then take the sum of those remaining ordinates which are one greater than a multiple of three, as the fourth, seventh, tenth, &c., and multiply it by two; and then take the sum of all the remaining ordinates, and multiply it by three. To the sum of these two products add the sum of the extreme ordinates, and multiply this sum by three eighths of the common interval between the ordinates; the result will be the approximate area required.

Their application find the contents solids.

Now, if we suppose that we have a solid formed by the revolution of a curve, and that the cubical content of that solid is required, we may first, by the application of either of the before-mentioned rules for obtaining the areas of curvilinear spaces, find the areas of a series of parallel and equidistant sections of the solid. Then, if we consider these areas as expressing ordinates to the abscissa of a curve, we shall have a curvilinear plane surface, the area of which will express the cubical contents of the solid. For it is evident that every increment of the assumed curvilinear area has correctly represented the contemporary increment of the solid.

We have here, then, rules of easy application, by which the areas either of the transverse vertical or the horizontal sections of a ship's body may be calculated, and by which also, from a series of the areas of either these vertical or these horizontal sections, the cubical content of a homogeneous solid, of the same shape and bulk as the immersed portion of the ship's body, may be determined; which cubical content, multiplied by the specific gravity of water, will give the displacement of the ship.

It will be seen, as we proceed with our subject, that it is necessary to ascertain the position of the centre of gravity of the homogeneous solid of the immersed part of the ship, and also, that in proceeding with the work of designing the heory.

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form of a ship's body, it will be necessary, in order, in the earliest steps, to confine the position of this point to certain limits, to calculate the situations of the centres of gravity of the load water-section and of the midship section; that these points, which will necessarily have great influence on the position of the centre of gravity of the displacement, may be determined with reference to their influence on the position of that point. These calculations are effected by a further application of the rules of approximation already given.

Every transverse ordinate of the load-water section being bisected at its intersection with the vertical longitudinal section passing through the stem and stern-post, the centre of gravity of the load water-section will necessarily be in the line of these intersections; it becomes therefore necessary only to find its position in this line. For the same reason, that of the bisection of the ordinates, the centre of gravity of the midship section will be in the line of its intersection with the vertical longitudinal section, passing through the stem and stern-post; and it becomes therefore only necessary to determine its position in this vertical line. And again, the centre of gravity of displacement must be always in the same before-mentioned vertical longitudinal section, unless the vessel be inclined from the upright, which consideration does not enter into the present question; it becomes therefore necessary to find its position in this section. In respect to length, this will be found in the line of intersection of some one of the transverse vertical sections with this vertical longitudinal section; and in respect to depth, in the line of intersection of some one of the horizontal sections with this same vertical longitudinal section; and, consequently, the position of this centre of gravity of the displacement, or, as some writers call it, the "centre of buoyancy," will be in the point of intersection of the three planes.

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In order to determine the positions of these several centres of gravity, we must make use of this proposition in mechanics. If perpendiculars be drawn from any number of bodies to a given plane, the sum of the products of each body, multiplied by its perpendicular distance from the plane, is equal to the product of the sum of all the bodies multiplied by the perpendicular distance of their common centre of gravity from the same plane; and also of its corollary, that if any of the bodies lie on the other side of the plane, their distances must be reckoned as being negative. In applying this theorem to find the centre of gravity of any curvilinear space, by the application of either of the before-mentioned rules of approximation, each ordinate must be multiplied by its perpendicular distance from some given line, usually in a section near one of the extremities of the vessel: these products are then used as ordinates, and the rule is applied, and the calculations made, in the same manner as for finding the area of a space, the result, however, being the moment of the space. The moment of the space on the opposite or negative side of the line that was assumed from which to measure the perpendicular distances of the ordinates, is calculated by the application of the same means if the area be large; if small, a more simple method will easily suggest itself, and the moment thus obtained is subtracted from the former moment; the remainder is the total moment of the space, estimated from the assumed line, and this, divided by the total area of the same space, will give the distance of its centre of gravity from the assumed line. In this manner the centres of gravity of the load water-section and of the midship section may be found.

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The position of the centre of gravity of the displacement is found by the application of the same rule of approximation. In order to determine its vertical distance below the load water-section, a series of equidistant horizontal sections must be drawn; then the area of each successive horizontal section is multiplied by its perpendicular distance below the load water-section, and these products are used as ordinates in either of the rules. The result is the moment of the space between the load water-section and the lowest horizontal section; to this must be added the moment of that part of the body which is below the lowest horizontal section. This will be obtained by multiplying its solid content into the vertical depth of its centre of gravity below the load water-section; the sum of these two moments is the moment of the whole displacement, estimated from the load water-section; and this moment, divided by the total displacement, will give the vertical distance of its centre of gravity below that load water-section. The position longitudinally of the centre of gravity of the displacement is obtained in a similar manner, by calculating the moment of that part of the displacement which is situated before some one of the transverse vertical sections, and also the moment of that part of the displacement situated on the opposite or negative side of the same section; then subtracting the negative moment from the positive, the remainder, which is the moment of the whole displacement estimated from the assumed vertical section, divided by the total displacement, will give the distance of its centre of gravity from the assumed vertical section.

Means of shortening foregoing calculations.

Instead of multiplying each ordinate by its perpendicular distance from the given line or plane, it is more convenient to multiply the successive ordinates by 1, 2, 3, 4, &c., and the sum of these products by the common distance between the ordinates, which of course produces the same result. A little consideration, in the course of performing the foregoing calculations, will suggest methods by which some of the labour may be lightened; such as the arrangement of the results in tabular forms, and the connecting the calculations for determining the areas, contents, or moments of those portions of the curves or solids towards the extremities with the general calculations. The foregoing account of the method of making the above calculations is given merely as an outline. For some of the more minute details, see Inman's Notes to Chapman; and mature consideration of the principles on which the calculations are founded will suggest all that can be further required.

Recapitulation.

The constructor having completed the foregoing calculations, will have ascertained the area of the midship section, the area of the load water-section, the displacement, the positions of the centres of gravity of these two sections, and also the position of the centre of gravity of the displacement. The areas of the two sections, and the positions of their respective centres of gravity, were required to be determined, on account of the influence of these areas and these positions on the content of the displacement, and the position of its centre of gravity, and also in consequence of their influence on the stability of the ship. It must therefore be remembered, that if the results of these previous calculations do not accord with the intentions of the constructor, or are inadequate to the development of his design, he must make such alterations in his curves or in his dimensions as he may consider necessary, before proceeding further with his design. And if he shall have sufficiently informed himself on the theory of ships, he will be enabled to do so with considerable confidence at this stage of his progress, as to the final result of his work.

Conditions of equilibrium of a body floating on a fluid at rest,

We have before said that a body floating on a fluid is supported by the upward pressure of that fluid. This body will be in equilibrio when the direction of this upward pressure passes through the centre of gravity of the part of the body which is immersed in the fluid, and also through the centre of gravity of the body. These two centres will therefore be in the same vertical line, and this vertical line will be the line of intersection of the transverse vertical section in which the centres of gravity of the displacement and of the body are situated, with the longitudinal vertical section of the body. Consequently, when a ship is floating on the water in a state of rest, and only acted upon by the upward pressure of the water, the centres of gravity of the ship and of the displacement are in the vertical middle line of the same transverse vertical section.

When acted upon by an inclining force.

But when the ship is inclined by the action of some second force, as that of the wind, a part of the body which was previously immersed is emerged, and a part which was above the surface of the water is immersed; consequently the form of the portion of the body under the water is altered, and the centre of gravity of the displacement is carried over towards that side on which the increased immersion has taken place, while the position of the centre of gravity of the ship, with reference to its position in the ship, has remained unaltered, that being the point about which the revolution has taken place. But though the form of that part of the ship's body which is beneath the surface of the water after the inclination, will differ from the form of that which was beneath the surface before the inclination, the total displacement will continue the same, since the weight of the ship has not been either increased or diminished by the inclination; consequently the solid content, or the displacement of that portion of the body which is immersed by the inclination, will be exactly equal to the solid content, or the displacement of that portion which is emerged by the same cause.

Solids of emersion and immersion.

But the forms of these two solids, which we shall call the solids of immersion and emersion, are not necessarily similar, and therefore their centres of gravity are not necessarily situated in the same transverse vertical section of the vessel. If the centres of gravity of these two solids should be situated in the same transverse vertical section, the inclination of the ship will be round her longitudinal axis; but if the centre of gravity of the solid of immersion be situated either before or abaft the transverse vertical section in which the centre of gravity of the solid of emersion is situated, in either case the motion of the ship in performing the inclination cannot be round an axis coincident with its longitudinal axis; and the position of the centre of gravity of the displacement, in passing to leeward of the position which it occupied before the inclination took place, will be influenced by the relative situations of the centres of gravity of these solids of immersion and emersion.

Their effect on the centre of gravity of displacement.

As this irregularity of motion is injurious to the ship, it is desirable to obviate it by regulating the form of the body, both above and below the load water-section, in such a manner that the centres of gravity of the solids of immersion and emersion may be in the same transverse vertical section of the ship. The form of that part of the body situated above and below the load water-line is also dependent upon the following considerations. Although the total displacement after the inclination must necessarily be the same as that before the inclination, the shape of the ship's body may be such that there will be a tendency to immerse a greater or a less solid on the one side than is emerged on the other; which tendency will have the effect of causing the axis of rotation, and consequently the centre of gravity of the ship, to rise or fall in space during the inclination, and fall or rise in space during the return to the upright position; for since the total displacement of the ship continues constant, the solid which is actually immersed cannot exceed that which has emerged.

Their effect on the centre of gravity of the ship.

It is therefore evident that the existence and extent of this motion must depend upon the position of the centre of gravity of the ship, and also on the form of those parts subject to alternate immersion and emersion. For the better illustration of this point, we will suppose a ship of such a form, that when she is floating upright on the water, her sides between wind and water, that is, those parts of her sides subject to the alternate immersion and emersion, are vertical.

First case.

We will first assume that the centre of gravity of this ship is coincident with the centre of gravity of the load water-section. In this case there will evidently be no tendency in the ship either to rise or fall during the inclination, because the two prismatic solids intercepted between the load water-sections before and after the inclination are equal, and the axis of revolution of the ship is coincident with the line of intersection of the two load water-sections.

Second case.

Now, if we assume the centre of gravity of the ship to be situated beneath the load water-section, and the inclination to take place, this centre being the axis of inclination, there would be a much larger solid immersed than was emerged, because the line of intersection of the two load water-sections would be to windward of the longitudinal vertical section of the ship; but in order to restore the equilibrium between the upward pressure of the water and the weight of the ship, the axis of rotation or centre of gravity of the ship must rise until these two solids become equal.

Third case.

Again, in the case when the centre of gravity of the ship is situated above the load water-section, it will be evident that the tendency of the inclination of the ship round it would be to raise a larger solid out of the water than would be immersed on the other side, unless the weight of the ship, in its effort to restore the equilibrium between the upward pressure of the water and itself, were to cause the centre of gravity of the ship to be lowered until the two solids became equal.

General conclusions.

Now, if we suppose the sides of this same ship were formed in such a manner as to fall outwards from the load water-section upwards, we shall easily perceive, that in the case where the centre of gravity was supposed to be beneath the load water-section, the injurious quality would be increased; while in the case in which it was supposed that the centre of gravity was above the load water-section, it would be diminished. The foregoing examples are sufficient to illustrate the principle on which this cause of uneasiness of motion in a ship depends, and also to point out the means which must be taken to obviate it. We see, then, that it is essential, not only that the centres of gravity of the solids of immersion and emersion should be in the same transverse vertical section, but also that these solids should be as nearly equal to each other at all inclinations as possible, and that the greater the deviation from equality between the solids of immersion and emersion, the greater the strain the ship will be subjected to, and the greater will be the uneasiness of her motions.

Adjustment of these solids.

In order to obviate this fault, it would be necessary to compute the exact position of the centre of gravity of the ship when completely ready for sea, that the correct prismatic solids of immersion and emersion might be ascertained and adjusted to equality, and to have their centres of gravity in the same transverse vertical section.

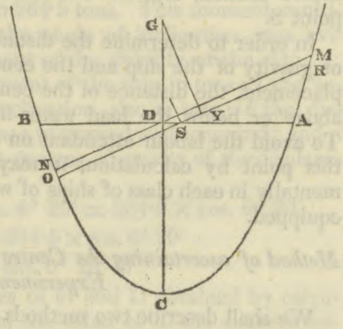
Labour attendant on determining centre of gravity of ship.

But the computation of the exact position of the centre of gravity of a ship completely fitted is a task of such magnitude, and, in consequence, of such hazard of incorrectness, that it can scarcely be considered practicable. Its position must be determined in relation to the three dimensions, length, breadth, and depth; relatively to two of these, however, it is ascertained from the consideration that it is necessarily in the same transverse vertical section as the centre of gravity of the displacement, and that, as it must also evidently be in the longitudinal vertical section of the ship, it must be in the line of intersection of this transverse vertical section with the longitudinal vertical section of the ship. But its position in relation to the load water-section, if not determined by experiment, must be ascertained by a most tedious and laborious calculation of the moments of the weights estimated from the load water-section, the sum-total of which moments being divided by the displacement of the ship, will give the perpendicular distance of the centre of gravity from the load water-section. This process has been gone through for several two-decked line-of-battle ships at the late School of Naval Architecture, and it was ascertained that the positions of their centres of gravity varied from seven to nine inches above the load water-section. We shall, in its proper place in this article, describe the manner of finding experimentally the position of the centre of gravity of a ship, merely here premising, it is assumed generally, that in ships of war the centre of gravity is rather above the load water-section.

In almost all classes of vessels, several of the transverse vertical sections on each side of the midship section are similar and equal to it, and generally the form of these sections is such, that there would be but little disturbance, during the inclination of the ship, in the adjustments of the solids of immersion and emersion; but the sections before and abaft these, as they approach the extremities, become more dissimilar in those portions of them above and below the load water-section; consequently, although, as has before been said, the total volumes of immersion and emersion must necessarily be equal, the areas of the sections of the immersed and emerged solids, at any given transverse vertical section of the body, need not be equal; it becomes therefore necessary to determine the position of the intersection of the inclined load water-section with the load water-section of the ship in her upright position.

T deter- m e line of in rsec- ti , of ho- ri ntal w in- ci ed load w er-sec- ti

Fig. 1.



Suppose G (fig. 1) to be the centre of gravity of the ship, AB the water-line when she is upright, and let it cut the vertical line GC in the point D. From the centre of gravity G draw GY, making the angle DGY equal to the supposed angle of inclination of the ship. Take GY equal to GD, and through the point Y draw the line OR perpendicular to GY. Then OR is the water-line which the ship will assume after the inclination. Let this inclined water-line intersect the water-line AB in the point S. Through D draw NM parallel to OR. It is clear that, supposing the centres of gravity of the solids of immersion and emersion to be in the same transverse section, in every vertical transverse section of the ship the distance DS will be the same, and the several points S, S, S, will be in the straight line forming the intersection of the two load water-sections, which line of intersection will be parallel to the longitudinal axis. Now, if, by a calculation of the contents of the solids of immersion and emersion, which are represented in the figure by the triangles ASR and BSO, which contents may be calculated by either of the rules for approximation, they are not found to be equal, they must be altered until they become so. In order to find the position of the point S, or the distance DS, we have the area ASR equal to the area BSO, which call equal to A, and let the area DSRM $= a$, and the area DSON $= b$,

$$\begin{aligned} \text{then ADM} &= A + a, \\ \text{BDN} &= A - b, \\ \text{and ADM} - \text{BDN} &= a + b = \text{MNOR} \\ &= \text{MN} \times \text{ST nearly}, \\ &= \text{MN} \times \text{DS} \times \text{sin. of inclin.} \end{aligned}$$

$$\text{or DS} = \frac{\text{ADM} - \text{BDN}}{\text{MN} \times \text{sin. of inclin.}}$$

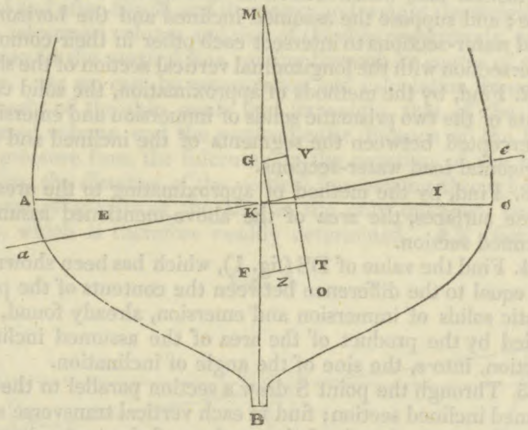
In order to obtain the areas of the sections of the prismatic solids, chords may be drawn in each, which will divide it into two others, a triangular and a parabolic area. The triangular area will be equal to half the product of the base multiplied into its perpendicular height. The parabolic area will be equal to two thirds the base multiplied into its perpendicular height. The moment of each of these areas may then be found by taking the sum of the product of the area of the triangle multiplied into the distance of its centre of gravity, estimated along the inclined line from the point S; and that of the product of the parabolic area multiplied into the distance of its centre of gravity, also estimated along the inclined line from the point S.

Explanation of the term stability.

We have said, that when a ship is floating in equilibrium on a fluid, the vertical upward pressure of the fluid acts in the straight line passing through the centres of gravity both of the displacement and of the vessel; but that when she is inclined by the action of any force, as that of the wind, the centre of gravity of the displacement is carried to leeward of its former position; and as the vertical pressure upwards of the fluid still takes place at the centre of gravity of the displacement, its direction should also pass to leeward of the position of the centre of gravity; and thus a force is generated the tendency of which is to enable the ship to recover her upright position. We will now investigate the expression for the value of this force, in order to show the principle on which the actual calculation of its amount in ships is necessarily founded.

Investigation of a General Expression for the Stability of a Ship, and Description of the Method of calculating the Stability.

Fig. 2.



Let ABC (fig. 2) be the midship section of a ship, and AC the line of its intersection with the surface of the water. Suppose *ac* to be the same line when the ship is inclined, K being the point of intersection of the two lines. Now, by the inclination of the ship, of which we have taken the midship section to be a representative, a solid will be immersed on the lee side of the longitudinal axis, and an equal solid emerged on the weather side of the same axis. Call these solids respectively I and E, and suppose them to be concentrated in their respective centres of gravity. Let the horizontal distance between the centres of gravity of these two solids be *b*. Then, since the inclination of the ship has had the effect of taking the solid E from the displacement on the weather side of the middle line, and has added the solid I to the displacement on the lee side of the middle line, the same effect is produced as if the solid E had been transferred to I; and the moment produced by this transfer, which would be *b*I or *b*E, is the moment which is actually produced in the horizontal direction along the distance *b*.

Let G be the centre of gravity of the ship, F the centre of gravity of the displacement when the ship is upright, O

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the centre of gravity of the displacement when the ship is inclined. Draw OM perpendicular to *ac*. Then, after the inclination, the line OM will be vertical. From F and G draw FT and GV, perpendicular to OM, and from G draw GZ parallel to MO, cutting FT in Z.

Now, when the ship has inclined so that the point O becomes the centre of gravity of the displacement, the upward pressure of the water acts on the then vertical line OM, with a force equal to the weight of the ship, because it supports that weight; that is to say, with a force equal to the displacement, which we will represent by D. But the axis of revolution is the point G the centre of gravity, and GV being drawn from this point perpendicular to the direction OM in which the force acts, D the displacement multiplied by GV, its perpendicular distance from the axis of rotation, will be the force exerted to right the ship, or make it resume its upright position. But, by the construction,

$$D \times GV = D \times FT - D \times FZ.$$

Now $D \times FT$ is the horizontal moment of the displacement produced by the transfer of the solid from the weather to the lee side of the middle line; it is therefore equal to the horizontal moment bI, and consequently we have the effort to right the ship, or the moment of stability, as it is called, $= bI - D \times FZ$.

But if s be taken = sin. of inclination,

$$FZ = s \times \text{rad. } FG,$$

or if $FG = d$, then

General expression. Its value.

moment of stability $= bI - D \cdot d \cdot s$.

Hence, in order to calculate the actual moment of stability of a vessel at a given angle of inclination,

1. Assume an inclined load water-section, cutting the horizontal load water-section at an angle of which s is the sine; and suppose the assumed inclined and the horizontal load water-sections to intersect each other in their common intersection with the longitudinal vertical section of the ship.
2. Find, by the methods of approximation, the solid contents of the two prismatic solids of immersion and emersion, intercepted between the segments of the inclined and the horizontal load water-sections.
3. Find, by the method of approximating to the area of plane surfaces, the area of the above-mentioned assumed inclined section.
4. Find the value of DS (fig. 1), which has been shown to be equal to the difference between the contents of the prismatic solids of immersion and emersion, already found, divided by the product of the area of the assumed inclined section, into s, the sine of the angle of inclination.
5. Through the point S draw a section parallel to the assumed inclined section; find in each vertical transverse section the areas of each of the sections of the true prismatic solids of immersion and emersion; and also find the horizontal moments of these areas from the point S.
6. Find the horizontal distance of the centre of gravity of the whole emerged solid from S, assuming the emerged solid to be equal to half the sum of the two solids of immersion and emersion, which are intercepted between the segments of the assumed inclined load water-section and the horizontal load water-section.
7. Find also the horizontal distance of the centre of gravity of the whole immersed solid from S, assuming the immersed solid to be equal to half the sum of the same two solids of immersion and emersion.
8. Add these two distances together; their sum will be the horizontal distance between the centres of gravity of the solids of immersion and emersion. Take the product of this distance multiplied into half the sum of the solids of immersion and emersion, and we shall have the value of the positive part of the expression for the moment of stability, or the value of bI.
9. The product of three quantities, the displacement, the distance between the centres of gravity of the ship and of the displacement, and the sine of the angle of inclination, will give the value of the negative part of the expression.
10. Subtract the value of the negative part of the expression from that of the positive part, and the remainder will be the value of the expression for the moment of stability of the ship at the given angle of inclination.

Theor

It will be seen that the calculation of the moment of stability of a ship is very laborious. Several of the steps above enumerated in order, will, however, have been already taken for other purposes. The calculations may be considerably shortened by assuming a value for the distance DS, or the distance that the point S is from the middle line of the ship. We have already described the method of ascertaining this distance correctly, but generally it may be assumed to be about two or three tenths of a foot at first; and if the solids of immersion and emersion are not found to be equal, or very nearly so, with that assumption, another point must be taken, either within or without the former, according as the solid of immersion or emersion is the lesser. If e be the difference between the two solids, and a the area of the first assumed inclined section, if x be the perpendicular distance between the true inclined section and the section we have assumed, ax will equal e nearly, or $x = \frac{e}{a}$, which distance must be set off perpendicularly to the assumed section, and we obtain the correct position of the point S.

In order to determine the distance d between the centre of gravity of the ship and the centre of gravity of the displacement, the distance of the centre of gravity of the ship above or below the load water-line must be ascertained. To avoid the labour attendant on obtaining the position of this point by calculation, it may be determined experimentally in each class of ships of war when fully stowed and equipped.

Method of ascertaining the Centre of Gravity of a Ship by Experiment.

On what principle founded.

We shall describe two methods of performing this experiment. The first of these was proposed by Chapman, and he strongly recommended that it should be made on ships of all classes. The principle on which it is founded is as follows. Various weights on board are removed in a transverse direction, so as to cause the ship to incline; and the momentum of the total weight so removed will necessarily be equal to the moment of stability. Now the momentum of the weight removed will be equal to the product of the weights, the distance they are removed in a transverse direction, and the cosine of the angle of inclination; which quantity, therefore, is equal to the moment of stability. If W represent the weights, a the distance they are removed, and c the cosine of the angle of inclination; then, $bI - Dds$ being the expression for the moment of stability, we have this equation,

$$W \cdot a \cdot c = bI - Dds,$$

$$\therefore d = \frac{bI - W \cdot a \cdot c}{Ds};$$

in which d, the distance between the centre of gravity of the ship and the centre of gravity of the displacement, is the only unknown quantity, and may therefore easily be found.

Its appli tion to t Scylla.

We shall now describe the method by which this experiment was applied to determine the centre of gravity of her majesty's ship sloop Scylla, of eighteen guns, and which was originally an eighteen-gun brig. She was lying in Portsmouth harbour in May 1830, under the command of Captain Hindmarsh, at whose request the experiment was performed, by the late Mr Morgan of the School of Naval Architecture, then a foreman of her majesty's dock-yard at Portsmouth, assisted by the writer of the present article.

These particulars are mentioned because it was the first, if it be not the only, example, in this country, of determining the position of the centre of gravity of a ship experimentally.

The draught of water was taken very correctly, the water being smooth, and was found to be, forward eleven feet six inches, abaft fourteen feet ten inches and a half. The depth of the keel and false keels below the lower edge of the rabbet of the keel was, forward one foot nine inches, abaft one foot three inches. The ship was perfectly upright, all the weights, inclusive of the crew, being equally balanced on each side. A large quadrant marked to a scale of degrees, with a plumb attached to the centre, was fixed in the main hatchway, to measure the inclination. The stations of the carronades and long gun on one side were marked on the deck, they were then moved to the other side, keeping them in the same transverse lines; the shot, the hammocks, and the crew, were also passed over to the inclined side, under the same condition. The distance which every weight had been moved was then measured. The weight of the shot moved was known, the weights of the long gun and the carronades were taken from the weights marked on them, and the weights of the men and hammocks were obtained by weighing them. The inclination of the ship was then observed to be 6° 20′. The product of the weights which had been moved, multiplied into the distances they had been moved in a transverse direction, in feet, was equal to 264·5 tons. This moment, multiplied into the cosine of the angle of inclination, was evidently equal to the moment of the stability of the ship.

Let D be the displacement of the ship in tons; I the volume immersed by the inclination, also in tons; b the distance between the volumes immersed and emerged; and d the distance between the centres of gravity of the displacement and the ship.

Then $bI - dD \times \sin. 6° 20' = 264·5 \times \cos. 6° 20'$,

$$d = \frac{bI - 264·5 \times \cos. 6° 20'}{\sin. 6° 20'\ D}.$$

By substituting the values of bI and D obtained by calculation, in this expression, the value of d, the distance between the centre of gravity of the displacement and the centre of gravity of the ship, is obtained.

$$d = \frac{446·2 - 262·8}{50·85} = 3·6 \text{ feet.}$$

The distance of the centre of gravity of the displacement below the load water-line being equal to 3·97 feet, 3·97 − 3·6 = ·37 will be the distance of the centre of gravity of the ship below the load water-line at the time of making the experiment.

When the ship was at Spithead, completely fitted out, with every thing on board that was deficient at the time of making the experiment, and with her provisions and stores for four months, the draught of water was again taken, and found to be, forward twelve feet six inches, abaft fourteen feet ten inches. The weights of all the articles brought on board since the experiment amounted to 33·4 tons, and the moment of these weights calculated above the water-line at the time of sailing was = 193 tons; the height of the centre of gravity of the sails being estimated as in the case of a top-gallant breeze.

The moment of weights below this water-line at the time of making the experiment = 401 tons,

$$\frac{401 - 193}{494·4} = ·42 \text{ feet.}$$

The situation of the centre of gravity of the ship was ·42 foot, or five inches, below the water-line, at the time of sailing.

Cor t- ness f the expe ment dou ul.

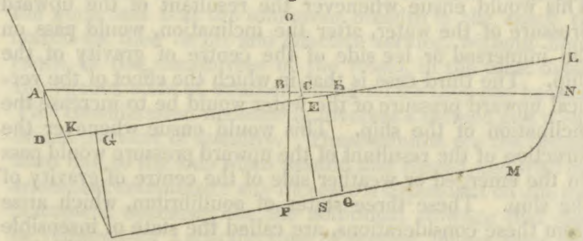
The correction to the result of this experiment which we see had to be made at Spithead, in consequence of the additional weight that had been taken on board after the ship had left the harbour, must, from the great hurry incidental to any observations made at the time of a ship's sailing, throw some doubt on the correctness of the final result; and it would be therefore desirable that it should receive the confirmation of a second trial on some similar ship, before its being assumed as conclusive to be the correct position of the centre of gravity of a sloop of war.

Experimental method when a ship is docked.

The second method was proposed by Mr Abethell, a member of the late School of Naval Architecture, and was published in the second volume of the Papers on Naval Architecture. It is applicable whenever a ship is taken into dock with the under side of her keel deviating from parallelism with the upper surface of the blocks. This is almost always the case; and it also not unfrequently occurs that ships are docked "all standing," and with so large a portion of their armament and stores on board, that the correction necessary to be made to the result which would be obtained by the experiment and investigation about to be described, in order to make that result agree with the circumstances of any additional armament and equipment, would be comparatively easy. We will now quote from the article in question.

"We will suppose, by the falling of the tide in the dock, the after-extremity of the keel to come first in contact with the blocks; then, as the tide continues to fall, the after-body is gradually forsaken by the water, and the fore-body further immersed, a constant equilibrium being maintained between the total weight of the ship and the pressure of the water against the immersed part of the body, until the ship is aground fore and aft. At any intermediate instant the ship may be considered as a lever of the second kind, of which the fulcrum is the transverse line or point of contact of the keel and after-block, and the power and weight the weight of the immersed volume and that of the ship respectively, each acting in the vertical line passing through its centre of gravity. As we can, by mensuration and calculation from the draught of the ship, easily find its weight, that of the immersed volume, and the perpendicular distance of the line of pressure from the fulcrum; in the equation of the moments, the distance of the vertical line passing through the centre of gravity of the ship is the only unknown quantity, which is therefore readily determined. AN (fig. 3) represents the water-line corresponding to the floating position of the ship, and KL the observed water-line just previously to the fore-part of the keel touching the blocks. The line PBO, perpendicular to AN, passes through the centre of gravity of the displaced volume AFMN, and consequently through that of the ship. Draw QH through the centre of gravity of the volume KFML, perpendicular to KL, and FG through the fulcrum F, parallel to QH Then, putting the total displacement AFMN = V, KFML $= v$, and GH $= b$; if the line SEO, parallel to QH, be drawn at the distance GE from G equal to $\frac{bv}{V}$, it will, as well as PBO, pass through the centre of gravity of the ship, which will be in O, the point of their intersection.

Fig. 3.



"To obtain from these considerations a general expression for the perpendicular distance of the point O from the

Theory.

water-line AN, draw AD perpendicular to EG, and meeting it, when produced, in D; and, having calculated the values of AB and GE, put AB $=a$, DE or DG + GE $=d$, and the angle of inclination between the water-lines AN and KL $=\Delta$; then BO $=\left(\frac{d}{\cos.\,\Delta}+a\right)\frac{1}{\tan.\,\Delta}$; which must be set off upon the perpendicular PBO, above or below AN, according as $\frac{d}{\cos.\,\Delta}$ is greater or less than a."

Other methods.

There are several other methods by which the centre of gravity of a ship may be found experimentally. One was proposed by Don Juan d'Ulloa, a Spanish writer on naval science, and a navigator and mathematician of very great eminence, whose works are among the best extant on the subject of the theory of ships. They have been translated into French; and the description and investigation of the experiment for finding the centre of gravity of a ship has been translated into English by Mr Read, in the Essays and Gleanings on Naval Architecture, a periodical work conducted for a short time with great ability by Messrs Laire, Read, and Chatfield, all members of the late School of Naval Architecture. Another method was proposed by a student at the same establishment, since dead, named Barton. This method was published in the fifth number of Papers on Naval Architecture.

Error in the assumption that the vertical pressure necessarily tends to diminish the inclination.

We have hitherto, throughout our investigations, assumed that the vertical pressure upward of the water to support a ship acting in the direction of its resultant, must exert a force tending to resist the force of the wind by which we have supposed the ship to be inclined. We shall now proceed to show that this is not necessarily the case, but that the tendency of this force may not be to act in the manner we have hitherto assumed it as acting; and that its effect is dependent upon the position of the centre of gravity of the ship, the point around which she is supposed to revolve in inclining. There are three cases which may occur. The first is, that the vessel, when acted upon by the force of the wind, may assume a permanent inclination. This permanent inclination would ensue if the resultant of the upward pressure of the water were, after the inclination, still to pass through the centre of gravity of the ship. The second case is that in which the vessel would recover the upright position immediately on the removal of the inclining force. This would ensue whenever the resultant of the upward pressure of the water, after the inclination, would pass on the immersed or lee side of the centre of gravity of the ship. The third case is that in which the effect of the vertical upward pressure of the water would be to increase the inclination of the ship. This would ensue whenever the direction of the resultant of the upward pressure would pass on the emerged or weather side of the centre of gravity of the ship. These three states of equilibrium, which arise from these considerations, are called the state of insensible equilibrium, of equilibrium of stability, and of equilibrium of instability.

Three cases.

On the Metacentre.

A limit to the position of centre of gravity of a ship.

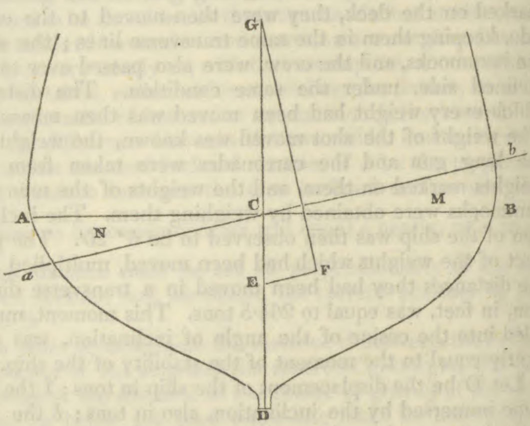
It is evident, from the foregoing considerations, that there is some limit to the height of the centre of gravity of a ship, and below which it must necessarily be placed, in order that the upright position may be recovered; that is, that the ship, when inclined by the force of the wind, may be in an equilibrium of stability. The situation of this point was first investigated by Bouguer, who called it the *metacentre*, which name has been generally adopted by subsequent writers on naval architecture. Its height is determined in the following manner: The vessel is supposed to be inclined through an infinitely small angle of inclination, that the intersection of the new load water-section with that previous to the inclination may not be supposed to deviate from the middle line of either, so that the infinitely small solids of immersion and emersion may be considered to be equal to each other. Then the point in which the new line of direction of the vertical upward pressure of the water will cut the line of direction of the same vertical pressure before the inclination, is the point beneath which the centre of gravity must necessarily be situated to insure the vessel's floating on the water in the equilibrium of stability.

Height of metacentre.

Theo

In order to determine the height of the metacentre above the centre of gravity of the displacement, let the half breadth at the water-line AB of the midship section ADB (fig. 4) $=y$. Let E be the centre of gravity of the displacement before the inclination, F the centre of gravity of the displacement after the inclination, and let ab be the new water-line; then through E and F draw EG and FG respectively perpendicular to the water-lines AB and ab. They will meet each other in some point G. G, the point of their intersection, is the metacentre, and EG is the height of the metacentre above the centre of gravity of the displacement.

Fig. 4.



The triangles ACa, BCb are equal, by the conditions of the construction; and if x be the length of the prismatic solids of immersion and emersion, AC$a\cdot dx$ and BC$b\cdot dx$ are equal, and may be supposed to be concentrated in their respective centres of gravity M and N, MN being by construction $\frac{4}{3}y$. Then the moment of the transfer of the solid of emersion to the position of the solid of immersion $=$ BC$b\cdot dx\cdot\frac{4}{3}y$. Let A$a=$ B$b=b$. But the triangle BC$b=\frac{yb}{2}$, therefore the moment of immersion $=\frac{2}{3}y^2bdx$, therefore $\int\frac{2}{3}y^2bdx=\mathrm{D}\cdot\mathrm{EF}$; but

$$b:y::\mathrm{EF}:\mathrm{EG}\;\therefore\; b=\frac{\mathrm{EF}}{\mathrm{EG}}y.$$

By substituting and multiplying both sides by $\frac{\mathrm{EG}}{\mathrm{EF}}$

$$\int\frac{2}{3}y^3dx=\mathrm{D}\cdot\mathrm{EG},\qquad\int\frac{2}{3}\frac{y^3dx}{\mathrm{D}}=\mathrm{EG}.$$

A meas of stabil

The height of the metacentre is the measure of stability used by the French naval architects, and indeed generally by all since the first investigation of its principles by Bouguer in his *Traité du Navire*. The error in its practical application is, that the investigation involves the erroneous supposition, that the transverse sections of the immersion and emersion are right-angled triangles, and that the horizontal distance between their centres of gravity is two thirds the breadth of the load water-line. These assumptions are only true at an infinitely small angle of inclination, and at such only, therefore, is the height of the metacentre a correct measure of stability. Atwood, who published two papers on the stability of floating bodies, in the Philosophical Transactions for the years 1796 and 1798, was the first who pointed out the error in the metacentric measure of stability, and who proved that it was necessary to involve the actual content immersed or emerged, and the correct distance between the centres of gravity of the solids of immersion and emersion, in the expression, in order to apply it to the measuring the stability of bodies at finite angles of inclination. It is therefore to him that the theory of ships is indebted for the correct solution of the problem on which the stability at finite angles of inclination depends.

Atwood agrees with Bouguer in his general reasoning on the metacentre, and even admits that it may be used at very small angles of inclination, as a sufficiently accurate measure of the stability; but asserts the danger of its application to practice as a measure at all angles. He shows that two ships may have precisely the same load water-section, which, supposing the relative distance between the centres of gravity of the ship and of the displacement equal in both ships, will determine the height of the metacentre to be the same, and consequently, according to the metacentric theory, the stability to be equal; and yet, from a difference in the forms of the ships' bodies within the limits of the immersion and emersion, the moments of stability, when correctly measured, may be very different. But while we state this as the result of Atwood's inquiry, we must observe, that the practical error between the metacentric method of Bouguer, and the certainly correct method investigated by Atwood, is not of any importance for small angles of inclination, especially in large ships; and further, that a constructor who is acquainted with Atwood's investigations, and who is therefore aware of the correct principles on which the stability of ships depends, may safely apply the metacentric method in his practice, as his bodies will be formed in accordance with the results of Atwood's investigations. It will only be in cases of some important alteration from previously existing form, dimensions, or services, that the labour attendant on the calculations involved in Atwood's expression will be necessary.

The question may probably be stated to resolve itself nearly into this. That ships might be built, in which the stabilities calculated by the two methods would vary very considerably; also, that at very great angles of inclination the stabilities of ships, such in form as are sometimes built, would be found to differ very greatly when calculated by the two methods, but that a constructor acquainted with both methods would never construct a ship, using only the metacentric method in the progress of his work, which would be proved unstable if Atwood's calculations were applied to the finished design.

In applying the expression $\int \frac{\frac{2}{3} y^3 dx}{\text{D}}$ to find the height of the metacentre, we may again have recourse to the rules of approximation. The common rule for obtaining the area of a plane surface may be applied, substituting the cubes of the ordinates of the load water-section instead of the ordinates themselves.

The result will be the value of y^3dx, and two thirds of this value divided by the displacement will give the height of the metacentre above the centre of gravity of the displacement.

The reader who wishes to refer to cases of stability as connected with particular forms, should consult Atwood's papers in the Philosophical Transactions, or rather Mr Read's able simplification of them in the Essays and Gleanings on Naval Architecture, and also his Disquisition on the Metacentre, in Papers on Naval Architecture.

On the Principal Dimensions of a Ship.

Dimensions dependent on displacement.

In a ship of war the efficiency of the armament is necessarily the primary object of the design; this must therefore determine the dimensions: also, whether in a fleet or in a single ship, the greatest effective force must be obtained at the least expense; or, as when ships are built, masted, rigged, and their armament completed, all of similar materials, their expenses will vary as their displacements, the object to be attained is the greatest effective force with the least displacement.

Variable quantities to complete load-displacement.

But there is another point involved in the question of the efficiency of the armament, which very materially influences the displacement. It is the time for which a ship is intended to maintain her armament in an efficient state, without other aid than that which she can carry. This brings us to the consideration of the variable quantities which are to be added to those before enumerated, to complete the load-displacement. The crew is dependent on the armament alone, and therefore is included in the term armament. But the provisions for this crew, and the stores for the wear and tear of the ship and the service of the guns, are dependent on the time that the ship is intended to remain at sea without replenishing these resources. It is evident, that the longer this time, the greater must be the displacement, and, consequently, the larger should be the dimensions in proportion to the armament.

Practical advantages attending wide-spread possessions.

It results, from the foregoing reasoning, that the nation with the most wide-spread possessions, and therefore the most frequent opportunities for refitting and replenishing her fleets, has the advantage over all others. For she may maintain equal armaments at less expense, or superior armaments at an equal expense; while she may also avail herself, in the one case, of additional velocity, which may be attained with the diminished displacement.

Many arguments might be deduced from the same considerations in favour of the principle of occasionally designing specific ships for specific services. These of course would only apply to the fleets of those nations which aspire to wide-spreading and predominant naval power.

Length and breadth, under what limitation.

We shall now offer some general remarks on the two dimensions, the length and the breadth. It will be evident, from the foregoing observations, that the minimum length is the space required for the perfectly efficient working of the guns, and that the minimum breadth is the space required for their recoil and effective service, without hindrance to the manœuvres of the vessel, in the most disadvantageous state of weather during which they can be used. This consideration necessarily involves a defined and a sufficient moment of stability. These minima are the dimensions due to the ship when masted and rigged, and with her armament completed: any increase is dependent on the displacement necessary for the additional stowage that may be required for a specific time of service, longer than that time for which the ship, as thus determined, would be adequate. Then the increased dimensions due to this increased displacement being ascertained, under the same conditions of perfect efficiency in the vessel, any increase of one dimension must be followed by a diminution of the other; or the displacement, and consequently the expense, will be above the limit required for the armament.

Effect of increase;

of length,

We shall now proceed to show the effect on the qualities of the vessel, of the separate increase of either dimension; always premising, that in each case all things else are supposed to remain the same, excepting the dimension under consideration. First, then, the length. The displacement, the stability, and the resistance to leeway, vary directly as the length; therefore we increase all these qualities in proportion to the additional length. But we also increase the violence of pitching and 'scending; for the momenta of the weights in the fore and after bodies vary as the squares of their distances from the axis of rotation, consequently we increase the strain on the combinations of the structure; and as the strength to resist this strain varies inversely as the length, we diminish the power to resist this increased strain. By an increase in the length we also increase the effect of the resistance of the water to the rotation of the vessel in the manœuvres of tacking, wearing, and other changes of her course.

of breadth.

By increasing the breadth, and by breadth we mean the whole breadth of that part of the body included in the limits of the immersions and emersions, we increase the stability, which varies as the cube of the breadth. Also, the angular momenta of the weights, estimated from the axis of rotation, vary as the squares of their distances from that axis, and the momentum of the stroke of a wave is increased in the same proportion; therefore the increase of stability is accompanied by increased violence in the motions, and consequent increased strain on the combinations and materials of the structure, and especially danger to the masts, by which the safety of the vessel may be compromised. The stability of a ship being the quality on which the efficiency of her armament is essentially dependent, and which also, by enabling her to carry a press of sail in circumstances of danger, as a lee shore, or an enemy of superior force, is essential to her safety; the only limit to its increase is involved in the consideration of easiness of motion. But if this consideration be neglected, and the breadth be such that the moment of stability in proportion to the moment of sail is so large, or of such sudden increase, that the masts are endangered or the combinations of the structure prematurely destroyed, the object for which a large moment of stability was desirable is frustrated. The breadth, therefore, is limited by easiness of motion.

By increase of breadth we increase the stowage, which varies as the breadth; but since the direct resistance to the progress of the vessel also varies as the breadth, in this case we do not gain increase of stowage without an increase of the direct resistance.

Small ships should have greater relative breadth than large ships.

Having thus pointed out in general terms the effects of an increase either of length or breadth, we shall quote from a very able article in the fifth number of Papers on Naval Architecture, written by Mr Bennet, a member of the abolished School of Naval Architecture, containing some more particular observations on the breadth of vessels in proportion to their armament and in relation to their stability. "The capacities of ships increase as the cubes of their dimensions, whereas the stability increases as the fourth power of their dimensions. The inference to be drawn from this is, that small ships should have greater relative breadth than large ships. This, however, must be understood with certain limitations: it may be a general, but not an universal truth. Were all ships homogeneous; thus, if a navy consisted entirely of corvettes, the corvette of eighteen guns ought to be relatively broader than the corvette of 120 guns: this is a rule without any exception. It may be farther observed from the previous remarks, that the corvette of eighteen guns should be relatively broader than the three-decked ship of 120 guns; but if a ship were built to carry 120 guns on four or even on five decks, her relative breadth should then approximate to, and should most likely exceed, that of the corvette, in order to insure sufficient stability. The consideration of this simple case may tend to elucidate the principles of stability when applied to cases of greater difficulty. If a three-decked ship of 120 guns is to carry the same force on a greater number of decks, her absolute length would of course be reduced; and supposing her breadth to remain the same, the positive part of the expression of stability would be thereby diminished. The displacement, which is one element of the negative part of the expression, would probably remain nearly the same, as the additional weight of topside might counterbalance the reduction of weight occasioned by less length. If the displacement be equal in each case, the draught of water would be increased from the diminution of length; this would lower the centre of gravity of displacement, which, together with the centre of gravity of the ship being raised by the additional weight above the water, would increase the distance between the centre of gravity of the ship and that of the displacement. On the whole, therefore, the positive part of the expression would be diminished and the negative part increased, so that the stability would be less in a ship of the same force and breadth as another ship, but which carried her guns on a greater number of decks.

Least ve sel of e class lia to be de cient in stability.

"Having seen the necessity, in the case of a ship carrying the same number and weight of guns as another ship, but on more decks, of increasing the breadth, in order to avoid a deficiency of stability, we may evidently trace the same principle existing between the largest ship of an inferior class, and the least ship of a superior class, in which, if the number of guns be not equal, it approximates sufficiently to make the application apparent; so that in the several gradations of corvettes, frigates, two-decked ships, and three-decked ships, the least vessel of each class is liable to be wanting in stability, from its small comparative dimensions not sufficiently counteracting the effect of additional decks and guns. In this case, therefore, above all others, particular care should be taken to give sufficient breadth to compensate for a tendency to deficiency in stability; so that, without much liability to error, we may conclude,—

General conclusions.

"1st, That the small frigate should be relatively broader than the large corvette.

"2d, That the small two-decker should be relatively broader than the large frigate.

"3d, That the small three-decker should be relatively broader than the large two-decker.

"Between each of these varieties there will be a certain point, if the expression may be used, where the superior and inferior classes of ships should have the same ratio of length to breadth. This arises from the enlargement of their dimensions increasing the stability in a greater proportion than the weight of additional decks and guns diminishes the stability. Thus,

"4th, The middling-sized frigate should have the same ratio of length to breadth as the large corvette.

"5th, The middling-sized two-decker should have the same ratio of length to breadth as the large frigate.

"6th, The middling-sized three-decker should have the same ratio of length to breadth as the large two-decker.

"As corollaries from the first three observations, we may remark,

"7th, That the large corvette should be relatively broader than the large frigate.

"8th, That the large frigate should be relatively broader than the large two-decker.

"9th, That the large two-decker should be relatively broader than the large three-decker."

Draugh water de pendent locality.

The depth or draught of water is more dependent on local circumstances than on accurate principles. A fleet intended to traverse the Atlantic may have far different draughts of water from the ships of one that is destined for the Baltic. Cruizers for the open seas may be much deeper than those intended to watch an enemy's coast.

May be proxima ed to.

The average light draught of water which a ship will swim at, or the average load draught of water that will be found necessary for her, may be easily and accurately approximated to by means of the calculations of the displacement which have been already explained.

The actual water-line, with the difference of draught of water which it may be considered necessary to insure to the vessel, may also be approximated to in the design of a ship, or approximately determined from the drawing of a ship already designed, on the following principle. Suppose the body of the vessel to be divided, at the vertical transverse section passing through the centre of gravity of the displacement, into two, the fore and after bodies; then, if the depths of the centres of gravity of the displacements of the two parts of the vessel below the assumed water-line be determined, a line joining these centres of gravity will necessarily be nearly parallel to the seat which the vessel will assume in the water.

Tables have been formed by Mr Cradock, a member of the late School of Naval Architecture, for facilitating the stowage of the ballast in ships, in order that they may sail at a determinate trim. These tables, being deduced from various ships in her majesty's service, afford approximations for similar vessels; but when there is a dissimilarity in size and form, we quote from the preliminary remarks to the tables, "in order to place the ballast in such a position, that when all the weights are on board no alteration in it shall be necessary. The difference between the light draught of water, and that to which it may be proposed to bring the ship when fully equipped, being known, the centre of gravity of this part of the displacement may be found. And if through this point a transverse vertical plane be supposed to pass, the ballast must be so placed that its moment from it, together with the moments from the same plane of all the other weights put on board, may be equal to nothing." The length of these calculations is a convincing proof of the value of such approximating tables.

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It is almost an universal custom in all vessels to give a greater draught of water abaft than forward. Occasional attempts have been made to discontinue this practice, as involving a supposed unnecessary increase in the water required for floating a ship; but the increased draught of water for the after-body has been reverted to as essentially requisite in practice.

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There are several minor advantages which result from this arrangement; such as the more easy and unchecked flow of the water to the rudder, and its consequent increased effect in governing the motions of the ship; also the diminution of the negative resistance which the vessel would otherwise experience from the greater difficulty with which the flow of water would fill the vacuity caused by the passage of the vessel, if the fulness of the after-body were such as would be required to preserve an even draught of water; and again, the adjustment of the resultant of the resistance of the water to that position of the masts which experience has determined to be requisite for the facility of manœuvring the sails. But the principal reason for the inequality in the draught of water appears to be the advantage which results from it to the more easy regulation of the motions of the vessel by an adjustment of the resultant of the resistance of the water on the lee side when on a wind.

This will be more apparent in a future portion of this article, in which we shall consider the forces which act on a ship when in motion. The idea intended to be conveyed is, that the flatness of the after-body along the deadwood may be considered as a reserve of lateral resistance, to be brought into operation whenever the pressure of the water on the lee-bow would otherwise draw the resultant of the water too far forward.

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The dimensions of the merchant-shipping of England have been so shackled by the operation of the tonnage laws, that it is in vain to expect to find in their proportions any approximation even to those which experience has proved are most advantageous for safety and for velocity. We take the following table from Hedderwick's Treatise on Marine Architecture, which being the most modern work on the mercantile navy, we presume contains details of the most modern practice.

"Sloop Margaret, 60 tons, breadth to length as 34·8 to 100.
"Smack Regent, 142 tons, breadth to length as 34·2 to 100.
"Smack Matchless, 170 tons, breadth to length as 33·4 to 100.
"Smack Royal Sovereign, 204 tons, breadth to length as 32·0 to 100.
"Schooner Charlotte, 101 tons, breadth to length as 31·5 to 100.
"Schooner Glasgow, 155 tons, breadth to length as 31·0 to 100.
"Brig Down Castle, 149 tons, breadth to length as 30·0 to 100.
"Brig William Young, 303 tons, breadth to length as 28·6 to 100.
"Ship Mary, 368 tons, breadth to length as 27·9 to 100.
"Ship Albion, 505 tons, breadth to length as 25·10 to 100.

"The average depth of the sloops and smacks is about five ninths of their breadth; schooners and brigs, from seven twelfths to three fourths; and large brigs and ships, from three fourths to two thirds."

This immense proportionate depth is the natural result of the old rule for calculating the tonnage; according to which tonnage the worth of the ship was estimated, and all the dues and duties levied. The rule involved only the dimensions of length and breadth, and consequently left the depth to be increased without limit, or rather with no other limit than the depth of the harbours the vessel was destined to trade to. Now, Chapman, in the *Architectura Navalis Mercatoria*, gives an expression to which he says the velocity may be considered proportional: it is $\frac{B^{\frac{1}{2}} \cdot L^{\frac{4}{3}}}{D^{\frac{3}{2}}}$; in which B represents the breadth, L the length, and D the depth to the bilge; from which expression it is evident the depth is the dimension the most detrimental to the velocity. Valuable tables of some of the elements of design of the present classes of merchant-ships have been published by Mr Parsons, formerly of the School of Naval Architecture, under the title of Scales of Displacements.

Investigation of the Forces which act on a Ship when in Motion, as they influence her Form and Qualities.

Preliminary observations.

We have now described the methods by which the several calculations for determining the elements of the design for a ship may be performed; and have also pointed out, in general terms, the dependence of the several principal dimensions upon each other, and their respective influence on the qualities of a vessel. We shall proceed to offer some more particular remarks on the forces of the wind on the sails and of the water on the hull when the ship is in motion, and investigate some of the principal phenomena of their action; as it is only by a consideration of the influence of these forces on the motions of the vessel that the naval architect can form a correct idea of the essential requisites for the design of a ship's body, or the position or proportion of the masts, the area of the sails, and the position of their centre of effort. The investigations into which we shall enter in this portion of the subject may perhaps be found in some cases equally useful to the sailor as to the naval architect, as he will trace in them the means for developing the powers of the vessel he may command, or of obviating by the appropriate remedy any error inherent to her design or equipment.

Questions interesting alike to the sailor and the naval architect.

Pitching and 'scending.

The motion of pitching is generally the most violent action to which a ship is subjected, and the most injurious, both to the connection between the parts of her structure, and the velocity of her sailing. It is the longitudinal motion, caused by the variable support afforded to the body by the waves as the vessel passes over them when on a wind, and by the constant action of the gravity of the unsupported part of the body to recover the state of equilibrium which, before the commencement of the motion, had existed between it and the buoyancy of the fluid. The motion will continue as long as the course of the vessel remains the same in relation to the set of the seas, and as long as the inequality of the surface of the water continues; but when the direction of the wind on the vessel becomes such that she no longer meets and passes over the seas, so that it may be said to act in conjunction with gravity, in offering a constant opposition to the vessel's oscillations, the motion will cease. For these causes, the pitching motion can only exist to any great extent when a vessel is on a wind: then, its force will depend on the degree of inequality of the surface of the water, on the quickness or slowness of the succession of the waves, on the direction in which they strike the bow of the vessel, and on the shape of the bow, as this greatly influences the degree of violence with which it meets the water, and the resistance it opposes to submersion.

may be diminished.

The least injurious action of pitching occurs when the state of the sea is such that the motion of the ship may be supposed to take place round a line passing through its centre of gravity as a fixed axis of rotation; for then the motion may be compared to the oscillations of a pendulum, and its extent may, in a great degree, be regulated by either increasing or diminishing the length of the isochronal pendulum, according as the state of the sea appears to require the oscillations to be made in longer or shorter periods. These effects may be severally produced, by removing weights further from, or by approaching them nearer to, the axis of rotation; that is, by increasing or diminishing the moments of inertia of the fore and after parts of the body round its axis of rotation.

But it is, as has before been said, only in some states of the sea that the pitching motion in a vessel can be compared to the oscillations of a body round a fixed axis of rotation passing through its centre of gravity, and where the moments of inertia of both the fore and after bodies oppose the motion; for, under many of the circumstances of heavy seas, though, at the commencement of the motion, the axis of rotation may pass through the centre of gravity of the ship, it will pass abaft it as the wave passes aft. In this case, then, the moment of inertia of the body before the axis of rotation, which, when this axis passed through the centre of gravity, was equal to the sum of the particles in that body multiplied by the squares of their distances from the axis of rotation, will become, at any instant afterwards, when the axis of rotation shall have passed abaft the centre of gravity, increased, by the difference between this quantity and the sum of the products of the particles in the then fore-body, multiplied by the squares of their distances from the new axis of rotation; consequently the moment of inertia of the fore-body will be constantly increasing until the end of the motion, while the moment of inertia of the part abaft the axis of rotation will be constantly diminishing, under the same limits; that is, the force which has an injurious effect on the violence of the pitching increases, while that which diminishes its violence decreases. As the direction of the motion of the waves is opposed to that of the vessel, the momentum with which the bow of the ship will meet the sea at the expiration of the motion, is equal to the sum of the momenta of the bow and the sea; and this impulse is often so great in practice, as to be sufficient completely to check, for several seconds, the motion of the vessel in her course. Frequent recurrences of these shocks must, therefore, not only be extremely injurious to the strength of the fabric of the ship, but must materially affect her progress through the water, and may even, in some situations, involve her safety, from the increased liability of shipping seas, especially in deep-waisted vessels; and also, unless a ship can contend with advantage against a head sea, her chance of escaping the danger of a lee shore must be considerably diminished, as in such a situation her safety would in a great measure depend on the possession of that property.[1]

Evils resulting from its violence.

Angular momentum.

From these considerations, it is evident that every alteration which can be made to diminish the extreme violence of this motion, when it takes place under the circumstances which have been described, either by lessening the moment of inertia of the fore-part of the ship, or by giving that part the form which will the most conduce to render its impact with the water more gradual, must be advantageous with respect to the velocity, to the preservation of the strength of the ship, and even to the increasing the safety of the crew. But since the bow of a ship is subjected to shocks of such a violent nature, it must necessarily consist of a vast combination of materials to insure an adequate degree of strength to resist them: great care, however, should be taken that there be not more weight than this renders absolutely necessary. These considerations point out at once one limit to the position of the masts; for it is evidently desirable that the weight of the fore-mast and the pressure of the head-sails should act with as little injurious effect in increasing the violence of the pitching, as is consistent with the necessity for head-sail; this will be better understood as we proceed with our investigation of the various forces which act on a ship when in motion.

A limit t the positions of t masts.

Resultan of forces.

When the ship is under sail, there are two forces acting on it; the one, the force of the wind on the sails, to propel the ship; and the other, the resistance the water opposes to her motion. These forces, immediately the ship has acquired the velocity due to the strength of the wind, are equal, and, as is the case with all forces, may each be reasoned on as if acting on only one point of the surface over which its effect is diffused. This point is that in which, if the whole force were to be concentrated, its effect would be the same as when dispersed over the whole area: it is usual to call these, "resultants of forces," and the points on which they are supposed to act, "centres of effort."

Centres effort.

Action of wind on t sails, and water on the hull.

From what has been before said, the resultant of the force of the wind on the sails, and the resultant of the force of the water on the hull, are equal; the one acting on the weather side of the ship, in the direction into which the force of the wind resolves itself, and the other opposed to it, acting on the lee side, in the direction into which the force of the water resolves itself; and their effect is necessarily in proportion to their distance from the centre of gravity. If they are equally distant, they will destroy each other, and the ship will remain at rest with respect to the line of its course; if the resultant of the resistance of the water passes before the resultant of the wind, the ship will turn to the wind; but if the resultant of the wind passes before that of the water, the effect will be the contrary, and the ship will fall off from the wind. In either case it will be necessary to equalize the forces, by the action of the water on the rudder, on its lee side, to bring the resultant of the water more aft, and on its weather side to destroy a part of the effect of the wind. This is the principle of the action of the wind on the sails, and of that of the water on the hull, with respect to the course of the ship through the water; and it is on these considerations only that the various alterations can be regulated, which it may from time to time be necessary to make in the trim either of the sails or of the ship; and hence the accurate determination of the positions and directions of these two forces is a point of great importance in naval architecture. The position of the centre of effort of the wind on the sails may be found under certain reservations; and that being known, enough is determined to lead to correct conclusions on the other circumstances attendant on the subject.

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[1] Mr Henwood, a member of the late School of Naval Architecture, has advanced some new views on the subject of the pitching and 'scending motions in ships, which we think of sufficient importance to endeavour to explain. They are as follow,—that these longitudinal motions of a ship depend both on the form of the immersed part of the body, and on the positions of the various weights which compose the lading or equipment; and the form of a ship, and the positions of the weights, determine the situation of the centre of gravity through which the axis of the pitching and 'scending motions passes. It is the position of this point or axis which, Mr Henwood has stated and endeavoured to show, might and ought to be so determined in all ships, that the pitching and 'scending motions would be diminished to the lowest possible degree.

In order to construct a ship on this principle, the fore-part of the ship, viz. that before the centre of gravity, would be formed in the usual manner; but the after-part would be constructed so as to have precisely the same cubic content as the fore-body, and its centre of gravity at the same distance from the centre of gravity of the ship as that of the fore-body.

In the stowage of a ship thus constructed, the weights must be so disposed that one half of the total weight of the ship and her equipment may be on each side of the vertical and transverse plane, through the centre of gravity.

The object intended to be gained by the fulfilment of the above conditions is, that a ship should perform her longitudinal or pitching motions exactly as she does her lateral or rolling motions; and that as there is the same tendency to roll either side equally deep, so there should be a like tendency of the fore and after ends to pitch and 'scend. The pitching and 'scending motions would, Mr Henwood considers, thus be reduced to a minimum, and the velocity of sailing retarded in the least possible degree.

This proposed desideratum in the construction of ships is irrespective of the form of the midship section, or of the water-lines, &c. It is simply the constructing of one end of a ship upon the basis of the other end, so as to insure the attainment of the object in view,—the least possible degree of pitching and 'scending.

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In order to find the distance of the centre of effort of the wind on the sails before the centre of gravity of the ship, the moment of each sail is calculated by multiplying its area by the horizontal distance of its centre of gravity from that of the ship; the sum of the negative moments, or those abaft the centre of gravity of the ship, is then subtracted from the sum of the positive moments, or those before the centre of gravity of the ship; the remainder is then divided by the total area of the sails, and the result gives the required distance of the centre of effort of the wind on the sails before the centre of gravity of the ship. The situation of this point with respect to the length of the vessel must determine in a considerable degree the positions of the masts; for experience has proved, that it is among the most essentially requisite good qualities of a ship, that she shall carry a weather helm.

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It does not at first appear evident why the rudder should have more effect on the ship when it meets the water on one side of the middle line, than it has when put to an equal angle on the other side; the reason has, however, been partially explained by several writers on naval architecture, from the consideration of the direction of the motion of a ship through the water. Among these Don Juan has been the most explicit. The reasoning he pursues is as follows: That as a great portion of the force of the wind, in all oblique courses, tends to drive the ship bodily to leeward, and as this effect cannot by any means be wholly destroyed, the true course of the ship is not in the direction of its own middle line, but in that of a line passing from the lee bow to the weather quarter, parallel to the ship's wake; and he supposes that the fluid meets the rudder in the direction of this line of lee-way, both on the lee and weather side of the ship; and that therefore, when the helm is a-weather, the angle of incidence of the fluid on the rudder is equal to the sum of the angle of lee-way, and the angle made by the direction of the rudder with the middle line of the ship; while, when the helm is a-lee, the angle of incidence is only equal to the difference between these two angles, and that therefore, when they are equal to each other, this difference vanishes, and all action of the water on the rudder ceases; and this, under Don Juan's suppositions, would occur when the rudder was in the direction of the line of lee-way. And hence, as the most advantageous general position for the rudder is that in which, by offering no obstacle to the passage of the water, it offers no resistance to the velocity of the ship, and yet may by the least variation from this inactive position be brought to act effectively, it follows, either that Don Juan's reasoning is incorrect, or that the most advantageous general position for the helm should be a-lee. But experience proves, that with the helm a-lee, the rudder would not have the effect on the ship which has been described; therefore, although Don Juan's reasoning shows the main principle of the greater effect of the rudder when it is to leeward of the middle line of the ship, than when it is inclined at an equal angle to windward of the middle line of the ship, it is insufficient to account for the fact, that the general position of the helm should be a-weather; indeed his reasoning, on the contrary, proves that it should be a-lee; which error arises from the incorrectness of the assumption which he makes, that the fluid meets the rudder on the weather side of the ship, in the direction of the line of lee-way. Now when a ship is on a wind, her course, we have said, is along a line passing from the lee bow to the weather quarter, which line is also that of the direction in which the ship impinges upon the particles of water. Each particle of water, after its impact with the lee bow, will be reflected from it in a direction which, according to the law of the collision of bodies, will form an angle with the bow, and consequently with a tangent to the bow at the point of impact, and would therefore, if produced to cut the middle line of the ship, form a greater angle with that line than would be formed by this tangent to the bow at the point of impact, produced to cut the same line.

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The results do not agree with practice.

Error in the preliminary assumption.

Correction of this error.

This will be the case with the whole of the particles of water which come in contact with the lee bow, and along all that part of the lee side of the ship, a tangent to which, if produced, would meet the line of the ship's course at any finite distance before her bows; so that as a ship progresses along the line of her course, since these motions may all be supposed to become constant, her lee side will pass through water having an absolute motion with respect to the motion of the ship, the direction of which forms an acute angle with the middle line of the ship produced aft.

We will now consider the effect of the accumulation of the water at the bows of the ship, either to diminish or to increase this angle. Since there must be a constant tendency in the particles of water which compose this accumulation to recover their level, there must also be a constant run of particles from the apex of this accumulation to its base; the ultimate direction of the sum of all these motions would therefore evidently form an acute angle with the middle line of the ship produced forward; and consequently, by the composition of forces, the action of the particles of water to recover their level would increase the angle which the direction of the motion of the water makes with the middle line of the ship produced aft.

By extending the same reasoning to the motion of the water on the weather side of the ship, a very little consideration will show that the principal effect the passage of the ship through the water would have on the particles of water on that side, would be to cause them to rush aft in a direction inclined towards the middle line of the ship, in order to fill the vacuum created under the weather quarter by the passage of the vessel along the line of lee-way.

We may therefore assume that the particles of water have a motion at the stern of the vessel, the direction of which forms an acute angle with the middle line of the ship produced aft, which angle will evidently be dependent on the fulness or the fineness of the after-part of the body, and on the angle which the line of the ship's course, or that of the lee-way, makes with the middle line of the ship, consequently the inactive position of the rudder will be when it forms this angle with the middle line of the ship, that is, when the rudder is to leeward, and consequently the helm a-weather. And this position should be the theoretic limit of the degree of weather helm a ship should carry, as in any other position there must be a force acting on the rudder, which must increase the resistance the ship expe-

Experience confirms these views.

Weather helm.

riences in her passage through the water. A practical confirmation of the correctness of this principle, and of the fact that this generally advantageous position of the rudder is a-lee of the middle line of the ship, may be drawn from the common observation, that when a ship is in good trim, the helm, being a-weather, has a very perceptible tremulous motion, which must arise from the rudder's being in a position in which it is not acted upon on either side by any constant force. This method of considering the direction of the flow of the water to the rudder considerably diminishes the estimate of the excess of its effect on the lee side of the rudder over that on the weather. But there are several other considerations which operate in increasing the effect of the weather-helm. From the direction in which the water flows past the ship, there will be a much greater reduction of pressure on the weather side of the rudder when the helm is to windward, and therefore a greater positive pressure on its lee side to turn the ship, than will occur under the opposite circumstances, or when the helm is a-lee. Also, the broken and disturbed state of the water on the after-part of the weather side of the ship, and the consequent various degrees of resistance it opposes, must lessen its effect when the helm is a-lee.

Ships with lee helm leewardly.

Effect mistaken for cause.

It has been said to be proved by practice, that ships which carry lee-helms cannot be weatherly, that is, will fall faster to leeward than those which carry weather helms. But though the fact is correct, the reason assigned is in some degree mistaking the effect for the cause. It has before been said that a part of the force of the wind acts in driving a ship bodily to leeward; of course its effect will be greater or less in proportion to the lateral resistance opposed to it, and the ship which opposes less lateral and greater longitudinal resistance to the water than another, will in the same period of time have fallen farthest to leeward, and the line of her course will have made a larger angle with her middle line, by which the effect of the water on the after-part of the lee side is increased, while that on the fore-part, both of the lee and weather sides, is diminished, and the helm must consequently be kept less a-weather. A practical proof of the correctness of this reasoning may be drawn from the practice of the merchant-vessels, which are generally, from form, more leewardly than men-of-war. They have their fore-mast placed much nearer the centre of the ship than is usual in sharper and finer formed bodies. This has evidently arisen from the operation of the cause above mentioned, which has shown that they require the resultant of the effort of the wind on the sails to be proportionately farther aft to insure their carrying a weather-helm. From this reasoning it is evident that, under some circumstances, it may be the leewardliness of the ship which causes her to carry a lee-helm; and that when such is the case, the defect might be remedied, not only by the usual methods of placing the masts farther aft, and altering the draught of water, but by increasing the lateral resistance by the addition of false keel, or by greater depth in the water.

Disadvantage of lee helm.

There is another disadvantage arising from a ship's carrying a lee-helm, which is, that the action of the water on the weather side of the rudder acts in conjunction with the force of the wind in forcing the ship bodily to leeward; while, on the contrary, when the helm is a-weather, the action of the water on the rudder is in opposition to the force of the wind.

Effect of sail on helm.

Having now pointed out wherein the necessity consists, that a ship should carry a weather helm under all circumstances, and explained the principles by which the position of the helm is governed, it next remains to consider in what manner this position of the rudder may be affected when the ship is under sail. This is the more necessary, because there are occasions in which ships that generally carry good helms will carry them a-lee; it therefore also remains to be examined whether this defect might not either be wholly removed, or at least ameliorated.

Ardenc

The ardency of a ship, which is her tendency to fly to the wind, depends, as has been explained, on the relative positions of the resultant of the effort of the wind on the sails, and the resultant of the resistance of the water on the hull. A consideration of the effects produced on these forces, when a ship is under way, will lead to the object of our inquiry.

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When a body passes through a fluid, it causes an accumulation of the fluid to take place towards its foremost extremity, and a depression of the fluid towards the opposite. The degree of this accumulation and depression will depend on the velocity with which the body passes through the fluid, and its increase must necessarily have a great effect in drawing the position of the resultant of the water farther forward; therefore, from this cause, a ship becomes more ardent as her velocity is increased. Also, as the ship on a wind inclines by the force which communicates motion to her, an increased surface of the bow is immersed; while, from the fulness of its shape both above and below the original water-line, the angle of incidence with which it meets the water does not undergo much alteration: consequently the tendency of the inclination is to draw the resultant of the water forward, in so far as the shape of the bow is involved. By the inclination, the effect of the water on the after upper portion of the lee-side is so diminished as to be almost destroyed, in consequence of the decrease of the angle of incidence with which it meets the water, arising from the sharpness of the after-body under the lee quarter, which, by the inclination, is made to approximate to a horizontal plane: consequently the tendency of the inclination is to draw the resultant of the water forward, in so far as the shape of this part of the body is involved. That lower portion of the after-body which is nearly vertical when the ship is upright, and, until the vessel is on a wind, is subjected to little more than the mere friction of the water, immediately that a ship is on a wind offers great lateral resistance, even after the inclination of the ship; and it is this lateral resistance of the after-body which, being brought into action simultaneously with the increased direct resistance of the fore-body, tends to prevent too great an effect from that direct resistance in drawing the resultant of the water forward, and therefore acts in aid of the helm in preventing the ship from flying up into the wind, and thus obviates the necessity of such violent action of the rudder as would be injurious to the velocity of the ship.

The larger the area of this portion of the after-body, the less necessity therefore is there for extreme and consequently detrimental action of the rudder under the circumstances of increased wind and inclination. It appears, however, that in ships generally, the inclination increases the ardency, by drawing the resultant of the water forward.

Of incre ed imme sion of t ter-body

This train of reasoning shows us in what the advantage consists which arises from the increased immersion given to the after-extremities of ships; and it enables us to form the following general rule, as an approximation to correctness of principle in determining the increased draught of water to be given to the after-body. The difference in draught of water should increase or diminish in proportion as the area which a ship offers to direct resistance is great or small in relation to the area offered to lateral resistance; or, in general terms, the difference of draught of water in ships, *cæteris paribus*, should vary directly as the ratio which the breadth bears to the length.

Sails assumed to plane su faces.

The position of the centre of effort of the wind on the sails is calculated under the supposition that the sails are plane surfaces, and equally disposed with regard to the longitudinal axis of the ship; but when a ship is on a wind, as the force of the wind acts in a direction oblique to the surface of the sails, a greater proportion of the sail is carried to leeward of this axis, and the whole sail assumes a curved surface, the curvature of which increases from the weather to the lee side. From these circumstances, the centre of

eory.

E t of th cur-va e.

effort is in fact carried gradually farther aft as the action of the wind takes place on the sails. Also, as the force of the wind inclines the ship, the centre of effort of the wind on the sails is carried, by this inclination, over to the lee side, by which, as also by the effect produced on the resultant of the water, which has been before mentioned, the distance between them is farther increased. It therefore appears that, the quantity and disposition of the sail set remaining the same, the ardency will increase as the force of the wind increases, and diminish as that force diminishes; but as it is found in practice that ships very generally require their helms a-lee in light winds, although it is evident that the several circumstances which have been mentioned as creating the tendency of ardency must still exist in a small degree, it would appear that the ardency must increase and decrease in a faster ratio than the force of the wind. Now, as the direct and lateral resistances vary respectively as the squares of the velocities of the ship in these two directions, it is evident that the lateral resistance will diminish in a quicker ratio than the direct resistance, and that, consequently, as the wind decreases, the angle of lee-way, or that of the ship's course, will be increased, which, it has before been proved, will draw the resultant of the water aft, and diminish the ardency; therefore the increase and diminution of the ardency of a ship will be in proportion to the difference of the ratios of increase and decrease of the direct and lateral resistances.

O crease o nd.

M s of di ishing le elm.

From the causes which have been assigned for a ship's carrying a lee helm in light winds, it is evident the defect may be lessened by all those means of trimming either the sails or the ship, which have been mentioned as tending to increase the distance of the resultant of the water before the centre of effort of the wind.

Le helm de dent on ate of the a,

But when a ship's carrying a lee helm is occasioned, as it sometimes is, by the state of the sea, the waves of which, strike the ship on the weather bow, and in their passage cause a great immersion of the lee quarter, any attempt to bring the resultant of the water forward would, from the consequent greater immersion of the bow, and the necessary addition to the momentum, increase the effect of the impulse. The evil may be lessened by diminishing the quantity of head-sail, which will both bring the centre of effort of the wind aft, and diminish the violence of the pitching; and also, if the inclination of the ship were increased, that, by increasing the effect of the water on the lee bow, and diminishing its effect on the lee quarter, might in some cases prove advantageous.

and n the po on of the asts.

In heavy weather, ships under a small quantity of sail very generally carry slack helms, partly in consequence of the position of the centre of effort of that sail, and partly owing to the state of the sea. Under these circumstances it is generally impossible to carry enough of after-sail to remedy this defect; and to trim the ship by the head would be only to increase it, on account of augmenting the pitching. There is therefore no other remedy than that which would arise from such an original disposition of the masts as would render the power of creating a balance between the effects of the sails more easy. But here we would observe, that before making any alteration in the position of the masts, great caution is necessary; for possibly one of the first requisites in a ship is, that she should work quickly, which quality depends on the proportion of sail before and abaft the axis of rotation, and not on the position of the centre of effort of the whole surface of the sail. Therefore no alterations can be made in the position of the centre of effort of all the sails, or in the positions of the masts, unless due consideration be given to the effect they would have on these proportions.

Too reat arde y.

It may now be necessary to observe, that a ship may, on some occasions, be too ardent. In addition to the alterations which will suggest themselves in this case, from what has been already said, it may be observed, that as the curvature of the sails, and the inclination of the ship, both tend to increase the ardency, it may be diminished by taking in sail, especially those which, from their greater breadth, assume a greater degree of curvature.

Theory.

Erroneous objections.

It is sometimes objected by practical men, that trimming a ship according to the principles laid down by theory, has not the effect which was to have been expected; but this often arises from an ignorance of the necessary degree of trimming, or from a mistaken notion of the effect which a certain degree will produce. In order, in some measure, to obviate this difficulty, the following table is given. It contains the weight which it will be necessary to move a distance of forty feet, either aft or forward, to produce an alteration of one foot in the trim of a ship. The length and breadth of the ship are given in the table, merely as being more correct data for the comparison of size than the class of the vessel or the number of guns.

Class of Vessel and number of Guns.		Length.	Breadth.	Weight to be moved a Distance of Forty Feet.
		Feet.	Feet.	Tons.
First rate............	120	205·25	54·50	112
Second do............	84	192·25	51·44	90
Fourth do............	60	174·00	43·67	58
Fifth do..............	46	159·70	40·50	38
Sixth do..............	28	120·20	33·67	22
Sloop..................	18	111·25	30·50	14

If any other alteration in the trim be desired, it may be deduced from the results given in the above table, by a simple proportion. And since the effect produced on the centre of effort of the sails, by taking in or setting any sail, may be estimated in the manner described in the course of these remarks, the alterations necessary to be made in order to produce any desired effect may be easily determined. Another source of error may arise from the various rakes of the masts; from which the angle of incidence, and consequently the force of the wind, which is as some function of the sine of the angle of incidence, varies considerably for the sails of each mast; and if the trim of the ship be altered, there must be a corresponding effect produced in this angle; by which the relative proportions of the force of the wind on the several sails will be altered, as will also its total effect on all the sails.

Bracing of the yards.

Most of the writers on naval architecture have considered the problem of determining the angle which should be formed by the yard with the keel, under the different circumstances of wind. Don Juan, whose highly scientific and thorough practical knowledge entitles his opinions to more than common attention, on a subject in which the researches of theory require to be aided by the deductions from experiment, has determined these angles for a ship of sixty guns, and has also given some general rules to guide any variations from them. When this ship was close-hauled, with all sail set, he found that the angle the yard should make with the keel should be 28° 47′, and with the wind on the quarter, 50° 11′; but when the wind was so high that only a small quantity of canvass could be set, these angles were respectively increased to 40° 42′ and 56° 21′. He also arrives at the general conclusion, "that, the greater the quantity of sail set, the less should be the angle made by the yard with the keel;" and also, as he makes the relation between the direct and lateral resistances enter into his investigations, "the sharper and the more adapted for velocity a vessel is, the smaller should be the angle made by the yard with the keel;" consequently frigates and smaller vessels should, under similar circumstances, have their yards braced sharper than line-of-battle ships; and again, "that the nearer the sails approach to plane surfaces, the less should this angle be."

Erroneous position of fore-mast.

According to the present positions of the masts of a ship, the sails on the fore-mast are generally not capable of being so sharply braced as those on the main-mast; but as theory and practice, as may be instanced in fore-and-aft rigged vessels, concur in fixing the limits to which it would be desirable to brace the yards, within even what can generally be attained on the main-mast, much of the force of the wind on the sails of the fore-mast must be lost; and as this less sharpness of bracing, common for the yards on the fore-mast, is even found to be necessary in many ships, to enable them to carry their helm sufficiently a-weather, it would appear that the position of the fore-mast is too far forward, and that moving it aft would be advantageous; besides the good effect it would have, as has been shown, in diminishing the violence of the pitching motion.

The position of the fore-mast appears to have remained nearly the same as it was determined in the early part of the last century, although many of the reasons which then fixed it at about one ninth the length of the ship from the stem have ceased to exist. Our ships are now longer, and there is consequently room for working the sails, without those of one mast coming in contact with, or destroying the effect of the wind on, those of the other. The after-parts of the hull above water are very considerably reduced, and do not therefore render so great a proportion of head-sail necessary to counterbalance the effect of the wind on them. The bodies of the ships are, from the increase of the dimensions, much finer abaft, and consequently the resultant of the resistance is farther aft. From these considerations, and from the fact that it is found that complaints are made of ships carrying lee helms, it appears not improbable that the generality of our ships would be improved by an alteration in the position of their fore-masts.

The forms of our ships, and indeed those of some of the more modern French vessels of which we are possessed, have approximated more to that recommended by Chapman, and since his time adopted by the Swedes and Danes, than to that of the old French bodies, which were for such a series of years the chief guides of the English ship-builder. The marked characteristics of the old French body were, a flat floor, with a sharp and, beneath the water, hollow fore-part, and a comparatively very full after-part. The character of the Swedish construction is, the rising floor, full fore-body, and extremely fine after-body. The generality of the English ships of the present day are built with the rising floor, and approximating more, towards the extremities, to the Swedish than to the old French characteristics. It seems therefore but reasonable that the positions of the masts of our ships should partake of the principle which appears to have dictated the alteration in the form of their bodies. With this view, and for a general example as to the positions of ships' masts, and of the ideas of various constructors, the following table has been formed, of the positions of the masts of the vessels contained in Chapman's "large work," of some of the present Swedish ships, of the various classes of English ships, and of several other vessels which have either some peculiarity in this feature of their construction, or are remarkable for an excess of any good or bad quality dependent on it. The other data in the table are necessary for completing the comparisons which may be made.

Table of the Stations of Masts in Ships.

Ships' Names.	No. of Guns.	Length on the Load Water-line.	Distances of the Masts abaft the foremost extremity of the Load Water-line.			Ratio of the Distance of the Masts from forward, to the length of the Load Water-line.			Ratio of Difference of Draught of Water to the Mean Draught of Water.
			Fore-mast.	Main-mast.	Mizen-mast.	Fore-mast.	Main-mast.	Mizen-mast.	
		Feet.	Feet.	Feet.	Feet.				
Swedish ships, from Chapman's large work	110	205·2	28·8	118·5	174·0	·1398	·579	·848	·094
	94	190·1	27·0	112·2	164·1	·1402	·580	·857	·085
	80	182·1	25·7	105·5	154·2	·1402	·578	·845	·089
	74	177·9	24·8	102·7	150·0	·1398	·576	·848	·083
	66	174·0	24·3	100·0	146·8	·1400	·578	·844	·082
	52	164·1	22·9	93·2	138·4	·1390	·569	·845	·103
	40	149·6	23·3	86·5	125·2	·1570[1]	·580	·840	·100
	32	125·3	19·5	72·5	104·4	·1550[1]	·578	·831	·093
	20	113·6	17·5	65·5	94·6	·1540[1]	·578	·837	·142
Carl XIII., Swedish	80	177·9	24·3	102·0	148·6	·1380	·578	·858	·108
Corvette, Swedish	20	108·5	15·6	61·7	90·8	·1440	·570	·835	·120
The Chapman, Swedish	...	149·8	28·0	89·5	124·2	·187[2]	·598	·835	·000[3]
President, French	46	159·5	24·0	87·5	132·2	·150	·550	·831	...
Do. altered to the Piedmontaise	46	159·5	21·0	87·5	132·2	·132	·550	·831	...
Comet, bomb	...	109·0	13·4	61·7	90·5	·123	·565	·831	·000[3]
Do. as altered	...	109·0	17·4	61·7	90·5	·162	·565	·831	...
Pearl, Mr Sainty	18	114·7	18·7	64·0	97·4	·163	·557	·850	...
Do. altered by his request	18	114·7	18·7	66·5	99·4	·163	·577	·863	...
Caledonia	120	205·25	25·0	113·0	171·7	·122	·552	·835	·057
Asia	84	192·25	22·3	109·0	160·2	·116	·568	·832	·053
Southampton	60	174·0	20·7	97·2	146·7	·119	·560	·845	·048
Seringapatam	46	159·7	21·2	85·6	132·3	·133	·535	·832	·076
Leda	46	151·0	18·8	85·3	128·7	·124	·565	·854	·089
Euryalus	42	146·0	17·7	82·2	123·8	·124	·563	·848	·104
Sapphire	28	120·2	14·7	68·7	102·4	·122	·568	·850	·066
Orestes	18	111·25	14·5	64·7	97·4	·129	·573	·864	·060
Queen	110	202·2	24·33	118·0	175·84	·121	·585	·870	·085
Vanguard	80	188·2	25·7	110 9	164·3	·137	·584	·823	...
Vernon	52	176·7	27·6	104·5	154·7	·156	·590	·874	...
Pique	36	160·6	23·5	94·4	139·5	·146	·587	·867	...
Vestal	26	131·0	20 3	77·3	114·6	·155	·590	·874	...
Rover	18	109·8	15·1	64·8	96·2	·138	·590	·874	...
Inconstant	36	160·0	20·0	90·33	138·0	·125	·564	·860	...
465 tons. Merchant-ships.	...	115·0	16·6	65·0	99·2	·145	·565	·861	...
450 tons. Merchant-ships.	...	116·6	16·8	66·0	98·0	·144	·570	·840	...
435 tons. Merchant-ships.	...	114·8	16·2	67·1	96·4	·142	·584	·840	...
400 tons. Merchant-ships.	...	108·5	16·9	66·2	92·7	·156	·610	·850	...

[1] An increase in the rakes of the stems.

[2] The fore-mast raked four inches in ten feet.

[3] On an even keel.

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tion of s in hant- s.

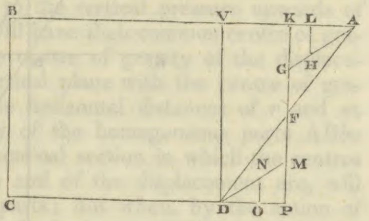
From this table it will be seen that the position of the fore-mast in the ships of different rates in her majesty's service is considerably more forward than in the Swedish ships; and that in Chapman's experimental frigate, the Chapman, it is remarkably far aft. The Comet, as altered, after being sold out of the service, the Pearl, built by Mr Sainty, and the four merchantmen, are proofs of the practice, before alluded to, of the merchant builders; the alteration in the position of the masts of the Comet having taken place under the direction of the late Mr Fearnall, a gentleman of high character for a knowledge of his profession.

The stations of the masts in the ships built after the designs of the present surveyor of the navy, Sir William Symonds, approximate very nearly to those of the Swedish ships; the main and mizen masts are even rather farther aft in proportion to the length of the ship.

C rect p t from w h to m sure the p ions of th masts.

The positions of the masts are given, in the table, in relation to the foreside of the rabbet of the stem; but though this point has been adopted in compliance with the usually received custom, and to avoid the introduction of a feature which might have rendered comparisons more difficult, a more correct method would be to estimate the station of the masts from a point K (fig. 5), at a distance AK from the foremost extremity of the load water-line; such that, KP being drawn perpendicular to the load water-line, it shall intersect AD, the foremost boundary of the longitudinal vertical section of the vessel, in such a manner that the resistance to angular motion round an axis of rotation BC, passing through the centre of gravity of the vessel, shall be equal to the triangles AKF and DFP, DP being the lower boundary of the false keel produced.

Fig. 5.



The point K being determined for all ships, comparisons might be correctly made of the positions of the masts in vessels with the most dissimilar rakes of the stem; which feature, from its effect on the resultant of the resistance, must have a considerable influence on the positions of the masts, and which cannot be estimated in distances measured from any other point.

The following proof will show, that if BK be taken equal to the arithmetical mean between BA and CD, the point K will be determined sufficiently correctly for all practical purposes.

From D (fig 5) draw DV perpendicular to AB. Bisect KF and FP in G and M, and draw AG and DM. Take AH $= \frac{2}{3}$AG, and DN $= \frac{2}{3}$DM; then H and N will be the respective centres of gravity of the triangles AKF and DPF. From H and N draw HL and NO perpendicular to BA and CP. Let $AB = a$, $CD = b$, $AV = a - b = c$, $AK = x$, $AL = \frac{2}{3}x$, and $VD = h$. Then the resistance to rotation of the triangle AKF is proportional to the area

$$\text{AKF} \times \text{BL} = \frac{\text{AK} \cdot \text{KF}}{2} \cdot \text{BL}.$$

$$\text{Now, AK : KF :: AV : VD} \therefore \text{KF} = \frac{hx}{c}$$

$$\text{the resistance} = \frac{hx^2}{2c} \cdot \left(a - \frac{2x}{3}\right).$$

And in the same manner, the resistance of DFP is

$$= \text{area DFP} \cdot \text{CO} = \frac{\text{DP} \times \text{PF}}{2} \cdot \text{CO},$$

$$\text{PF : DP :: DV : AV} \therefore \text{PF} = \frac{h \cdot \overline{c - x}}{c}.$$

Theory.

Hence the resistance $= \frac{h \cdot \overline{c - x}|^2}{2c} \cdot \left(b + \frac{2}{3}\overline{c - x}\right)$, and these resistances must be equal to each other,

$$\therefore x^2\left(a - \frac{2x}{3}\right) = \overline{c - x}|^2\left(b + \frac{2}{3}\overline{c - x}\right)$$

$$\text{and } x = a - \sqrt{a^2 - \left(bc + \frac{2c^2}{3}\right)};$$

from which expression, if numbers be substituted for the several quantities, it would be seen that, assuming BK equal to the arithmetic mean between AB and CD, will be sufficiently correct.

Recapitulation.

The method of finding the horizontal distance of the centre of effort of the sails, either before or abaft the centre of gravity of the ship, has now been explained as being a necessary element to be determined in forming the design of a vessel. The effect which the action of the water on the hull, and of the wind on the sails, would have, under various circumstances, on the relative positions of this point with respect to the centre of gravity of the ship, has been described, and also the necessity of regulating the trim of the ship and sails according to the state of the sea and wind, that the most advantageous proportionate distance may be preserved between them.

Height of effort of sails.

We shall now investigate the principles on which the determination of the vertical height of the centre of effort of the sails above the centre of gravity of the ship depends. This problem, though it is one which may be classed among those of which the "solution resolves itself to laws of nature which are yet imperfectly developed," may be solved by induction from experiment; and we shall show that sufficient data may by this means be obtained, to render the abstract principles of science, on which it depends, practically available, so as to overcome the difficulties which at present oppose themselves to the perfecting one of the most important elements of naval architecture, the sizes and proportions of the masts and yards.

Moment to resist inclination.

In describing the circumstances attendant on the inclination of a ship from the upright position, we have said that the moment of the force exerted by the vertical pressure to resist the inclination will be measured by the perpendicular distance from the centre of gravity to the direction of the resultant of the vertical upward pressure of the water after the inclination, which necessarily passes through the centre of gravity of the displacement. We have hitherto called this the moment of stability, but it may be more properly termed the moment of hydrostatical stability, as being dependent on the laws of the equilibrium of fluids. But if the force which has been described as inclining the ship round its centre of gravity also communicates motion to the system, another moment of stability will be generated by the resistance which the water opposes to the motion. This resistance, as has been before explained, may be supposed to act in a resultant, the direction of which will necessarily depend on the form of the vessel. Now, if the form be such that the direction of this resultant will pass above the centre of gravity of the ship, its moment, estimated from that centre of gravity, will act in conjunction with the moment of hydrostatical stability before described, and will diminish the inclination; a contrary effect will ensue if this resultant passes below the centre of gravity. Now, if the moment of this force to diminish the inclination were equal to the moment of the force which acts to produce it, the ship would remain in a vertical position; but if it be not equal to it, the inclination will be caused by the action of the excess of the moment of the inclining force over the moment of the force acting to diminish the inclination, and the ship will revolve until this part of the inclining force shall be destroyed by the moment of hydrostatical stability which will be generated by the inclination. The moment of sta-

Hydrostatical stability.

Hydrodynamical stability.

bility resulting from this cause may be called the moment of hydrodynamical stability, as being dependent on the motion of the body in the fluid, that is, on the relative motion of the fluid. This does not agree with the usual definition of hydrodynamical stability adopted by writers on naval architecture, as that also involves the elements of the hydrostatical stability in its terms; but it is thought that keeping each moment of stability distinct, by referring it wholly to its own generators, tends to simplify the consideration of them; and also, the explanation of the principles on which the height of the centre of effort of the sails depends may by the same means be divested of some obscurity.

Equilibrium of wind on sails, and water on hull.

Now, when, by the action of the wind on the sails, motion is communicated to a vessel from a state of rest, at first the effort of the wind on the sails is much greater than that of the water on the hull, and by the effect of the excess the velocity of the vessel is accelerated: but the velocity with which the wind acts on the sails is diminished in proportion as the velocity of the vessel is increased, therefore also the force with which it acts on them is gradually lessened: but as the velocity of the vessel increases, the resistance the water opposes to its motion is also increased; consequently the two forces, the effort of the wind on the sails, and the resistance of the water on the hull, will ultimately become equal to each other; and as they act in opposite directions, the vessel will, by the laws of motion, continue to move uniformly in the direction of its course with the last acquired velocity; and this velocity will be in proportion to the moving force, that is, to the force of the wind and the area of sail exposed to its action, or, if the force of the wind be supposed constant, will be in proportion to the area of the sail.

Uniform motion of the vessel.

Limit to height of centre of effort.

From what has been before said, it is evident that the moment of sail must be in proportion to the stability of the ship; and since the velocity will be in proportion to the area of sail exposed to the action of the wind, the height of the centre of effort of the sail should be determined from the consideration of acquiring the greatest effective area of sail of which the powers of the ship will admit.

Bouguer, from reasoning on the facts which have been explained, which are, that when a ship has acquired an uniform velocity in any direction, the action of the wind on the sails to propel her in that direction becomes equal to the resistance opposed to her motion by the water, and that the moment of the resistance, calculated from the centre of gravity or of rotation, that is, the moment of hydrodynamical stability, subtracted from the moment of the action of the wind on the sails, estimated from the same point, will give the force by which the ship is inclined, conceived the idea that the sails of a vessel might be so disposed that she should maintain the same vertical position when under sail as when at anchor. This he proposed to effect by adjusting the sail in such a manner that its centre of effort should be situated in a point, which he has named the "*point velique*," and which he describes as being such, that when the centre of effort of the sails coincides with this point, the moment of the force of the wind to incline the ship will be wholly destroyed by the moment of hydrodynamical stability. But such an arrangement of the sail is not practically applicable to the cases in which the direction of the action of the force of the wind is oblique to that of the course of the vessel; for, from the small proportion which the breadth of a vessel bears to her length, the moment of hydrodynamical stability will, under these circumstances, be less than when the directions of the wind and of the ship's course coincide, while the resultant of the effort of the wind will act at the same height above the centre of gravity of the ship in either case; therefore Bouguer only insists, that since the moment of the hydrodynamical stability cannot, consistently with other circumstances, be made to destroy the whole of the effort of the wind to incline the ship, care should be taken that these two forces should be so proportioned to each other, that a sufficient moment of hydrostatical stability may be acquired to resist the excess of the moment of the wind on the sails over the moment of hydrodynamical stability, without too great an inclination of the ship.

Point velique.

Not practically applicable in oblique courses.

Of impor ance in d rect cours

But when the direction of the wind coincides with that of the course of the vessel, it is of great importance that the change from a state of rest to one of motion, or rather from one velocity to another, should be performed without any longitudinal inclination towards either extremity, and that the vessel should preserve that seat in the water which has been determined as most advantageous with reference to the longitudinal position of the centre of effort of the sails.

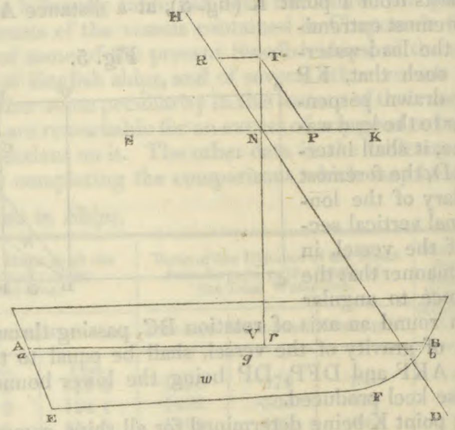
Bouguer reasons false premises, y valuable

The course of reasoning which Bouguer has pursued to determine the position of this point involves suppositions which are at variance with the facts attendant on a vessel's motion through the water, and therefore the conclusion at which he arrives is erroneous; still, as an elucidation of the principle, his method may be advantageously explained.

Investig tion of p sition of *point velique.*

He supposes DH (fig. 6) to be the direction of the resultant of the direct and vertical resistances experienced by the fore-part of the vessel AEFB, moving in the direction AB; and the line SK to be the direction of the resultant of the whole force of the wind acting on the sails. Let it meet DH in N. Now since, when the ship has acquired an uniform velocity, the forces which oppose the motion are equal to those which produce it, and as these forces act horizontally and destroy each other, the forces which remain must be vertical. Take NR and NP to represent in quantity and direction the force of the water on the bows, and of the wind on the sails; then complete the parallelogram NRTP, and join NT; NT will represent, in quantity and direction, the force remaining after those parts of the forces NR and NP, which are equal and opposite, are destroyed; and therefore NT will act in a vertical direction to lift the ship. But though this will be the direction of the action of NT on the vessel, its effects may also be to produce a rotatory motion round her centre of gravity. This will depend on the position of the point N, the intersection of SK and DH. If we suppose the direction DH to be constant in position, and SK to vary in position according to the height of the sails, we shall see, that when the masts and sails are high, the direction SK will cut the direction DH at a point near the stern; and therefore the action of the force NT taking place so near one extremity of the vessel, and one side of the centre of gravity, will tend to immerse the opposite extremity. On the contrary, if the masts and sails are low, the direction SK will intersect the direction DH more near to the bows of the ship, and the action of NT being before the centre of gravity, will raise the fore and immerse the after part; and this in-

Fig. 6.



eory.

clination will continue until the force which causes it is destroyed by the moment of the hydrostatical stability generated by the inclination. From this, Bouguer concludes that it is only when the masting is of such a height that the direction SK intersects DH at a point at some mean distance between the bows and stern, and at which neither of these effects will be produced, that the ship will have no tendency to longitudinal oscillation, and the only effect of the force NT will be to lessen the part of the ship which is immersed in the water when she is at rest; and this point he has called the *point velique*. Bouguer determines the position of this *point velique* in the following manner. From *r*, the centre of gravity of the load water-section, as being nearly coincident with the centre of gravity of the lamina, AB*ba*, of the vessel which is lifted by the action of the force NT, the vertical line VT is drawn, and the point N in which it intersects the direction of the resultant of the resistance of the water to the bows will be the point through which the horizontal line SK, representing the direction of the action of the wind on the sails, should pass, in order that the ship may move in the direction of its course without a depression of either extremity. In order to prove that this will be the case, he supposes the displacement ABFE of the ship to be made up of the two homogeneous parts AB*ba* and *ab*FE; and therefore, when the ship is only subjected to the vertical pressure upwards of the fluid, these parts will have their common centre of gravity, which will be the centre of gravity of the displacement, in the same vertical plane with the centre of gravity of the ship. The horizontal distances of *r* and *w*, the centres of gravity of the homogeneous parts AB*ba* and *ab*FE, from the vertical section in which the centres of gravity of the ship and of the displacement are, will be inversely as those parts; but when, by the action of the force NT at *r*, the displacement is diminished by the quantity AB*ba*, the vertical pressure upwards will be diminished by that same quantity, and will act at *w*, the centre of gravity of the new displacement *ab*FE, with a force equal to the weight of *ab*FE; therefore, the forces being inversely proportionate to the distances of their action from the common centre of gravity of the ship, and both acting upwards in a vertical direction, will maintain the ship in equilibrio round that centre of gravity. This reasoning of Bouguer on the position of the point N is incorrect in its application to practice. It depends on the supposition, that when by the force of the wind motion is communicated to the vessel, she will rise in the water from the effect of the action of the force NT, and the water-line AB will become *ab*, the displacement being diminished by the quantity AB*ab*. It is not enough to satisfy the conditions of Bouguer's reasoning, that NT should exert an effort at *r* equal to diminishing the displacement by the quantity AB*ba*; for unless the diminution of the displacement actually takes place, the position of its centre of gravity cannot be affected in the manner assumed in the reasoning, but will continue in the vertical section passing through the centre of gravity of the ship; and then, by the action of the force NT at *r*, the ship will revolve round the centre of gravity *g*, until, by the motion of the centre of gravity of the displacement, incidental to the revolution, a moment of hydrostatical stability is generated equal to the moment of NT to incline the ship. Now it is proved from experiment that the displacement is actually greater when a ship is in motion than when she is at rest; therefore, reasoning on the supposition of its diminution is inapplicable to practice. There would be an alteration in the position of the centre of gravity of the displacement resulting from this increase, which might either act in opposition to, or with the effect of NT, to incline the ship, according to the relative form of the body above the original water-line.

T error of uguer.

But it is evident that the principal error made by Bouguer throughout the investigation of the position of his *point velique* is, that it is conducted with reference only to the resultant of the positive resistances which the vessel experiences, instead of to the resultant of both positive and negative resistances. Chapman, while he adopts Bouguer's views on the existence of some limit to the situation of the centre of effort of the sails above the centre of gravity of the ship, has avoided this error, and has investigated its position from the data of the total resistance experienced by the ship. He first determines the quantity and direction of the mean resultant of both the positive and negative resistances of the water; then, since the force of the wind must be equal to the resistance of the water opposed to it, if the directions of the resultants of these two forces were exactly opposed to each other, their moments, estimated from the centre of gravity of the ship, would be equal, and consequently the force of the wind would have no effect in making the ship revolve round its centre of gravity; therefore, if the surface of the sail was perpendicular to the resultant of the direct and vertical resistances experienced by the ship, there would be no limit, arising from these considerations, to the height at which the centre of effort of the sails might be placed; for, whatever might be its position in the line of direction of the resultant of the resistances of the water, the moments, estimated from the centre of gravity of the ship, would be constantly equal, since the perpendicular distance between that point and the directions of the actions of the forces would remain constant, however the force of the wind, and consequently the resistance of the water, might be increased or diminished. But since the directions of the wind and of the course of the vessel are both horizontal, and the sails are placed nearly at right angles to the horizon, the action of the force of the wind, and its moment round the centre of gravity of the ship, to counteract the moment of the resistance of the water, must be estimated in a horizontal direction; and consequently the height of the centre of effort of the wind on the sails must be measured on a vertical line drawn from the centre of gravity of the ship, and must be such that the horizontal moment of the wind shall be equal to its moment, estimated under the supposition that its action is in a direction opposed to that of the resultant of the resistances of the water, when it will have no tendency to depress either extremity of the vessel.

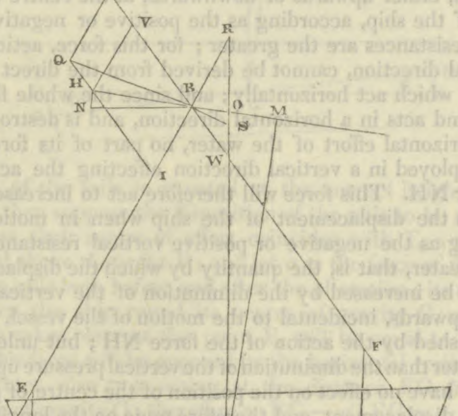
Theory.

He neglects the negative resistances. Chapman has avoided the error of Bouguer.

Chapman's investigation is as follows: Suppose DF and EC (fig. 7) to represent respectively, both in quantity and direction, the resultants of the direct and vertical resistances against the fore and after parts of the vessel. Produce

Chapman's investigation.

Fig. 7.



DF and CE to intersect each other in B; then on DB produced take $BV = DF$, and on BC take $BI = EC$; complete the parallelogram VBIH, and BH will represent, in quantity and direction, the resultant of the whole of the direct and vertical resistances against the fore and after parts of the ship; and BH, multiplied into GM, GM being drawn from the centre of gravity G of the ship, perpendicular to BH produced, will represent its moment to make the ship revolve round its centre of gravity. The centre of effort of the sails must therefore be at such a height that the moment of the wind, estimated from the centre of gravity of the ship, may be equal to this moment. If HM represent the line of direction of the effort of the wind on the sails, the force of the wind acting in that direction will be represented in quantity by HB; but as the action of the wind is horizontal, and is equal to the horizontal effort of the water, if BH be resolved into BN and NH, then BN represents, in quantity and direction, the horizontal resistance of the water, and NB in the same manner represents the horizontal effort of the wind; and if GO be drawn from G perpendicular to the horizon, meeting HB in O, we have, from similar triangles, HBN and OGM, $NB \times GO = HB \times GM$; that is, O, the point in which a vertical line passing through the centre of gravity of the ship intersects the direction of the resultant of the resistances of the water against the fore and after parts of the ship, is the correct height at which the centre of effort of the sails should be placed, that the ship's horizontal water-line, when she has acquired an uniform velocity, may not be affected by any change in the force of the wind.

The point found by Chapman not the *point velique.*

This point O does not fulfil the conditions of Bouguer's *point velique*, as it only determines the position of the centre of effort of the sail as to height above the centre of gravity of the ship; for the moment of sail acting in a horizontal direction, estimated above that centre of gravity, will be the same at whatever point in a horizontal line passing through O the centre of effort may be placed; therefore this point O may be more properly called the height of sail. The position of the centre of effort of the sails in a horizontal line at this height of sail, will depend on the considerations which have been explained in a former part of this article. It may therefore differ very considerably from that determined by Bouguer, not only in its vertical, but in its horizontal position.

From this investigation of Chapman's, it evidently appears, that unless BH coincides with NB, that is, unless the resultant of the resistances of the water is horizontal, there will be a force NH or HN acting in a vertical direction, either upwards or downwards, at the centre of gravity of the ship, according as the positive or negative vertical resistances are the greater; for this force, acting in a vertical direction, cannot be derived from the direct resistances, which act horizontally; and since the whole force of the wind acts in a horizontal direction, and is destroyed by the horizontal effort of the water, no part of its force can be employed in a vertical direction affecting the action of HN or NH. This force will therefore act to increase or diminish the displacement of the ship when in motion, according as the negative or positive vertical resistances are the greater, that is, the quantity by which the displacement would be increased by the diminution of the vertical pressure upwards, incidental to the motion of the vessel, will be diminished by the action of the force NH; but unless NH is greater than the diminution of the vertical pressure upwards, it will have no effect on the position of the centre of gravity of the displacement, and therefore none on the longitudinal inclination of the ship. The force HN, acting in conjunction with the diminution of the vertical pressure upwards, will affect the position of the centre of gravity of the displacement in the same manner as that affects it, that is, dependent on the relative form of the body above the water. Therefore in this case the ship may have a slight tendency to longitudinal oscillation, even though the centre of effort of the sails be placed at the height of sail, as determined by Chapman; but this will not affect the correctness of Chapman's principle, and a ship may be easily constructed with such a form at the parts about the surface of the water, that this inconvenience will not occur.

Case in which l gitudin oscillat may en

Now, if we suppose BV and BI to be given in position, the force NH or HN will depend, in quantity and direction, on the proportion between BV and BI, that is, on the proportion of DF to EC. Now when BH coincides with NB, or when the direction BH of the resultant of the water is horizontal, the force NH or HN vanishes; therefore, if we suppose HB to coincide with BN, then HB is parallel to CD; and the angle VBH will be equal to the angle BDC, and the angle BCD will equal the angle $HBC = VHB$. Now $VH : VB :: \sin. VBH : \sin. VHB :: \sin. BDC : \sin. BCD$; and since $VH = BI = EC$, and $BV = DF$, therefore $EC : DF :: \sin. BDC : \sin. BCD$; consequently we have, that the positive and negative vertical resistances are equal to one another, and the direction of the resultant of the resistances of the water will be horizontal, when the resultant of the direct and vertical resistances of the water on the bows of the vessel is to the resultant of the direct and vertical resistances on the stern, inversely as the sines of the angles which the respective directions of these resultants make with a horizontal line.

General theorem

The extremities of a vessel of the usual form may, for the purpose of determining the proportion between the direct and vertical resistances which they experience, be considered as planes moving obliquely in a fluid, and consequently the proportions between the direct and vertical resistances will depend on the angles of inclination which the surfaces of these extremities make with the direction of the vessel's motion, that is, with a horizontal line; and the sum of the direct resistances on either extremity will be to the sum of the vertical as the cosine to the sine of the angle of inclination; consequently, as long as the inclinations of the bow and stern to a horizontal line remain unchanged, this proportion between the direct and vertical resistances experienced by those parts respectively, that is, the proportion of DK to KF, and of LC to EL, will be invariable; and therefore, as far as these considerations are involved, the directions of the resultants DF and EC will remain constant, whatever alteration may take place in their relative proportion to each other, arising from any increase or diminution in the velocity of the vessel.

Propor between direct a vertica sistance invarial

Since, when the direction of the resultant of the water is horizontal, $EC : DF :: \sin. BDC : \sin. BCD$, then $EC \cdot \sin. BCD = DF \cdot \sin. BDC$; now let us suppose the proportion of DF to EC to be altered, so that $EC \cdot \sin. BCD$ will be greater than $DF \cdot \sin. BDC$, that is, let us suppose the comparative proportion of DF to EC to be increased.

Produce DV to P, and make BP to BI in the increased proportion of DF to EC, complete the parallelogram BPQI, and draw the diagonal BQ; BQ will represent the direction of the resultant of the resistance of the water, after the alteration of the proportion between DF and EC.

Produce QB to S, then the angle $PBQ =$ the angle DBS, and since BP is parallel to IQ, the angle PBQ is equal to the angle IQB, and the angle IHB is greater than the angle IQB; consequently the angle DBM, which is equal to the angle IHB, is greater than the angle IQB, that is, the angle DBM is greater than the angle DBS, and S, the point in which the direction QB cuts the vertical line GO, will be within or below the point O; therefore GS will be less than GO. If EC, that is, BI, had been increased in proportion to DF or BV, the point S would, in the same manner, have been found to be above the point O; consequently, from this we may deduce the following

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general proposition, that as the proportion which the resultant of the direct and vertical resistances on the bows of a vessel, bears to the resultant of those resistances on the stern, is greater than the proportion which the sine of the angle made by the resultant of the after-resistances with a horizontal line, bears to the sine of the angle made by the resultant of the fore-resistances with a horizontal line, the height of sail will be diminished, and as this proportion is diminished, the height of sail will be increased. Now when DF is infinite in comparison with EC, that is, when the negative resistances vanish, BQ will coincide with BP, and the height of sail will be at W, the point in which the vertical line drawn from the centre of gravity of the ship intersects the direction of the resultant of the positive resistances. But if DF vanishes in comparison with EC, BQ will coincide with BI, and the height of sail will be at R, the point in which the vertical line drawn from the centre of gravity intersects the line BC; consequently the points R and W will be the limits between which the position of the height of sail must be situated. The directions of the resultants of the resistances on the bow and stern being known, the position of this point within these limits will depend upon the velocity of the ship, in as far as that velocity affects the ratio which these resultants bear to each other. And since the negative resistance depends on the degree of vacuum which the vessel creates by the velocity of its passage through the water, it will evidently be very inconsiderable as long as the velocity continues small. In fact, this is found to be the case experimentally, as is also that, after certain limits, this negative resistance increases in a greater ratio than the velocity. We may therefore draw the general conclusion, that the less the velocity of the ship is, the nearer will the height of sail approximate to that of its lowest limit; and, on the contrary, the greater the velocity of the ship, the nearer will this point approach its highest limit. But as we are not yet sufficiently acquainted with the laws of the motion of fluids to determine the ratio of the increase or decrease of the positive and negative resistances experienced by bodies in their passage through the water, we cannot ascertain how near the ultimate position of the height of sail with the greatest velocity which the vessel can acquire will approximate to the limit which has been assigned to it.

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One circumstance which may affect the height of sail remains to be noticed; this is, the deviation of the apparent water-line of the ship when she is in motion, from her horizontal water-line, which is occasioned by the accumulation of fluid at the fore-part of the ship, and the depression of it at the after-part, that is incidental to the motion of a body on a fluid. This will vary in degree in proportion to the velocity of the ship. Now if this addition to the one and diminution from the other of the resisting surfaces alter the proportions between their respective vertical and direct resistances, the directions of the resultants of the resistances on these surfaces, which depend on these proportions, will also be altered. If the extremities of the vessel were formed by plane surfaces, neither the accumulation nor the depression would alter the directions of the resultants of the resistances, since the angles of incidence would be the same for every part of the surfaces; but as the extremities of the vessel are curved surfaces, the effect produced on the direction of the resultants of their respective resistances will depend on the relative inclination to the horizon of the curve of that part of the body beneath the horizontal water-line, and of the parts above or below the water-line, which will be affected by the accumulation and depression of the water. Since the lower parts of the vessel's body, both forward and abaft, are those which are generally most inclined to the horizon, it is probable that the direction of the resultant of the resistances on the bow is lowered by the accumulation of the water against them, and that the direction of the resultant of the resistances to the stern is rather raised by the depression of the water at that part. At the same time it must also be observed, that, by the effect of the accumulation, the centre of effort at which the resultant of the resistances against the bows acts will be raised, while, by the effect of the depression, that at the stern will be lowered.

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Theory.

The position of this point will determine the height above the centre of gravity of the ship, at which the common centre of effort of the sails should be placed, not only when the directions of the wind and of the ship's course coincide with each other, but also whatever may be the direction of the ship's course with regard to that of the wind; for, under all circumstances, that portion of the force of the wind which acts in propelling the ship in the direction of her course, will be subject to the same laws which govern the action of the whole force of the wind when it acts in that direction.

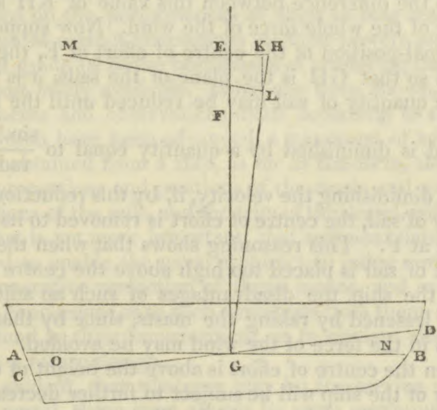
Addition or diminution.

It is also evident, that it is not only necessary that the centre of effort of the surface of those sails which are usually set, and for which the position of the height of sail is generally recommended to be estimated, should coincide with this point; but also, that when additions are made to the quantity of sail set, care should be taken to preserve the common centre of effort of the whole surface as nearly at this same height above the centre of gravity of the ship as is possible.

Velocity may not increase with increase of sail.

It is frequently observed that a ship's velocity does not increase or decrease in proportion to the additional quantity of sail set or taken in. It is evident, from the principles which have been explained, that these apparent anomalies must arise from the mal-position of the centre of effort of the sail; and, in fact, it is even possible that the velocity of a ship may be decreased by the addition and increased by the diminution of sail, if the centre of effort is improperly placed. That this may be the more evident, suppose AB (fig. 8) to be the water-line of a ship, when the centre of effort of the sails is situated at the correct height of sail GF; then suppose the disposition of the sails to be so altered that their centre of effort coincides with E, a point situated above the point F; and let $a =$ the force of the wind on the sails both before and after the alteration; its moment to turn the ship round its centre of gravity G, when its action takes place at the point E, will be equal to $a \cdot EG$, and this force will be opposed by the horizontal resistance of the water, also $= a$, acting at the distance FG from the centre of gravity G; therefore $a \cdot EG - a \cdot FG = a \cdot EF$ will be the force exerted by the wind to make the ship revolve round G, its centre of gravity, and immerse the bows; and the inclination will continue from the effect of this action until the moment of hydrostatical stability, which it will generate, becomes sufficient to counteract it. It should

Fig. 8.



here be observed, that by the difference which the inclination of the ship will make in the angles of incidence of the water on the bows and stern, the correct height of sail, after the inclination, will most probably not coincide with F, but the alteration arising from this circumstance in the position of this point will depend on the form of the vessel's body.

When the force $a \cdot EF$ is destroyed, suppose the water-line to coincide with CD, then from G draw GH, making with GE the angle EGH equal to the angle of inclination DGB; take GH = GE, then H will be the position of the centre of effort E of the sail after the inclination, and the angle BGH will represent the inclination of the plane of the sails to the horizon, they having been supposed to be vertical before the inclination of the ship. Now from H draw HM horizontal, and take MH to represent the whole force of the wind acting in that direction, at the points H and F; then from M draw ML perpendicular to GH; and from L draw LK perpendicular to MH; MK will represent the horizontal force of the wind acting to propel the ship in the direction of its course, when the centre of effort of the sails is at E. Since MH represents the quantity of this force when the centre of effort of the sails is at the true height of sail F, KH will represent that part of the horizontal force which is lost by the mal-position of the centre of effort; and if MH, the whole force of the wind, be assumed equal to radius, then from similar triangles MHL, LHK, we get the value of KH equal to the square of the sine of the angle of inclination divided by the radius, when radius is equal to the whole force of the wind. Therefore, if the removal of the centre of effort from its correct position at the height F had been accomplished by an addition to the quantity of sail set, instead of by an alteration in its disposition, unless the increase of MH, the force of the wind arising from the increase in the area of sail set, was greater than this value of KH, which represents the force lost, the velocity must be diminished instead of being increased, by the addition to the force of the wind; since its effective force to propel the ship would be diminished by a quantity equal to the difference between this value of KH and the increase of the whole force of the wind. Now suppose that by the mal-position of the centre of effort at E, the ship is inclined so that GH is the plane of the sails, it is evident that the quantity of sail may be reduced until the force of the wind is diminished by a quantity equal to $\frac{\sin.^2 EGH}{\text{rad. } MH}$, without diminishing the velocity, if, by this reduction in the quantity of sail, the centre of effort is removed to its correct position at F. This reasoning shows that when the centre of effort of sail is placed too high above the centre of gravity of the ship, the disadvantages of such an adjustment may be lessened by raking the masts, since by that means the loss in the force of the wind may be avoided.

If centre of effort of sail be above height of sail.

When the centre of effort is above the height of sail, the velocity of the ship will be subject to further decrease from the increase of resistance which will result from the immersion of the full parts of the body forward, and the consequently greater area of midship section. Also, in the case which has been supposed of the plane of the sails being vertical before the commencement of the action of the wind, when the longitudinal inclination EGH takes place, a part of the action of the force KL will act to increase the displacement, and consequently the resistance. This disadvantage may also be diminished by raking the masts.

Excess of moment of sail over moment of hydrodynamical stability.

There are other circumstances arising out of the longitudinal inclination of the ship, caused by the excess of the moment of the wind on the sails over the moment of hydrodynamical stability, which are disadvantageous to the good properties of the ship. The equilibrium which ensues between the excess of the moment of the wind and the moment of hydrostatical stability, which has been described as being generated by the inclination, will not be constant, as every increase or decrease in the force of the wind will cause an increase or decrease in the moment of stability, which must be obtained by a corresponding change in the inclination; therefore a ship in which the centre of effort is placed above the true height of sail, will be subject to an alteration in her water-line at every change in the force of the wind; and it will, owing to this circumstance, not only be impossible to adjust the longitudinal position of the centre of effort to any fixed trim of the ship which may have been found to be advantageous, but it will be equally impossible to determine the best longitudinal position for this point, after the ship is in a state of motion, since her trim will be subject to constant change.

Centre effort b low hei of sail.

If the centre of effort, instead of being supposed to be situated above the true height of sail, be considered to be below that point, the immersion will take place at the after-extremity of the ship, from the action of the excess of the moment of the resistance of the water. It must also be observed, that there will be this difference in the two cases. When the centre of effort is above the height of sail, at every increase in the force of the wind the ship will, from the increased immersion of the bows, fly up to the wind, while the effect of the immersion of the after-part will be to make her fall off from it. The ill effects which have been described as attendant on the mal-position of the centre of effort of the sails with respect to the height of sail, though they cannot be removed while the cause exists, and which may consist in the improper proportions of the masts and yards, can in some cases be diminished by an alteration in the disposition of the weights on board the ship. If, instead of supposing the ship to incline, from the action of the force of the wind at the point E, we suppose the effort of this force to produce the inclination to be counteracted by the removal of a weight (b) from a point N at the fore-part of the ship, to another point O at the after-part, then the ship will be maintained in a state of equilibrium by the action of the two equal forces $a \cdot EF$ and $b \cdot NO$; and she will therefore move without longitudinal inclination, as long as the force of the wind remains constant; but any alteration in that force must be counteracted by a corresponding alteration in the position of the weight: also, when, from the action of the water on the hull, the ship acquires an angular velocity, the angular momentum will be increased by that of these two forces, which may both be considered as weights acting at their respective distances from the centre of gravity of the ship. It is therefore evident, that an error in the position of the centre of effort of the sails cannot be advantageously remedied by any alteration in the disposition of the weights in the ship, except in peculiar cases of smooth water; and further, if the error be that the centre of effort is above the height of sail, the ship will labour under the disadvantage of a diminished area of sail, since the moment of sail must be in constant proportion to the moment of stability; and if the centre of effort is too low, the ship may not be able to obtain all the advantage of motive power that her stability would admit of her applying.

Disadva tages of mal-pos tion of centre of effort.

Centre effort a true hei of sail.

It appears, therefore, that unless the centre of effort of the sail be placed at the height of sail, a ship, however good her form, and the properties connected with it, may be, and whatever may be the care bestowed to render those properties most efficient, will labour under very serious disadvantages; while, on the contrary, a correct adjustment of this element, and a knowledge of the principles on which that adjustment depends, will place it in the power of a commander to obtain a maximum of advantage from the powers and properties of his vessel, since it will enable him to acquire the greatest possible efficient action from the motive power at his disposal.

As was before said, the determination of the height of sail must be classed among those problems of naval archi-

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tecture which, labouring under the difficulties attendant on our imperfect knowledge of fluids, cannot be attained by theory alone. It will now be shown that, by the aid of theory, sufficient deductions may be made from experiment to remedy its practical insufficiency. Throughout the foregoing considerations, the sails have been reasoned on as if they were plane surfaces. If this were the case, their centre of effort would coincide with their common centre of gravity; but, from the flexibility of the materials of which they are made, the sails become, when acted upon by the force of the wind, curved surfaces. However, from the whole surface of sail with respect to height being composed of several such surfaces, the error arising in practice from assuming the height of the common centre of gravity of the whole surface to be the height of the centre of effort, will be very inconsiderable; therefore, in practice the centre of effort of the sails may be represented, with respect to height, by their common centre of gravity.

Since we know, from the principles which have been explained, that when the centre of effort of the sails is at the true height of sail, the trim of the ship will not be subjected to alteration by any increase or diminution in the force of the wind, the height of sail for any trim may be determined by experiment, by first bringing the ship to that trim when she is at rest, and then adjusting the sails so that her water-line when in motion may be parallel to this trim. This being admitted, it is evident that, by proceeding on the principles already explained in this article, the maximum of advantage arising from the correct position of the centre of effort of the sail may be insured, by first ascertaining, from experiment and observation made with reference to the longitudinal position of the centre of effort with respect to the centre of gravity of the ship, the most advantageous draught of water, and then determining the correct height of sail with respect to that draught of water.

The observations necessary to effect these objects will require considerable patience and attention; but it must be considered that they will not only enable a commander to derive the greatest possible advantage from the means at his disposal, but that they will afford correct data for perfecting those means. The following observations may suffice to explain the principle which should be pursued. The draught of water previous to sailing should be observed; and an instrument which will correctly measure the angle of inclination should be fixed, in reference to this water-line, so that by means of it every deviation from this trim may be exactly known. This is rendered absolutely necessary, because, when a ship is in motion, her correct trim, that is, her horizontal water-line, cannot be observed, in consequence of the accumulation and depression of the water which is caused by the motion. In fact, any alteration made in the trim of the ship or the sails, founded on observations made with reference to the apparent water-line, might be extremely hazardous, and certainly would not produce the results expected, as the position of this water-line depends wholly on the circumstances which are in immediate operation. Having the instrument fixed, when the ship has acquired a uniform velocity observe the alteration which has taken place in her trim, as, until the velocity is uniform, the trim will be influenced by the force which accelerates the velocity. Then, if her longitudinal oscillations or her pitching motions appear to be only influenced by the state of the sea, the centre of effort is correctly placed at the height of sail. Therefore the height of the centre of gravity of the surface of sail set, will give the height of sail. But if at every change in the force of the wind the vessel experiences a sudden increase of longitudinal oscillation, observe by the instrument its nature and degree, and make such a change in the adjustment of the sails as the foregoing principles have shown to be necessary; and when the tendency to increased longitudinal oscillation ceases, find the height of sail by calculating the height of the centre of gravity of the surface of sail then set. In this manner the correct height of sail for any trim may be found; while, by observing at the same time the comparative qualities of the ship when at each of these trims (after the height of sail is determined for it), that trim of the ship and sails may be determined at which a maximum of advantage may be derived from the inherent good qualities of the ship, as far as the perfection of the *matériel* will admit, that is, as far as the position and proportion of the masts, yards, and sails, are adapted to the elements of the construction of the ship's body; while from knowing the best trim of the ship, and the true position of the centre of effort under the several circumstances of wind and sea, the naval architect will be in possession of sufficient data to make such alterations in the *matériel* as shall then insure a maximum of advantage with a maximum of the means. In fact, correct observations of this nature would go very far to remove much of the difficulty which theory, in its application to some points in the practice of naval architecture, at present labours under.

Recapitulation of principles.

The laws which govern the mutual action of the wind and water on a ship when she is in motion have now been explained, principally as they affect her equilibrium round a vertical or a horizontal axis of rotation; because by pointing out the various states of equilibrium which result between the action of the wind on the sails and the water on the hull, we are enabled to show the effects which may be produced on the qualities of the ship by modifications in these equilibrio; either by the use of the helm, by alterations in the trim of the ship, in the quantity of the sail set, or in the disposition of that quantity, so that in the various changes which may take place in the state of the wind or of the sea, the qualities of the vessel may either experience the least possible injurious effect, or the greatest possible degree of benefit, according as the tendency of the change may be injurious or beneficial. In pursuing this train of reasoning, we have also endeavoured to explain in what manner the principles that govern the mutual action of these forces may be made available in directing such observations on the performances of ships as may lead to the formation of correct conclusions on their powers and qualities, and guide us to the best means of rendering these qualities most easily available. It has also been shown, that by experiments and observations made according to the principles which have been advanced, a maximum of advantage may be obtained from a ship, as far as the form, the fitness of the proportions and positions of the masts and yards, the proportions of the sails, and the trim of the vessel, will admit; and, what is yet more important, that sufficient data may be obtained to enable the naval architect to judge correctly of the comparative perfection of those means, and so to form correct conclusions as to such deviations from them, as would either tend to their improvement or to obviate similar defects in a future design.

In every vessel a maximum of efficiency.

It is evident, that whatever may be the service required from a vessel, there must always be some maximum of efficiency with reference to those services, which is to be arrived at by a judicious combination of the powers of the vessel with the means which call them into action. The distinguishing division of the characteristics of the qualities required in vessels are mainly those peculiar to burden and those peculiar to velocity. In England, for the last century, we may say that burthen, to the sacrifice of every other quality, nay, even to an extent compromising the safety of the vessel and the lives of the crew, has been the solitary requirement in the design of a merchant-ship.

Distinct qualities, burthen and velocity.

In ships of war both necessary.

In ships of war, under almost all circumstances, it is a combination of the two which is the desideratum; and it is not sufficient that a vessel should be only capable of great velocity in direct courses, or when the propelling force acts in the direction of the keel; for it is in most cases of more importance that she should be capable of great velocity when acted upon by a force in a direction oblique to that of her length, and at the same time that the deviation of her course from this line should be the least possible.

Lee-way.

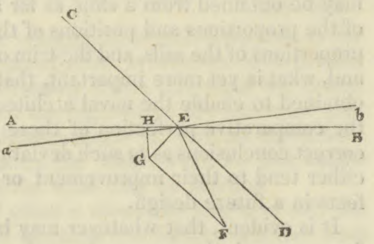
The principles on which this deviation of the course of a ship from the line of her keel, or the angle of lee-way, depends, will now be explained; and the causes will be shown which occasion the actual results of observations on ships to differ from the theoretic principles which have been advanced by writers on this subject; and such methods will be suggested for making further observations in reference to these qualities as may be desirable, with a view to collect data to supply the deficiencies resulting to the theory from the imperfect state of our knowledge respecting the resistances of fluids, particularly as they affect the oblique passage of a ship through the water.

Effective force of wind.

Whatever may be the angle which the direction of the wind makes with the plane of the sails, the only effective force of the wind on the sail is that part of the whole force which can be resolved into a direction perpendicular to the surface of the sails; therefore, whatever may be the whole force of the wind, its effective force will vary as the sine of the angle which the direction of the wind makes with the sail; and as the velocity of the ship is in proportion to the effective force of the wind, it will also, all things else remaining the same, vary as the sine of this angle. Now, as, when the ship is under sail, the direction of its motion should coincide with the middle line, that is, with the direction of the keel, since the plane of resistance is less when the ship moves in that direction than it is when the line of motion cuts the ship obliquely, all that part of the force of the wind which acts in any other direction than that of the keel must be disadvantageous to her progress, as tending to force her in a direction in which she will meet with an increased resistance from the water. From what has been said above, this injurious tendency must necessarily occur in every circumstance of the action of the wind on the sails of a ship, excepting in that under which the trim of the sails is at right angles to the middle line of the ship, as, under all circumstances, the force of the wind on the sail may be resolved into two, both of which will have effect on the ship, the one acting perpendicular and the other parallel to the middle line: or, if we suppose AB (fig. 9) to be the middle line of a ship, and CD the direction of the yard, making with AB the angle DEB less than a right angle; and suppose FE to represent the quantity and direction of the force of the wind; from E and F draw EG perpendicular and FG parallel to DC, and from G draw GH perpendicular to AB; then GE will represent the effective force of the wind on the sail, and GH and HE will be respectively equal to the parts of that force employed in propelling the vessel in a lateral and in a direct course. If CD, the direction of the yard, were perpendicular to AB the line of the keel, the lateral effort of the wind, or the force GH, would be lost, and have no effect on the ship; but when CD is oblique to AB, whatever may be the quantity or direction of the force FE of the wind with respect to AB, it may be resolved into two forces, both of which will be effective on the ship. As long as DEB, the angle formed by the direction of the yard with the line of the keel, remains the same, its complement, the angle GEH, will remain the same; and as GHE is a right angle, the triangle GEH will remain similar to itself, and the proportion between GH and HE will be invariable, and therefore the effort to cause the deviation of the course from the line of the keel, or the action of the force GH, will be in an invariable proportion to the force acting to propel the vessel along that line, or the force HE; and, as we know from what has been before said, that the forces GH and HE must be respectively equal to, and opposed by, the lateral and direct resistances of the water acting in the directions HG and EH, the motion of the ship must be along some line *ab*, such that the equilibrium between these forces may be maintained. This is the principle on which the deviation of the course of the ship from the line of the direction of the keel depends.

Investigation of the angle of lee-way.

Fig. 9.



The angle of lee-way is determined as follows: Suppose the direct and lateral resistances of the water to the passage of the vessel to be respectively R and *r*, and the surfaces respectively opposed to these resistances to be *d* and *e*, and the angle DEB which the sail makes with the line of the keel to be *c*; then, if the angle of lee-way be supposed to be *x*, we have

$$R : r :: d \cdot \cos.^2 x : e \cdot \sin.^2 x$$

$$\therefore \frac{R}{r} = \frac{d \cdot \cos.^2 x}{e \cdot \sin.^2 x} = \frac{d}{e \cdot \tan.^2 x},$$

$$\text{and } \frac{R}{r} = \frac{EH}{HG} = \frac{\sin.\ c}{\cos.\ c} = \tan.\ c$$

$$\therefore \frac{d}{e \cdot \tan.^2 x} = \tan.\ c;$$

$$\text{or, } \tan.^2 x = \frac{d}{e} \text{cotan. } c$$

$$\tan.\ x = \sqrt{\frac{d}{e} \text{cot. } c}.$$

From this equation, also, it appears that the angle of lee-way depends wholly on the angle of inclination of the sail to the line of the keel, without in any way involving the velocity of the ship; and most writers on naval architecture have in this manner considered the question of the equilibrium which exists between the force of the wind and of the resistance of the water in producing this angle. Bouguer has calculated an elaborate table of the angles of lee-way for various classes of ships for the several degrees of inclination of the sail to the keel, from 30° to 90°; but the results which he has obtained differ essentially from those derived from observation on the actual performances of vessels.

Bougue

According to the theory which has been explained, and on which Bouguer founded his calculations, the lee-way depends solely on the angle formed by the yard and the keel, and is uninfluenced by any other cause, and therefore is neither affected by the angle which the direction of the wind makes with the sail, nor by the velocity of the vessel; but this is contrary to the facts elicited by the experience of the actual motion of a ship under sail. From the geometrical construction which has been given, it is evident, that whatever may be the force or the direction of the wind, the proportion which GH bears to HE will increase as the angle DEB diminishes, and so far the theory agrees with experiment; but it is well known to all who have observed the motion of a vessel through the water, that without any alteration in the direction of the wind with the keel, the lee-way varies with every variation in the velocity of the vessel; and also, from this same cause, the alteration in the velocity, all things else remaining the same, if the angle formed by the direction of the wind with the keel be altered, the angle of the lee-way will also experience an alteration; in fact, so greatly does the angle of lee-way depend on the velocity of the ship, that in the same vessel, under similar circumstances of bracing of yards and direction of wind with the keel, the only varying circumstance being a difference in the force of the wind, the quantity of lee-way will vary from that which would occur by the ship's almost drifting in the direction of the sine of the angle of incidence of the direction of the wind on the sail, to that which would exist if her course almost coincided with the line of her keel, or to a quantity which, in practice, would evidently be scarcely observable.

Ex - me t va- riar with the ;

There is some difficulty in accounting for this difference between the results of theory and the facts observed from experience. It depends in a great measure on the imperfection of our knowledge respecting the laws of the motion of bodies in fluids, so that we are unable to estimate the circumstances of the resistance of the water on the bows and on the sides of the ship. The results of the theory of resistances, when applied to oblique impulses, vary very considerably from the actual resistances as observed by experiment, more especially as the angles of incidence become more acute. This discrepancy affects the lateral resistance, or the resistance on the broad-side, more than the direct, or that experienced by the bows of the vessel, and therefore has a corresponding influence in causing the actual lee-way of a ship to differ from the theoretic result. But this, again, is one of those difficulties arising from the imperfect state of the theory of resistances, which may be classed among those which were referred to in the early part of these observations, as requiring "only to be fully known and understood, to be, if not absolutely theoretically solved, at least, from the collection of facts, from experiment, and from analogy, so far overcome, as to leave nothing to be desired." The course of these remarks will tend to show the possibility of this. Professor Robison, in the excellent article on Seamanship, speaking of the results deduced by Bouguer, says, "that the person who should direct the operations on ship-board in conformity to the maxims deducible from M. Bouguer's propositions, would be baffled in most of his attempts, and be in danger of losing his ship. The whole proceeds on the supposed truth of that theory which states the impulse of a fluid to be in the proportion of the square of the sine of the angle of incidence, and that its action on any small portion, such as a square foot of the sails or hull, is the same as if that portion were detached from the rest, and were exposed singly and alone to the wind and water in the same angle....But let it be observed, that the theory is defective in one point only; and although this is a most important point, and the errors in it destroy the conclusions on the general propositions, the reasonings remain in full force, and the *modus operandi* such as is stated in the theory."

but t an ins oun- tab ob- jectn.

And er cau of dev on fro heo- reti n- clus s.

There is another cause existing to occasion the deviation which is observable in the practical results of the lee-way of a ship from the conclusions of theory, which arises from the theory's not embracing the whole of the circumstances attendant on a vessel's motion through the water. By recurring to the explanation which has been given of these circumstances in a previous portion of this article, some further elucidation may be afforded to the unsatisfactory result of the theory. When motion is communicated to a vessel from a state of rest, or from a lesser degree of motion, the effort of the wind on the sails is greater than that of the water on the hull, whether to propel the vessel in the direction HE of the keel, or, laterally, in the direction GH, and the velocity of the vessel in each of these directions is accelerated by the excess of the force of the wind over the resistance of the water, until, ultimately, by the diminution in the relative velocity of the wind, and the increase of the relative velocity of the water, an equilibrium ensues between the propelling and the resisting forces, and the vessel continues to move in the direction of the last acting force, and with the last acquired velocity. Now the resistances of the water in the direction EH and HG may be assumed to increase as the squares of the velocities, and from the nature of the form of a vessel, and from the comparative direct and lateral resisting areas, the resistance arising from form or area is much smaller in a direct than in a lateral direction, and therefore the equilibrium between the forces which act laterally may ensue before that between the forces which act directly; in which case the lateral motion of the vessel will become uniform before the direct motion, and consequently the ultimate course or direction of the vessel, when all the forces have arrived at a state of equilibrium, will approximate to that of the last acting force, that is, will more nearly coincide with the direction of the keel, and the angle of lee-way will be diminished. As this reasoning depends on the intensity of the force of the wind, the effect will vary as the cause; and the greater the force of the wind, and consequently the velocity of the ship, the greater must be the diminution of the angle of lee-way, that is, the angle of lee-way will, so far as it is affected by these considerations, vary inversely as the sine of the angle of incidence of the wind on the sail.

Romme.

Romme, in his *Traité du Navire*, differs from the opinions advanced by Bouguer; and though his reasoning on this subject is far from clear, his opinions are valuable, as he founds the conclusions at which he arrives, that the lee-way varies inversely as the square of the velocity, and that it increases with the obliquity of the sails to the keel, principally on observations and experiments on the actual performances of vessels; and these are the only means by which, as yet, we can hope to arrive at the solution of this problem. However, much further observation is necessary to afford sufficient data on which to found an approximation to the lee-way which a vessel makes. The general facts which influence it appear to be the greater or lesser angle of incidence of the wind on the sail, as the velocity of the ship is dependent on this; the angle of the inclination of the sails with the keel; the form of the vessel as it affects the ratio of the direct and lateral resistances; the form of the vessel as it affects the velocity; the stability as it affects the lateral resistances; the quantity of sail set; and the state of the sea.

Tables might be formed.

The distance which a ship falls to leeward of her course in any given time may generally be very easily ascertained; and it would not be a task of any great difficulty to form tables, from actual observation, for ships, under all the various circumstances which have been shown to affect the deviation of their course from the line of direction of the keel. In the open sea the quantity of lee-way made in any certain time may be easily ascertained by measuring the angle which the ship's wake makes with the line of the keel; then, if the distance run during the time for which the lee-way is to be observed be ascertained, as that distance is measured along the line of lee-way, the distance run in any period of time will be to the distance which the ship has fallen to leeward of her course during that time, as radius to the sine of the angle of lee-way. When a ship is in sight of land, the angle which the direction of the keel makes with the line of lee-way may be more correctly observed by means of a fixed object on the shore, whenever the state of the wind and sea may render an estimation of the lee-way desirable, that is, whenever the wind is sufficiently steady; as, of course, it is supposed that the angle formed by the direction of the wind with the line of the keel will remain constant during the whole time for which the distance fallen to leeward is to be ascertained. If, when the ship is either approaching or leaving the shore, her head be constantly kept to the same point of the compass, the ship's course will be along the line of lee-way; and as all things are supposed to remain constant during the time of the observation, this line will form a constant angle with the line of the keel, and therefore the point on the shore, which will have the same bearing from the ship as the line of lee-way, will remain at that bearing during the whole time in which the ship either approaches to or recedes from the shore. Consequently, if, when a ship either approaches to or recedes

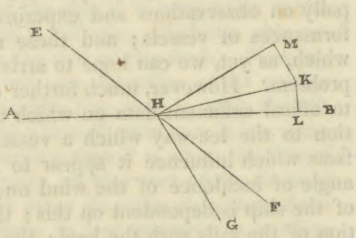
Experiments which may be made.

from a shore, an object on the shore be observed which has a constant bearing from the ship, it must be in the direction of the line of lee-way, and therefore the angle which it makes with the direction of the keel will be the correct angle of lee-way; and then, as before, if the distance run in any time be taken as the radius, the distance which the ship has fallen to leeward of her course in that time will be equal to the sine of the angle of lee-way to a radius equal to the distance run by the vessel in the time assumed.

The actual quantity gained to windward in any given time may also be easily ascertained. The motion of the vessel through the water may be considered in four directions, and the velocity with which it advances in either of these directions determined.

The actual velocity of the ship, or the velocity along the line of lee-way, which may be called the oblique velocity, may be resolved into two; the direct velocity, or that estimated in the direction of the keel, and the lateral velocity, or that which is in a direction at right angles to the line of the keel; and contemporaneous with these is the velocity with which the ship gains to windward. Let AB (fig. 10) be the direction of the line of the keel of the vessel, and EF the direction of the yard, cutting that direction of the keel obliquely. Then, whatever may be the direction of the wind GH, the course of the vessel will be along some line HK, forming an angle KHB with the direction of the keel; then suppose HK on the line of lee-way to represent the velocity of the ship in that direction, from K draw KL perpendicular to HB, and cutting HB in L; then the velocity HK is equal to the two velocities HL and LK; and HL and LK will represent respectively the direct and lateral velocities of the vessel, in proportion to the oblique velocity HK; and if from the points H and K, HM be drawn perpendicular and KM parallel to the direction of the wind GH, MK will represent the velocity with which the ship has gained to windward in the time in which she has described the space HK. For the origin of the wind being supposed to be at an infinite distance from the vessel, as HM is drawn perpendicular to GH, the direction of the wind, it may be supposed equidistant in every point from the origin of the wind; and as the angle GHK is less than the angle GHM, the line HK is within the line HM; and therefore the point K is nearer the origin of the wind than the point H, by a quantity equal to the perpendicular distance KM, of the point K, from the line HM; or the ship has gained the distance MK to windward in running from H to K. It is evident that if HM coincided with HK, the ship would neither have gained to windward nor fallen to leeward; and that if HM fell within HK, the ship would have fallen to leeward. When the distance HK run by the vessel along the line of lee-way, and the angle of lee-way KHL, are known, the value of KM may be easily determined; for since the angles GHF, FHL, and LHK, are all known, and the line MH is drawn perpendicular to HG, their complement, the angle MHK, is known; therefore, as HMK is a right angle, HK is to KM as radius is to the sine of the angle KHM; or KM is the sine of the angle KHM, to a radius equal to the distance run by the vessel in the space of time in which the required distance to windward, KM, was to be gained. The only difficulties in the practical solution of this proposition are, to determine the direction HM, or the perpendicular to HG, the direction of the wind, and the value of the angle GHF; for when the vessel is in motion, unless the directions of the wind and of the course of the vessel coincide, that is, unless the vessel is before the wind, the direction of the wind as shown by the vane on board will not be its true direction; for, from the velocity of the vessel through the air, the vane is subject to a force acting upon it in a direction opposed to that of the course of the vessel, the effect of which may be considered the same as if the vane was at rest, and was acted upon by a current of air having a velocity equal to that of the vessel, but acting in an opposite direction; consequently the vane is acted upon by two forces, the one in the real direction of the wind, acting with a velocity equal to the velocity of the wind in that direction, and the other acting in a direction opposed to that of the course of the vessel, with a velocity equal to that of the vessel in its course; and therefore the direction of the vane will be the diagonal of the parallelogram of which the sides represent these two forces in quantity and direction. It is therefore evident that, all things else remaining the same, the greater the velocity of the vessel, the more will the direction of the wind, as shown by the vane, or the apparent wind, deviate from the actual direction of the wind, or the true wind; and as this deviation arises from the action of a force in a direction opposed to the motion of the vessel, or acting along the line of the course from the fore-part of the vessel towards the after-part, the apparent direction of the wind will in all cases head the vessel more than the true direction of the wind, and consequently the vessel will always appear to lie nearer the wind than she actually does.

Fig. 10.



Vessels
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lie.

True di
tion of
wind.

The true direction of the wind may be found if the velocity and direction of the vessel be known, and also the velocity and direction of the apparent wind, as the corresponding velocity and direction of the true wind will form the third side of a triangle, of which the three sides will be to each other as the three velocities; and as two of these are known, and include a known angle, that formed by the direction of the apparent wind with the course of the vessel, the third side, or the direction and velocity of the true wind, may be easily found. But as there is a difficulty in ascertaining the velocity of the apparent wind, the most easy way of determining the direction of the true wind will be by observing the arc through which the ship's head passes from close-hauled on one tack to close-hauled on the opposite tack. The bisection of this arc will, all things else remaining the same, give the direction of the true wind, as the course of the vessel, in relation to the direction of the wind, will be the same on either tack. Or the directions of the apparent wind may be observed both before and after tacking, and the true wind will be the middle point between the two directions, as the cause of the deviation of the direction of the vane from that of the true wind, or the velocity of the vessel, will be equal on each tack; and when the direction of the true wind is known, all the other parts of the triangle may be found, as the direction and velocity of the ship are known, and also the angle made by the apparent wind with that direction.

Should the velocity of the vessel be greater on one tack than on the other, it will be necessary, in order to determine the direction of the true wind, to divide the arc described by the vane when the ship is tacked into two segments, which shall be to each other in the inverse ratio of the velocities of the vessel on the tacks adjacent to these segments.

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Writers on naval architecture and seamanship appear to have fixed the limit of the angle which is formed by the direction of the wind with the line of the keel, when a ship is close-hauled, at six points. This exceeds the angle which the writer of this article has repeatedly observed, by the means which have been described, as being formed by the direction of the wind with the line of the keel, on board the Acorn, one of the corvettes of the experimental squadron of the year 1827. The following table will show the results of some of the observations then made.

Ship's Head before Tacking.	Ship's Head after Tacking.	No. of Points difference.	State of the Wind.
S. S. E. ½ E.	W. ½ N	11	Fresh breeze.
W. by S. ½ S.	S. S. E. ½ E.	9	Light airs.
S. S. E. ½ E.	W. by S. ½ S.	9	Light airs.
W. ½ N.	N. by E. ¾ E.	9¼	Moderate.
N. W. by N.	E. by N.	10	Fresh breeze.
S. S. E.	W.	10	Very fresh.
W ½ S.	S. E. by S.	10½	Very fresh.

The second and third observations in this table were made on the same day. Their correctness receives farther confirmation from the circumstance, that when the Acorn was on the larboard tack, with her head W. by S. ½ S., the Columbine, another corvette of the squadron, was on the Acorn's beam, and it was ascertained from an observer on board the Columbine, she was lying about SE. by S. on the starboard tack; she must therefore have been lying as near the wind as the Acorn. The wind was very light, the rate by log being only one knot two fathoms; the angle of leeway, as observed by the wake, was seven degrees. It is desirable that similar observations should be made for all classes of ships; the circumstances of sea, wind, and rate by log, should also be noticed, that when any comparison is instituted, a due allowance may be made for their influence.

Li to the locity of ip.

We have seen that the velocity of the ship depends on the strength of the wind. Writers on naval architecture have advanced various opinions as to the practicable limit to the velocity of a ship, in comparison with that of the wind. Bouguer endeavours to prove that the velocity of a fast-sailing ship is, when going nearly before the wind, about $\frac{2}{7}$ths of the velocity of the wind, and that merchant-ships seldom attain to more than one fifth of its velocity; but he considers it not impossible that fast-sailing frigates may arrive at a velocity about equal to half that of the wind. Don Juan objects to Bouguer's limit, as too restricted; he corroborates the opinions he advances by the results which he has deduced from experiment and observation on the actual performances of ships. He says that fast-sailing vessels acquire a velocity nearly equal to that of the wind, even when going before the wind. The nearest approximation to this velocity which he observed was as twenty-one to twenty-three; the average conclusion at which he arrives is, that when the course of the ship and the direction of the wind nearly coincide, the velocity of the ship is from $\frac{2}{3}$ds to $\frac{20}{27}$ths of that of the wind.

Ma xceed tha the win

But in oblique courses it is very possible for the vessel to acquire a velocity even greater than that of the wind, if we admit the conclusions of Don Juan to be correct. The reason of this will appear evident on a very slight consideration. The velocity with which the wind acts on the sails after the ship has acquired motion is only its relative velocity, that is, the excess of its actual velocity above the velocity which the ship has acquired in the direction of the wind. Now, when the directions of the wind and of the course of the vessel coincide, this relative velocity of the wind is only the difference between the actual velocities of the wind and of the vessel; but when the course of the vessel is oblique to that of the wind, the relative velocity of the wind is the difference between the actual velocity of the wind and that part of the velocity of the vessel which can be resolved in the direction of the wind. Robison, in the article on Seamanship, says, that when the sails are square to the keel, and the wind right aft, the ship's velocity is in direct proportion to the relative velocity, and to the square root of the surface of the sails; therefore, he says, "in order to increase the relative velocity by an increase of sail only, we must make this increase of sail in the duplicate proportion of the increase of velocity."

When the sails are oblique to the keel, he says "the velocity of the ship is proportional to $\surd S \cdot V \cdot \sin. a$; that is, directly as the velocity of the wind, directly as the sine of the absolute inclination of the wind to the yard, and directly as the square root of the surface of the sails." This agrees with the conclusions that have been already drawn; and it is evident that, the velocity of the wind remaining the same, and the sine of the angle of inclination of the wind to the yard becoming equal to the radius, or if the whole force of the wind act in a direction perpendicular to the yard, the velocity of the ship will depend on the area of the sails set, and may therefore, even theoretically speaking, be increased without limit.

Rig of a vessel should be adapted to her form.

From all the conclusions which have been deduced in the course of these remarks on the mutual action of the wind and water on a ship, it appears evident that the degree of perfection in the performance of a ship, whether with reference to her motion round an axis of rotation, or to her course through the water, depends very greatly on the suitableness of the disposition and proportion of the sail to the form of the vessel. That there should be an analogy between these elements is evident; and experience and reason alike show, that the more nearly the rig of a ship is suited to the qualities of her form, the more nearly do her performances approach to perfection. Vessels which, from the proportions and form of their bodies, are capable of lying near the wind, and of maintaining a weatherly course, cannot evidently be made to develope these advantages of form to their full extent, unless their rig is also appropriate for rendering such qualities available; while vessels of which the form and proportions are not so adapted for sailing in oblique courses, by having a rig peculiarly adapted for such forms and courses, may even be unable to acquire the degree of advantage in these oblique courses that they would otherwise be capable of attaining, and at the same time fall far short of the velocity of which they might be capable in direct courses. In fact, in order that a ship may sail well, her form must not only be adapted for velocity and quickness of manœuvre, but her rig must be adapted to her form; and she must be commanded by an officer competent to develope the advantages of both form and rig.

The first of the following tables was compiled from a work, Scales of Displacements, &c. by Mr Parsons, a member of the late School of Naval Architecture. The second was formed by Mr Henwood, another member of the same establishment, and published by him in an article in the United Service Journal. The third was by Mr Fincham, the master shipwright of Her Majesty's dock-yard at Chatham, and published in the Papers on Naval Architecture.

These tables compose together a valuable analysis of some of the elements of construction of our ships of war, and, within their limits, cannot fail of proving useful to the naval architect; because, as we have before said, naval architecture is a science of comparisons and analogies. To the reader of the foregoing pages of this article it need scarcely be observed, that there yet remain many difficulties opposed to its being perfected, and that these can only be removed by a rigorous course of inductive investigation applied to the results of a patient, an attentive, and, above all, a competent comparison of the reported qualities and performances of ships, with an analysis of the elements of their design. When the School of Naval Architecture shall be re-established, as it most assuredly will be, the exercises of the students in their calculations, and their experiments on ships, may be made available to this end, by gradually obtaining the preliminary analysis of the whole navy of England; a work of very far too great labour for any thing but the combined endeavours of many individuals to accomplish; and when accomplished, of too vast extent, and of too varied and too conflicting results, to be grappled with by any but by a mind apt to conceive, to collate, and to generalize, and competent to submit these generalizations to the ordeal of strict mathematical investigation.

TABLE I.—*Of the principal Dimensions of the several Classes of Ships composing the British Navy, and of several of their principal Elements.*

Number of guns	120	84	76	74	Razée.	74	Razée.	60	46	42	28	Fir. 28	18	18	10	Cutters.		Steam Vessels.	
Burthen in tons	2808	2279	1925	1741	1741	1614	1614	1474	1073	943	499	499	429	382	235	160	108	296	237
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
Length of the gun-deck of ships of the line, and flush-decked vessels; and lower deck of frigates	205 5½	196 5½	182 0	176 0	176 0	168 0	168 0	172 9	151 9	145 0	113 8	113 8	109 6	100 0	90 0	70 8⅜	60 9	126 0	115 0
Length on the keel, for tonnage	170 11	161 11½	150 8⅞	145 1	145 1	137 10½	137 10½	144 9	126 8	121 9⅜	94 8⅜	94 8⅜	86 9½	77 3½	75 7	52 3¼	49 5	111 9¾	101 2⅞
Breadth, extreme	54 6	51 5¼	49 0	47 6	47 6	46 11	46 11	43 8	39 11	38 2	31 6	31 6	30 6	30 6	24 6	24 0	20 4	22 4	21 0
Breadth, moulded	53 9	50 8¼	48 4	46 10	46 10	46 3	46 3	43 0	39 3	37 6	31 0	31 0	30 0	30 0	24 0	23 7	19 11	21 10	20 7
Depth in the hold	23 2	22 6	20 6	21 0	14 0	19 9	13 3	14 6	12 9	13 3	8 9	8 9	12 9	12 9	11 0	11 0⅜	9 0	13 6	11 0
Main wale, thickness used in the calculations	0 10	0 9	0 8½	0 8½	0 8½	0 8½	0 8½	0 7½	0 6	0 6	0 5	0 5	0 4½	0 4½	0 4	0 3½	0 3½	0 5	0 4
Plank of the bottom	0 5	0 4½	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 3	0 3	0 3	0 3	0 3	0 2½	0 2½	0 3	0 2½
Depth from the lower edge of the rabbet in the keel, to the lower side of the false keel	2 3	1 7	1 9	1 9	1 9	1 9	1 9	1 6	1 3½	1 3½	1 4	1 4	...	...	1 8	1 3½	0 11½	0 9	0 7
Midship port above the water	5 6	5 6	5 6	5 8	8 8	5 4	7 4	8 0	6 0	7 0	4 9	4 9	4 6	4 6	4 2	4 1½	3 6	...	...
Draught of water when loaded, or with the above height of midship port from the water: forward	24 8	22 9	21 4	21 6	18 10	20 6	18 6	20 0	18 0	17 8	14 6	14 6	10 0	10 0	10 10	8 9	7 0	9 9½	7 2
abaft	26 1	25 9	23 4	23 6	20 2	22 6	20 6	20 0	19 4	18 8	15 6	15 6	13 2	13 2	12 5	13 6	11 0	9 9½	7 2
Draught of water when launched: forward	15 1	13 2	14 2	13 0	12 6	12 2	11 8	12 2	10 6	10 6	9 6	8 8	5 0	5 0	7 3	6 4	5 0	5 1	4 9
abaft	18 4	18 0	17 11	17 9	16 2	17 7	16 0	15 2	14 6	14 1	12 5	11 9	8 9	8 9	9 5	9 8	9 0	6 5	5 2
Displacement when loaded, measured to the mean draught of water in each body: fore-body, in tons	2400	1960	1576	1552	1268	1352	1152	1128	852	764	403	344	257	228	149	83	55	218	128
after do.	2320	1880	1526	1476	1136	1272	1064	1012	740	696	365	324	249	216	142	93	54	190	103
Sum of the displacements of the two bodies	4720	3840	3102	3028	2404	2624	2216	2140	1592	1460	768	668	506	444	291	176	109	408	231
Difference of the displacement of the two bodies	80	80	50	76	132	80	88	116	112	68	38	20	8	12	7	10	1	28	25
Displacement when launched: fore-body, in tons	1280	1024	960	880	780	760	676	568	436	408	225	144	136	108	78	53	41	87	68
after-body, do.	1120	824	824	720	640	624	544	472	324	320	180	120	96	70	57	31	22	68	52
Sum, or weight of the hull	2400	1848	1784	1600	1420	1384	1220	1040	760	728	405	264	232	178	135	84	63	155	120
Difference between the load and the launching displacements, or the absolute burthen, in tons	2320	1992	1318	1428	984	1240	996	1100	832	732	363	404	274	266	156	92	46	253	111

TABLE I.—*Continued.*

Number of guns……………	120		84		76		74		Razée.		74		Razée.		60		46		42		28		Fir. 28		18		18		10		Cutters.				Steam Vessels.			
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
Length of the vessel at the load water-line, that is, between the fore side of the rabbet of the stern and the aft side of the rabbet of the stern-post……………………	205	3	195	9	182	0	176	0	175	4	168	3	168	0	173	6	153	0	145	3	115	0	115	0	106	9	97	3	87	2	66	0	57	0	120	5	108	4
Extreme breadth at the load water-line…………	55	6	52	$2\frac{1}{4}$	49	9	48	3	47	9	47	8	47	8	44	3	40	3	38	6	31	10	31	10	30	3	30	3	24	8	23	8	20	6	22	8	21	3
Mean difference between the load and launching draughts of water…….	8	8	8	8	6	3	7	$1\frac{1}{2}$	5	2	6	$7\frac{1}{2}$	5	8	6	4	6	2	5	$10\frac{1}{2}$	4	$0\frac{1}{2}$	4	$9\frac{1}{2}$	4	1	4	$8\frac{1}{2}$	3	$3\frac{1}{2}$	3	$1\frac{1}{2}$	2	0	4	$0\frac{1}{2}$	2	$2\frac{1}{2}$
Distance of the centre of gravity of the displacement below the load water-line………………	10	0	8	$10\frac{8}{10}$	8	$2\frac{1}{2}$	8	$1\frac{2}{10}$	6	0	7	$7\frac{6}{10}$	6	$10\frac{8}{10}$	6	$8\frac{8}{10}$	6	9	6	6	4	$10\frac{8}{10}$	4	$6\frac{1}{2}$	4	$1\frac{2}{10}$	4	0	3	6	3	0	2	$8\frac{1}{2}$	3	$3\frac{6}{10}$	2	$5\frac{1}{4}$
Distance of the centre of gravity of the displacement before the middle of the length of the load water-line…………	2	0	1	$4\frac{3}{10}$	1	9	2	0	2	0	2	$1\frac{5}{10}$	2	0	2	9	3	$3\frac{1}{2}$	1	$11\frac{1}{2}$	1	$7\frac{2}{10}$	1	$7\frac{2}{10}$	0	$7\frac{9}{10}$	0	8	0	$5\frac{1}{2}$	0	0	0	$8\frac{4}{10}$	3	$2\frac{4}{10}$	2	9
Distance of the principal transverse vertical section before the middle of the length on the load water-line…………	18	0	13	6	8	6	20	0	14	4	15	6	13	3	8	6	10	0	15	0	15	0	15	0	13	0	8	6	8	0	2	0	5	6	10	6	8	6
The same distance in proportion to the length of the load water-line……	·088		·869		·041		·11		·081		·092		·08		·049		·065		·10		·13		·13		·12		·087		·091		·03		·098		·087		·079	
Area of the principal transverse vertical section, in square feet…………	1056		988		810		802		658		740		646		616		540		500		320		280		241		241		164		138		102		166		104·8	
Area of the load water-section, in square feet..	10012		8960		7952		7608		7176		6916		6672		6704		5260		4776		3264		3160		2632		2368		1796		1232		948		2400		1894	
Displacement per inch at the load water-section, in tons…………………	23·83		21·33		18·9		18·1		17·09		16·46		15·9		15·96		12·52		11·37		7·77		7·52		6·27		5·63		4·28		2·9		2·26		5·7		4·5	
Area of the launching water-section, in square feet………………………	8440		7176		6760		6280		6048		5812		5570		5336		4008		3760		2808		2288		2160		1680		1360		880		740		1808		1610	
Displacement per inch at the launching water-section, in tons………	20·0		17·1		16·1		14·95		14·4		13·83		13·26		12·7		9·54		8·95		6·68		5·45		5·0		4·0		3·24		2·09		1·75		4·49		3·83	
Area of the sails, viz. jib-driver, courses, top-sails, and top-gallant sails, in square feet…..	25619		26724		24226		23027		24374		23027		24374		23027		16651		16107		10152		10152		9605		9277		6246		4825		3502		…		…	

NOTE.—The depth of the lower side of the false keel, below the lower edge of the rabbet, for the brigs of eighteen guns, is not inserted in the table, as an additional false keel is put to these vessels when they are altered from brigs to ships, giving them an increase of six inches of false keel forward, and no increase aft. On this account the draught of water given for them in the table is measured from the upper side of the main keel.

TABLE II.

	Length of Load Water-line.		Breadth, extreme, at ditto.		Depth from ditto to lower edge of Keel Rabbet.	Draught of Water.				Displacement, in Tons.	Centre of Gravity of ditto before the middle of Load Water-line.	Displacement before Centre of Gravity.	Displacement abaft Centre of Gravity.	Difference of Fore and After Bodies.	Distance of Centre of Gravity of Fore-body from Centre of Gravity of the Displacement.	Distance of ditto of After-body from ditto.
						Forward.		Aft.								
	Feet.	In.	Feet.	In.	Feet.	Feet.	In.	Feet.	In.	Tons.	Feet.	Cub. Ft.	Cub. Ft.	Cub. Ft.	Feet.	Feet.
Rodney, 92 guns…………	204	0	54	4¾	21·27	23	0	24	1½	4165¾	2·445	73550	72250	37·14	40·99	41·72
Queen, 110 guns…………	202	5	59	8½	22·91	22	5¼	23	5¼	4482¾	1·843	79320	77574	49·9	40·51	41·42
Vengeance, 84 guns………	194	2	52	2½	20·655	21	7½	23	1½	3387	3·672	59856	58702	33·0	37·09	37·82
*Vengeance, 84 guns………	194	11½	52	2½	21·825	22	1	24	10	3680	2·467	64836	63974	24.1	37·74	38·25
Winchester, 52 guns………	172	7	44	3	19·1	20	1	21	2	2279	1·662	40180	39602	16·5	33·54	34 03
*President, 52 guns………	172	10	44	11	18·5	19	1	21	8	2123½	4·397	38059	36262	51·4	32·95	34·58
Seringapatam, 46 guns……	159	4	41	0	16 05	16	8¼	18	2¼	1531	2·84	27226	26366	24·6	31·56	32·58
Inconstant, 36 guns………	160	0	45	0	18·00	19	5	19	5	1862	2 79	32975	32192	22·4	30 74	31·49
Minerva, 46 guns…………	152	9	40	1¼	16 32	17	6	18	6	1428	2·38	26381	23949	69·4	25·103	27·688
Sapphire, 28 guns…………	120	0	34	0	13·42	14	1¼	15	5¼	770	1·76	13636	13330	8·6	23·22	23·75
Imogene, 28 guns…………	126	0	33	10	14·42	15	6	16	4	873	2·17	15517	15052	13·2	24·78	25·54
Challenger, 28 guns………	126	11	32	8½	15·1	16	7	16	7	943	2·35	16730	16288	12·6	24 76	25·43
Rover, 18 guns……………	109	9	34	0	13·05	13	11½	14	11½	563	2·253	10017	9722	8·4	20·74	21·37
Orestes, 18 guns…………	111	2	31	0	12·87	13	10	14	7	606	2·485	10805	10403	11·5	21·63	22·46
Champion, 18 guns………	110	10	31	1	12·92	14	6	14	6	615·8	1·226	10824	10732	2·66	21·94	22·12
Columbine, 18 guns………	102	7	33	2¼	13·4	14	4¼	14	10¾	524·8	4·25	9435	8933	14·3	18·79	19·84
Scylla, 18 guns……………	97	6	30	0	11·33	10	7	14	3	421·8	1·312	7526	7239	8·2	17·91	18·88
*Waterwitch, 10 guns……	88	11	28	9½	11·142	10	2	14	6	330·8	·167	5804	5774	·56	16·44	16 52
Britomart, 10 guns………	86	9	24	7	9·81	10	7¾	12	3¾	278·0	·517	4920	4808	3·5	16·66	17·05

* The calculations for the ships thus marked are made to the sea-going draughts of water; for the others, to the draughts of water on the drawings.

TABLE III.—*Moments of Sail, of Stability, and of Sail in terms of the Stability, in Ships which have carried their Sail well.*

Three-decked Ships.			Two-decked Ships.			Frigates.			Sloops.			Brigs of 18 Guns.			Brigs of 10 Guns.		
Moments			Moments			Moments			Moments			Moments			Moments		
of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.	of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.	of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.	of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.	of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.	of Sail.	of Stability at 10° Inclination.	of Sail in terms of Stability.
	Tons.			Tons.			Tons.			Tons.			Tons.			Tons.	
2,632,121	3452	762	1,750,165	2280	767	1,276,577	1647	775	554,484	547	1013	442,413	409	1081	247,645	207	1196

Description of several Mechanical Methods of Designing the Body of a Ship.

Mechanical processes substituted for correct principles.

The following mechanical methods of designing the forms of midship sections, and of ships' bodies, have been published in different English and French works on naval architecture. Some of these are for forming the midship section alone; others are for deducing the successive sections forward and abaft from a given midship section. Such methods of endeavouring to compensate for the absence of more correct principles on which to found the design of a ship, were rendered necessary whenever the vessel to be built was of too large a size to admit of being conveniently put up by the aid of the eye alone; and consequently almost every merchant-builder is in possession of some such empirical system, to enable him to form a design for a ship. Whether the ship built after the design so formed, will prove to be possessed of good or of bad qualities, does not generally enter into the consideration, excepting in so far as the crude ideas of the inventor of the system may have guided him in forming it. We say the crude ideas, because the builder whose judgment is sound enough to enable him to arrange facts and classify observations, and whose experience has been extensive enough to have furnished him sufficient facts from which to deduce principles, will abandon all such attempts as futile, and will pursue the study of naval architecture in the manner in which alone it can be studied to certain advantage, that is, as an inductive science. His success will depend on his fitness for the task.

If all the principles which are involved in the design for a perfect ship were developed, and correct results could be obtained by calculation on every point involved, a system might be formed. A system might also be formed combining all the present knowledge on the subject; but this is far from desirable; it would necessarily be imperfect, and it would be entailing imperfection on the future.

Metho for for midshi section

M. Bouguer, in his *Traité du Navire*, gives four methods which have been used for describing the midship sections of ships. He observes, that in these plans the midship sections are generally formed of arcs of circles; but that sometimes, through the ignorance of the inventors, of the fact, that for two arcs of circles to touch each other without cutting, their centres must be in the straight line which passes through their point of contact, the midship sections which they formed by these arcs had not even the advantage of being curves, but had angles in their contour. He shows how this error may be avoided. The first method he gives

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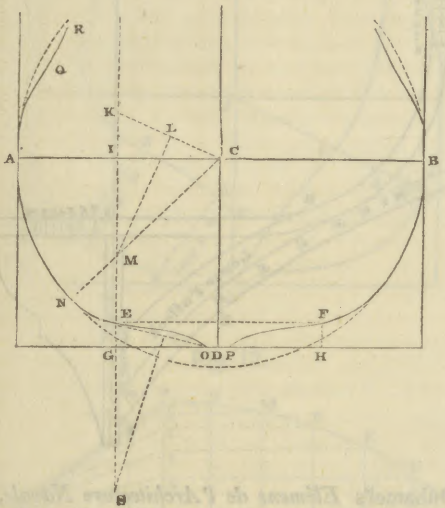
is that of Le Père Fournier. A straight line AB (fig. 11) is drawn, which he takes to represent the moulded breadth of the ship. A circle RANB, which has this line for the diameter, is then described; and, bisecting AB in C, he draws the perpendicular CD, equal to the depth intended to be given to the vessel, which extends from the under part of the beam to the upper side of the keel. Through the point D he draws a line parallel to AB, and, making DG and DH each equal to half the flat of the floor, equal also, if so determined, to one fourth of the whole breadth, he draws the verticals GE and HF equal to the rising of the floor. These may be assumed equal to the twenty-fourth, the eighteenth, or the twelfth part of GH. He then finds on GE, produced both ways to K and S, a point M, which he takes for the centre of an arc of a circle NE, that touches the first circle in some point N, and the straight line EF in E. Then with a point S assumed as a centre he describes the arc EO, which, touching the straight line EF or the arc NE in E, meets the side of the keel in O. He has thus ANEO for the form of half the section, and the other side is drawn in the same manner.

Fig. 11.



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Bouguer corrects this method thus: He takes EK equal to the radius CA of the first circle, or equal to half the length of the beam, and having joined the points K and C by the straight line CK, if it be bisected in L, and LM be drawn perpendicular to it, the intersection of this perpendicular with EK will be the centre M of the arc NE. For MC being equal to MK, and EK having been made equal to AC or to NC, it is evident that MN will be equal to ME, and consequently the arc of the circle described from the point M as a centre, and which will pass through the point E, will touch the first circle in N. To determine the other centre S, bisect the straight line EO, and from the point of bisection draw a perpendicular which will meet IG produced in the point S, which will be the centre of the arc EO. The arcs AQ and QR are described, the first round the point I as a centre with the radius IA; the second round any assumed centre with a radius equal to AI.

By de
Pal

Another method is for determining the midship sections of flat-floored ships. It was invented by M. de Palmi of Brest. A rectangle ABIL (fig. 12) is described, which has for its breadth the breadth of beam, and for its height the depth to the keel. At E and F, the extremities of the flat of the floor, the perpendiculars GE and HF are drawn equal to the rising. A line KE (fig. 13) equal to LG is assumed, and a square described upon it; two quadrants of circles AQE and AXE are inscribed in this square, and either arc AXE is divided into a certain number of equal parts, AV, VX, XY, YZ, &c. drawing from the points of division VO, XN, &c. perpendicular to the radius AK. The depth of the vessel to the rising of the floor is divided into the same number of equal parts; and transferring to level lines drawn through these last points of division O, N, &c. the distances OS, NR, MQ, &c. intercepted in fig. 13 between the radius AK and the arc of the circle AQE, it only remains to pass a curve ASRQPE, in fig. 12, through the extremities of all the perpendiculars or ordinates OS, NR, &c. and the form of half the first section is obtained. ED may be formed by an arc of a circle touching the first curve E, and joining the side of the keel at D.

Mechanical
Methods of
designing
Bodies.

Fig. 12.

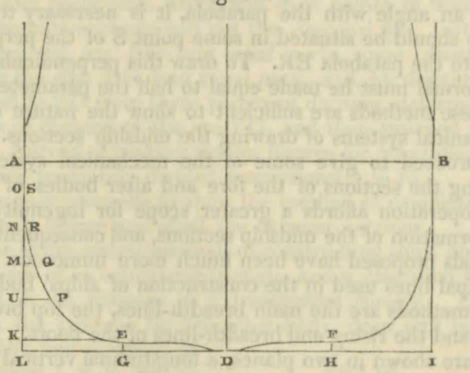
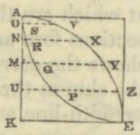


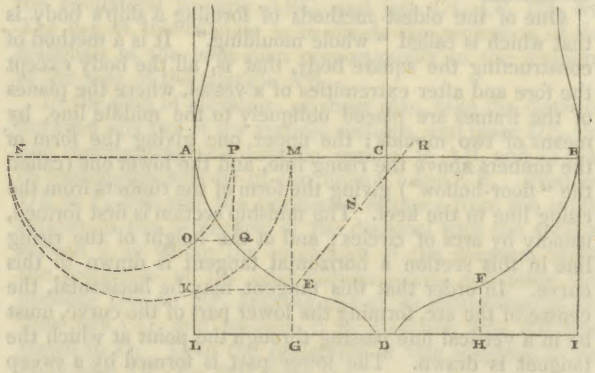
Fig. 13.



By Bouguer.

A third method, given by Bouguer, is for sharp ships. Form as before the rectangle ABIL (fig. 14), circumscribing the part of the section below the main breadth AB; then the rising GE or HF of the midship-floor is taken equal to a fifth or a sixth part of the flat of the floor GH. The points E and F being determined, two portions of parabolas AE and BF are described, A being the vertex and AC the axis of the one, and B the vertex and BC the axis of the other. The flat of the floor is formed by two arcs of circles, the convexity of the upper arc being below, and of the lower arc above. Having drawn from the point E, EK and EM perpendicular respectively to AL and AC, describe from a centre in AC produced indefinitely towards N, the semicircle MKN passing through the points K and M. Then AN will be the parameter of the parabola, which will serve to determine as many points in the curve as may be desired. If it be required to find a point in the vertical line PQ through which the curve will pass, it may be found by describing the semicircle NOP, and drawing from the point O, where the semicircle cuts AL, the horizontal line OQ, the point Q, the intersection of this line with PQ, will be a point in the parabola. In the same manner any number of points may be found. In order that the first arc of

Fig. 14.



Mechanical Methods of designing Bodies.

the circle of which the flat of the floor is formed, may not make an angle with the parabola, it is necessary that its centre should be situated in some point S of the perpendicular to the parabola ER. To draw this perpendicular, the sub-normal must be made equal to half the parameter AN.

Methods for forming the body.

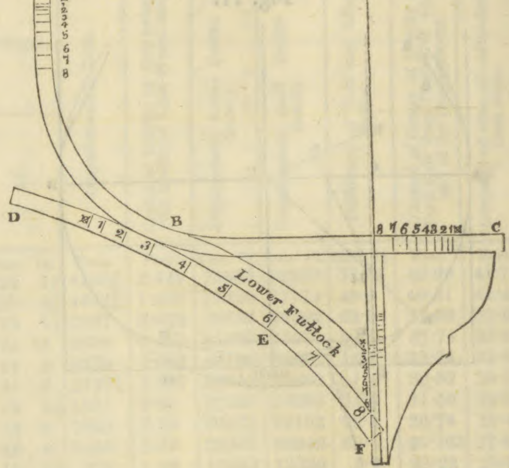
These methods are sufficient to show the nature of the mechanical systems of drawing the midship sections. We will proceed to give some of the mechanical systems of forming the sections of the fore and after bodies of ships. This operation affords a greater scope for ingenuity than the formation of the midship sections, and consequently the methods proposed have been much more numerous. The principal lines used in the construction of ships' bodies by these methods are the main breadth-lines, the top breadth-lines, and the rising and breadth-lines of the floors. These lines are shown in two planes, a longitudinal vertical plane, and a longitudinal horizontal plane. The rising of the main breadth-line shows the projection on the longitudinal vertical plane of the heights above the upper side of the keel, at which are the greatest breadths of the different vertical sections fore and aft; and the horizontal main breadth-line shows the corresponding distances from the middle line of the ship at the respective sections. The rising of the top breadth-line, and the horizontal top breadth-line, show in the same manner the heights from the upper side of the keel, and the horizontal distances from the middle line of the ship, of the different vertical sections at the top breadth of the timbers. At these heights, and at these distances from the middle line, arcs of circles are generally described, which give the form of parts of the vertical sections, or of the frames of the ship. The rising line of the floors gives in the same manner the heights above the upper side of the keel, and the horizontal breadth-line of the floors gives the distances from the middle line at which the floor-sweeps commence.

Whole moulding.

One of the oldest methods of forming a ship's body is that which is called "whole moulding." It is a method of constructing the square body, that is, all the body except the fore and after extremities of a vessel, where the planes of the frames are placed obliquely to the middle line, by means of two moulds; the upper one giving the form of the timbers above the rising line, and the lower one (called the "floor-hollow") giving the form of the timbers from the rising line to the keel. The midship section is first formed, usually by arcs of circles; and at the height of the rising line in this section a horizontal tangent is drawn to this curve. In order that this tangent may be horizontal, the centre of the arc, forming the lower part of the curve, must be in a vertical line passing through the point at which the tangent is drawn. The lower part is formed by a sweep which reconciles with the upper curve. Usually this sweep does not correctly touch the upper curve, although the inaccuracy is not very important in this method of construction. In forming the body-plan, the heights of the main breadth and rising lines at the different frames are set off, and the different sections drawn by the two moulds. On the horizontal part of the upper mould ABC (fig. 15) are marked the half main breadths of the different sections, as shown at C, and on the upper part of the mould their heights, as at A; the lower mould DEF is also marked where it meets the side of the keel at the different sections.

In moulding any timber, a square, called the rising square, with the heights of the different risings of the timbers marked on it, is used, by which the moulds are set according to the particular timber the form of which it is intended to obtain. On this square are also frequently marked the heights of the cutting down, by which the form of the inside of the timber is obtained at the same time. The operation of moulding a timber may be best seen by reference to the figure, where the moulds and rising square are set for moulding the lower futtock. No. 8

Fig. 15.



Method Duhame

In Duhamel's *Elémens de l'Architecture Navale*, there is a French method, nearly resembling this, of "whole moulding."

By Mun Murray.

In Mungo Murray's Treatise on Ship-building, a method is given for forming a ship's body by the use of the sector. This instrument is formed of two scales connected by a hinge, so as to open and shut like a common rule. Seven lines are drawn on each leg of the sector from its centre, divided at numerous points, indicating lengths which refer to differents elements of the body. The marks on the corresponding lines on the two legs of the sector refer to the same distances.

The lines on one side of the sector are divided for the fore-body, and on the other for the after-body. The manner of using these lines is thus described. "The general dimensions being determined, and a scale adapted to the drawing, take the half breadth with a pair of compasses, and placing one foot in the proper point for the half breadth of the midship section, which is shown on one of the lines, open the sector till the other foot reaches to the same point in the corresponding line on the other leg."

The sector being thus set, the different distances are taken by the compasses from the corresponding points marked on the corresponding lines, and set off in the different plans.

It is immediately evident that, by the use of the sector as described, all ships constructed by it would be similar to that according to which the distances were marked on these lines. If it is required to form a fuller or a sharper body than that by which the lines of the sector were divided, the midship section, with the foremost and aftermost sections, must be determined agreeably to the will of the constructor; and the intermediate sections will be determined on the diagonals by setting the sector separately for each diagonal, and then taking the distances from the lines as before for the formation of the different plans in the drawing.

By Bouguer.

The next method of constructing ships' bodies which we shall give is described by Bouguer; the diagonals in this method are formed of arcs of ellipses. The midship section is formed at will, and the extreme sections, forward and abaft, are formed in an arbitrary relation to the midship section. To form the after-body by this method, let ABC (fig 16) represent the midship section, FED the after section, and BE the projection of one of the diagonals. Describe the arc of a circle BA (fig. 17) whose radius is equal to three times the line BE (fig. 16), and whose versed sine BC is equal to BE. Divide the sine AC into any

Fig. 16.

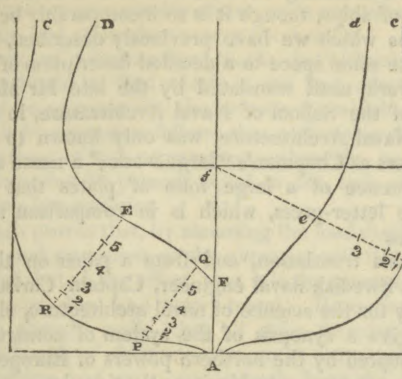
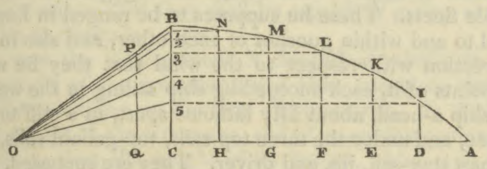
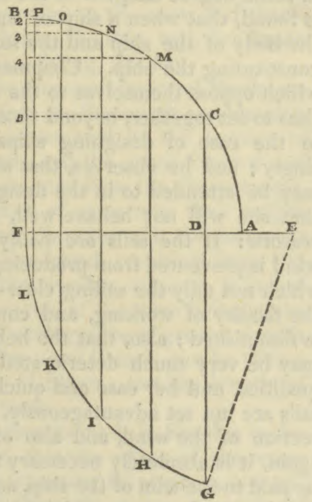


Fig. 17.



number of equal parts, according to the number of intermediate timbers it is intended to draw. From these points of division draw the lines DI, EK, &c. perpendicular to AC; and from the points where these lines intersect the arc of the circle draw I5, K4, &c. parallel to AC. Transfer the line BC, so divided at 1, 2, &c. to BE, in fig. 16, which will give points in which the intermediate sections will cut the diagonal BE. The other diagonals are divided similarly by taking any point O in AC produced (fig. 17), and joining OB, OI, &c. and placing the projection of any diagonal as PQ parallel to BC, and with its extreme points in OB and OC. Some constructors prefer dividing each diagonal separately, by describing arcs of circles BA with different radii; others, instead of dividing the sine AC into equal parts, divide the arc AB into equal parts, and then proceed as before.

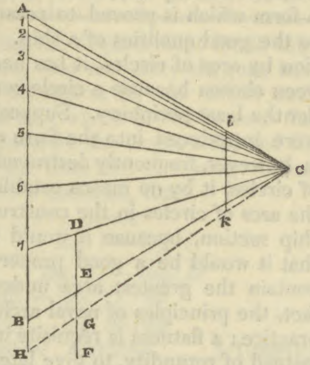
Fig. 18.



The fore-body is formed by nearly the same means, but is always made fuller than the after-body. Let *Abc* (fig. 16) represent the midship section, and *Aed* the extreme section forward; produce the projection of the diagonal *be* to meet the middle line of the body-plan in *f*. Describe the quadrant of a circle BA (fig. 18) with a radius equal to *fb* (fig. 16), and draw the sine DC equal to *fe*, and parallel to FB. From a point E in FA produced, describe an arc of a circle, with a radius equal to once and a half or twice FB, according as it is intended to make the fore-body fuller or sharper, meeting CD produced in G. Divide the arc FG into as many equal parts as it is required to find spots on the diagonal *be*, for the intermediate sections; and from the points of division H, I, &c., draw HM, IN, &c. parallel to BF; and draw P1, O2, &c. parallel to FA. Then transfer BF, so divided, at 1, 2, &c. to *bf* in the body-plan, which will give points in which the intermediate sections will cut the diagonal *bf*. Instead of dividing the arc FG into equal parts, some constructors divide the sine DG into equal parts, and, by drawing lines parallel to FD from these points of division, determine the points of division of the arc FG, and then proceed as before. Instead of making similar figures for other diagonals, they are frequently divided proportionally to *fb*.

Bouguer proceeds to show the method of completing the diagonals before and abaft the extreme sections.

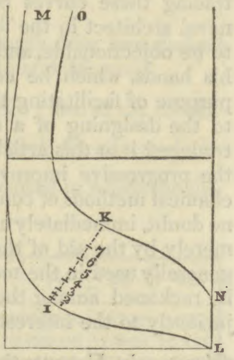
Fig. 19.



One of the easiest methods of constructing ships' bodies, is by means of an equilateral triangle, and is described by Duhamel in his *Elémens de l'Architecture Navale.* To construct the triangle for the after-body, draw any line AB (fig. 19), and divide it at the points 1, 2, 3, &c. so that the distance from 1 to 2 may be three times the distance A1, taken at pleasure, the distance from 2 to 3 five times A1, and so on; the number of points of division corresponding to the number of intermediate sections between the midship section and the stern-post, together with the after-section at the stern-post. Suppose the number of intermediate sections to be 7, let the distance from 7 to B be at least equal to the distance between the vertical sections on the plan of elevation. Describe on AB the equilateral triangle ABC, and join C1, C2, C3, &c. The use of this triangle is to divide the projection of the diagonals in the body-plan proportionally to the divisions of the base of the triangle AB.

In the plan of elevation, or sheer plan, take the distance between any two of the vertical sections, and place DE, the line representing this distance, parallel to AB, and so that its extremities may be in the lines C7 and CB. Produce DE to F, and take the horizontal distance from the intersection of the projection of the diagonal with the vertical section 7, to where the projection of the diagonal meets the projection of the after fashion-piece; and place this distance DG on DF, keeping one of its extremities in D; then join CG, and produce it to meet the base AB produced in H. Take the projection of this diagonal in the body-plan IK (fig. 20) from the midship section LIM to the fashion-piece NKO, and place it in the triangle parallel to the base AB, and with its extremities *i* and *k* in CA and CH; the lines C1, C2, C3, &c. will divide the line *ik* proportionally to the divisions of the base of the triangle AB. Transfer this line so divided to its place in the body-plan: the points 1, 2, 3, &c. will give spots through which the intermediate vertical sections will pass.

Fig. 20.



Some who have used this method of forming ships' bodies placed the projections of all the diagonals parallel to the base of the triangle; others placed them at different angles with the base. Duhamel recommends their being placed as follows. The projection of the lower diagonal representing the floor ribband parallel to the base; the projection of the second diagonal at an angle of

Chapman's Parabolic System.

60° 30′ with that part of the side of the triangle above the projection of the diagonal; the third at an angle of 68°; the fourth at an angle of 86°; the fifth at an angle of 65°; and the projection of the sixth or top-breadth ribband at an angle of 60°.

To construct the fore-body, a nearly similar process is adopted; but the base of the triangle is differently divided,—generally in a geometrical progression whose common multiplier is 2. The divisions of the bases of the triangles, however, are altogether arbitrary, as well as the angles of inclination at which the projections of the diagonals are placed, for both the fore and after bodies.

Objections to the use of such processes.

These are some of the most esteemed mechanical methods of constructing the midship sections of ships, and the fore and after bodies in relation to them. The inspection of them already shows that there is no attempt to describe a form which is proved to possess any property conducive to the good qualities of a ship. In forming a midship section by arcs of circles, it has been said that this figure has been chosen because a circle contains the greatest area under the least periphery. Supposing even that this principle were introduced into the form of a midship section, which is, however, frequently destroyed by the use of several arcs of circles, it by no means establishes the propriety of using the arcs of circles in the construction of the form of a midship section, because it would first be necessary to show that it would be a good property for a midship section to contain the greatest area under the least periphery. In fact, the principles of naval architecture require a contrary practice; a flatness is requisite in some parts of this section instead of rotundity, to give lateral resistance, great stability under a given area, and fine water-lines. The use of the ellipse is equally arbitrary. Little can be said in favour of either of the methods of designing bodies which we have described, nor need any thing be urged against them: it will evidently be perceived, that they are the resources of persons who are called upon to give designs of ships, and who, being ignorant of any correct data on which to form their design, are necessitated to adopt some such system of construction that they may designate as their theory. In no case do we find that those who have published systems such as the foregoing, attempt to prove that ships built after these systems are in consequence good ships; the utmost assumption appears to be, that by proceeding with a drawing after the course laid down, the result will be the design for the body of a ship. All such methods are to be deprecated, as being mere empirical substitutes for knowledge, and because they not only oppose a barrier to legitimate attempts towards improvement, but they actually prevent the application of such knowledge to the designing of ships' bodies, as may really be possessed. If we look upon systems for tracing these curves merely as aids to the well-informed naval architect in the formation of his drawing, they cease to be objectionable, and become mere mechanical means in his hands, which he can use or vary at pleasure, for the purpose of facilitating the mechanical operations incidental to the designing of a ship. They are also necessarily introduced into this article, as forming an essential feature in the progressive improvement of naval architecture. Mechanical methods of constructing designs for bodies followed, no doubt, immediately upon the method of constructing them merely by the aid of the eye, and they continue to be very generally used in the merchant-service, and may, no doubt, be reckoned among the causes which have operated so injuriously to the interests of our mercantile navy.

Chapman's Exponential and Parabolic Systems of Construction.

Chapma Parabol System

Chapman work trans lated in Papers on Nava Architec ture.

These were described in the last work of the celebrated Swedish naval architect Chapman; it was published in 1806. The parabolic system must be classed in this division of our subject, as among the mechanical methods of designing the forms of ships, though it is so incomparably beyond all those plans which we have previously described, that we shall devote some space to a detailed description of it. The Swedish work, until translated by the late Mr Morgan, a member of the School of Naval Architecture, in the Papers on Naval Architecture, was only known to English ship-builders as Chapman's "large work;" a name acquired in consequence of a large folio of plates that accompanies the letter-press, which is in comparison not very voluminous.

From this translation, and from a paper on the same work by a Swedish naval engineer, Captain Carlsund, unfortunately for the science of naval architecture, also dead, we shall give a synopsis of the system of construction at present adopted by the northern powers of Europe.

Criterio of the qu lities of ships.

Chapman commences his investigation by assuming a case, which he presumes may be taken as a criterion of the qualities of ships. This case is an engagement between hostile fleets. These he supposes to be ranged in lines parallel to and within gunshot of each other, and also in such a direction with respect to the wind that they lie within six points of it, each succeeding ship sailing in the wake of the ship a-head, about fifty fathoms apart, in a stiff top-sail breeze, and under the three top-sails, top-gallant sails, fore-topmast stay-sail, jib, and driver. They are supposed, when under these circumstances, not to incline more than seven degrees, and must be capable of fighting their leeward lower-deck guns with a heavy sea running; be good sailers, and work well to windward; so that although the ships may be of different sizes, and carry different weights of metal, yet, in equally high winds, and under similar sail, their angles of inclination being nearly the same, their guns may be worked with equal convenience, they may be all equally efficient in point of velocity, and under all circumstances manœuvre with equal facility. Chapman then says, of two hostile fleets opposed to each other, the fleet which is composed of the stiffest and best-sailing ships is master of the attack, and can begin and end it at pleasure. But that, as the operations of many such ships together, although of different sizes, should at once produce the same effect as if they constituted but one machine, it is necessary that they should keep in company, and be effective in proportion to their size. As they must sail equally well, the area of their sails must be proportional to the resistance they experience from the water; and as all the guns must be used and worked with like advantage, their inclination must be nearly the same, so that the form of the ships below the water will be in some degree adapted to the same area of sails; hence it is found, that when a ship of the line is to be constructed, the body of the ship and the sails are to be considered as constituting the ship. Chapman points out the difficulties which oppose themselves to the designing bodies which are thus to act together, beyond those which present themselves in the case of designing ships intended to sail and act singly; and he observes, that although all the rules of art may be attended to in the design of a ship, it may happen that she will not behave well, and this for the following reasons: If the sails are badly cut and made, so that the wind is prevented from producing its full effect on them, by which not only the sailing close-hauled is injured, but also, the facility of working, and consequently of manœuvring, is diminished; also, that the behaviour of a ship under sail may be very much deteriorated as regards her weatherly qualities, and her ease and quickness of working, if all the sails are not set advantageously, both in respect to the direction of the wind, and also of the ship's course. And, again, it is absolutely necessary that great attention should be paid to the trim of the ship, and to the adjustment of the positions of the masts, which have a great effect on a ship's qualities. Such, he says, are the reasons why it so frequent-

Ships an sails to b considere together.

Trim of t ship.

C man's bolic tem.

ly happens, that a ship may in one voyage possess very bad, and in another very good qualities, or at one time be a very bad sailer, and at another a very good sailer.

The natural inference from this is, that although the form of a ship should be that which is the best adapted for all that may be necessary to the service for which she is intended, it by no means follows that such a ship shall realize the intentions of her constructor, unless she be equipped and commanded by persons equal to the task of properly developing her qualities.

E omy to ve la ships an eavy m l.

He then proves that, by assuming the load displacements, the crew and provisions as the expense, and the weight of a round of shot as the effect, that it is the greatest economy to have large ships and heavy metal. Repeating the observation already made, that all ships forming a line-of-battle, although of different sizes, must act as parts of the same machine, and must consequently have the same qualities, which cannot be effected if the ships be similar, it follows that the rules by which they are designed must be of such a nature that they shall be capable of giving similar qualities to dissimilar ships.

Di ace- me de- pe ent on ar ment.

He says the displacement is dependent wholly on the total weight of the armament, and then considers the various items making up the total displacement. It consists of the weight of the armament, and of every thing connected with it; then the weight of the ballast, which is in proportion to the armament.

Ba st.

Ballast, he says, is necessary for a ship of the line, in order to preserve its qualities at the end of a long voyage, when the greater part of the provisions and ammunition will have been consumed. Also, as these weights are so considerable that the ship may be lightened to such an extent that her centre of gravity may not only rise a foot higher above the water from this diminished immersion than it was at the commencement of the cruise, but will rise so much the more from the influence this diminution of the weights in the hold will have in elevating its position, the stability is also necessarily diminished. It is therefore proper, in order that this loss of stability may not be too great, to have such a quantity of ballast that the remaining weight in the hold may not be too little in relation to the constant weight above the water. And also, he says that the consideration that a ship necessarily lightens from the consumption of stores, renders it necessary that all the calculations which relate to her stability should be made in relation to a water-line, assumed as that which she would have after the expiration of about a quarter of the cruise; and it should be from this water-line that the masts, &c. should be determined.

The next component of the displacement consists of the provisions, which are in proportion to the crew, and therefore to the armament; and, lastly, the ship, with her masts, yards, rigging, anchors, cables, fitting, &c. &c.

Le h and bre h.

Having determined the displacement required for the armament, the next considerations are the length and breadth. These have hitherto been determined by the number of ports, the space between them, and the space forward and aft; but they should be determined from the displacement, for the product of the number of guns into their weight determines the displacement, therefore the displacement determines the length. If the length resulting from this be considered too great for the number of ports, it is because the sum-total of the weights of the guns being given and constant, it follows that if each gun be of greater weight of metal, the number is smaller; and if each gun be of less weight of metal, the number is larger; but the length of the ship is nevertheless the same.

Res nce.

It appears that, from experiments made in Sweden in the year 1794, it was determined that the effect of the water on the after-end of a body, in opposing its progress, is a minimum when the surface of the body makes an angle of 13° 17′ with its middle line, and that consequently Chapman designed the after-bodies of his ships in accordance with this result.

Chapman's Parabolic System.

General rule for length and breadth.

In order to form general rules, according to the exponential system, for deducing the length and the breadth from the displacement, he proceeded in the following manner. The greatest breadth at the water-line for all line-of-battle ships is called B; and the length of the "construction water-line," which term will be afterwards explained, is called *l*. Then, he says, "designs of two classes of ships composing the line-of-battle were constructed with great care, and the following table formed."

	110	94	66
Displacement, D.............. ... =	152875	128297	88722
Length, *l*.......................... =	207·59	196·65	175·48
Breadth, B......................... =	56·27	53·32	48·46

In finding the length *l* from the displacement for all ships of the line, the ships of ninety-four and sixty-six guns have been used. Put therefore $128297 = \mathrm{D}$, and $88722 = D$, also $196{\cdot}65 = \mathrm{l}$ and $175{\cdot}48 = l$, where it will be seen that the Roman characters are used for the larger ship, and the Italic for the smaller. Then from the foregoing reasoning the following proportion is deduced, that

$$\mathrm{D}^{\mathrm{v}} : D^{v} :: \mathrm{l} : l; \text{ hence}$$

$$\text{the exponent } v = \frac{\log.\ \mathrm{l} - \log.\ l}{\log.\ \mathrm{D} - \log.\ D}$$

$$= \frac{\log.\ 196{\cdot}65 - \log.\ 175{\cdot}48}{\log.\ 128297 - \log.\ 88722}$$

196·65..................2·2936940   128297.........5·1082165

175·48..................2·2442276   88722..........4·9480313

0·0494664   0·1601852

$$\frac{0{\cdot}0494664}{0.1601852} = 0{\cdot}3088 = v$$

2·2936940

5·1082165×0·3088 = 1·5774172

0·7162768...5·2033 = the co-efficient.

2·2442276

4·9480313×0·3088 = 1·5279520...5·2033 = the co-efficient.

Thus the length $l = 5{\cdot}2033\ \mathrm{D}^{0{\cdot}3088}$ is obtained for all the line-of-battle ships.

To find the breadth B from the length *l* for three-decked ships the same method is used. Thus, the exponent for 110 and 94 gun ships, $v = \dfrac{\log.\ 56{\cdot}27 - \log.\ 53{\cdot}32}{\log.\ 207{\cdot}59 - \log.\ 196{\cdot}65} = 0{\cdot}9947$; and as the co-efficient is found to be a divisor $= 3{\cdot}5863$, the breadth B for all three-decked ships of the line $= \dfrac{l^{0{\cdot}9947}}{3{\cdot}5863}$.

To find the breadth B from the length *l* for two-decked ships. The exponent v of ships of 94 and 66 guns, $= \dfrac{\log.\ 53{\cdot}32 - \log.\ 48{\cdot}46}{\log.\ 196{\cdot}65 - \log.\ 175{\cdot}48} = 0{\cdot}8391$; and as the co-efficient is a divisor $= 1{\cdot}5767$, the breadth B for all two-decked ships of the line $= \dfrac{l^{0{\cdot}8391}}{1{\cdot}5767}$; according to which the following table is calculated.

	110	94	80	74	66	52
Displacement, D =	152875	128297	107400	96422	88722	66753
Length, *l*..........=	207·59	196·65	186·15	180·05	175·48	160·72
Breadth, B.........=	56·27	53·32	50·92	49·51	48·46	45·01

Having explained the method of determining the principal dimensions, we shall refer for a description of the parabolic system of construction to the paper we have already

Chapman's Parabolic System.

mentioned as having been written by a Swedish naval engineer, Captain, then Lieutenant Carslund. It says,

Whether sections of ships follow a general law.

Curve of sections.

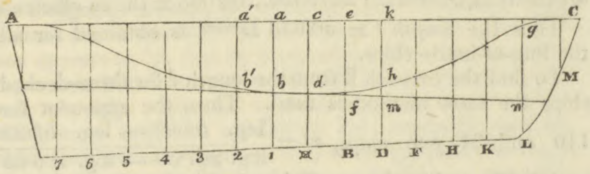
Chapman endeavoured to discover whether or not the areas of the several transverse sections in well-constructed ships followed any law; and if so, to find that law. For this purpose he calculated the areas of the sections of several ships; and in order to make the numbers more convenient, he divided these areas by the breadth of the midship section; then, at their respective stations on the drawing, setting off from the water-line, distances equal to the quotients, he traced a curve representing the areas. This curve he called the curve of sections. He then endeavoured to find the equation to the curve, or rather that of another curve which would coincide with this for the greatest length; and he found, that if the power and parameter of a parabola were so determined as to allow that curve to pass through three given points of the curve of sections, the two curves would nearly coincide. In the fore-body the three points were taken; one forward, one at the midship section, and one midway between. In the after-body the points were similarly situated. In some ships the exponent to the curve was higher in the after-body than in the fore-body, in some it was the same for both. It was also found that there were ships in which the curve of sections almost exactly agreed with the parabola, and these ships invariably bore excellent characters. Chapman consequently concluded, that if the areas of the several sections of a ship were made to follow the law of the abscissas of a parabola, a vessel possessing good sailing qualities might be formed, and the process of construction much simplified.

This account shows that the method is applicable to all sorts of constructions, as it only requires that the relative areas of the sections shall decrease from the midship section towards the extremities in a certain relation, which can be varied to infinity; it is therefore equally useful in constructing the sharpest man-of-war as the fullest merchant-man.

To construct the curve of sections.

Suppose a ship is found to answer well at some given water-line, AC (fig. 21). Let the areas of the transverse vertical sections be divided by some constant quantity, as, for instance, the breadth; and suppose the distances *ab*, *cd*, &c. equal to the quotients, to be set off on the respective sections from the water-line; then a curve drawn through the points *b*, *d*, &c. will be the curve of sections. It will be found to be convex to the water-line at the extremities.

Fig. 21.



The order of the parabola which coincides for the greatest distance with this line may easily be found.

To find the assimilating parabola.

Let the general equation to the parabola be expressed by $y^n = ax$; then it is always possible to determine n and a, so that the parabola shall pass through two points besides the vertex. Any two points between b and C may be taken, but it is evident that the farther apart the three points are taken, the longer will the parabola coincide with the line of sections. Of course, neither point may be in the convex part of the line of sections. It will be found that the point g at the foremost frame, and h in the middle between g and b, are the points which should be taken.

Draw a tangent to the curve at the point b, which will be parallel to the water-line; then mh and ng are abscissas, bm and bn ordinates to a parallel passing through b, h, and g; put $mh = x'$, $ng = x''$, $bm = y'$, and $bn = y''$; then, substituting these values in the equation to the parabola, we have

$$y'^n = ax', \text{ and } y''^n = ax'',$$

$$\text{or } n \log. y' = \log. a + \log. x', \text{ and}$$

$$n \log. y'' = \log. a + \log. x'';$$

$$\text{hence } n = \frac{\log. x' - \log. x''}{\log. y' - \log. y''}$$

$$a = \frac{y'^n}{x'},$$

$$\text{and } \log. a = \frac{\log. x' \cdot \log. y'' - \log. x'' \cdot \log. y'}{\log. y' - \log. y''}.$$

We have now the values of n and x, and by calculating several other abscissas, we can trace the parabolic curve. The same operation applied to the after-body will give the exponent and parameter of the parabola, which is the most similar to the curve of sections in that body.

It generally happens that the exponents are nearly the same in both bodies, if the place of the midship section be determined in the manner to be shown in the sequel.

It will be found that the parabola and the line of sections very nearly coincide, the former being sometimes a little within the latter between g and h, and without at the foreside of h, and sometimes, but much more seldom, the contrary. The parabola always cuts the water-line at a short distance from the rabbets, this distance being rather greater forward than abaft.

This sy tem app to Ame can ship

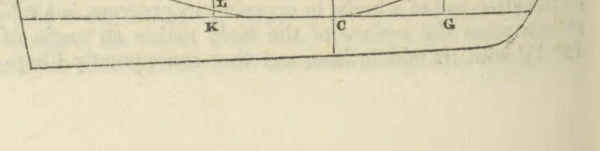
Several American ships of war have been submitted to this method of investigation, which was found to answer very well with their bodies. Indeed there can be no great deviation, as the parabola varies according to its exponent and parameter; if the ship is full, a large exponent adapts it to that shape; and if the ship is lean, a small one. If the body has a long straight of breadth, and sharpens quickly at the extremities, by deducting a part in midships from the comparison, the system may still be applied; or if, as is the case generally with English merchant-ships, there is a very great draught of water in proportion to the breadth, by deducting a part from the water-line downwards, this method may be applied to the remainder.

From this reasoning, it appears that ships may be constructed to coincide exactly with the parabolic line, without deviating from the forms which experience has proved to be the most conducive to giving ships good qualities. Chapman stated that this would most probably be superior to the old system, and the result has confirmed his statement; for ships of the line, frigates, and merchant-men have been constructed after it, all of which have been very fine vessels.

Displa ment.

From the manner in which the curve of sections is formed, it follows that its area multiplied by the breadth is equal to the displacement, and that the centre of gravity of the area is in the same transverse section as the centre of gravity of the body; but the area of this curve, supposing it to be a parabola of a certain power, is a known part of the rectangle formed by the greatest ordinate and the abscissa; hence, by making the areas of the sections decrease in the ratio of the abscissas in the parabola, we obtain certain equations between the quantities. To find these equations, suppose the parabolic line, now also representing the line of sections, to be ACB (fig. 22), cutting the water-

Fig. 22.



pman's abolic stem.

line at some distance from both rabbets; let C be the place of the midship section, and DC the greatest abscissa. Put $AB = l$ and $DC = d$, let the exponent of the parabola before and abaft $= n$, and the displacement $= D$; then the area of the parabolic line $BDACB = \frac{n}{n+1} \cdot l \cdot d$, and the displacement $\frac{n}{n+1}\, l \cdot d \cdot B$ (B representing the breadth); but $dB =$ area of the midship section; hence $\frac{n}{n+1} \cdot l \cdot$ (*area of midship section*) $= D$............(1).

ship ion be- middle ength.

Let E be the middle point of the water-line AB, which we may call the construction water-line, F the place of the centre of gravity in point of length; let ED, the distance the midship section is before the middle of the water-line, $= k$, and EF, the distance the centre of gravity is before the middle, $= a$. We will now determine the place of the midship section in reference to the situation of the centre of gravity F.

As BCD represents the displacement of the fore-body, and CDA that of the after-body, the moments of these two parts will give the common moment.

The centre of gravity of the parabolic area is at a distance from the abscissa DC

$$= \frac{n+1}{2n+4} \times \text{the ordinate DB},$$

and for the parabolic area DCA it

$$= \frac{n+1}{2n+4}\, DA.$$

The moment of DCB from the point E

$$= \left(k + \frac{n+1}{2n+4} \cdot DB\right) \cdot DCB,$$

and the moment of DCA from the same point

$$= \left(\frac{n+1}{2n+4} \cdot DA - k\right) DCA.$$

But the areas DCB and DCA are proportional to DB and DA, and the sum of the above moments $= EF \cdot BCA$, or $a \cdot l$, l representing the area; hence

$$al = \left(k + \frac{n+1}{2n+4}\, DB\right) DB - \left(\frac{n+1}{2n+4} \cdot DA - k\right) DA$$

$$= -\frac{n+1}{2n+4}\, (DA^2 - DB^2) + k\,(DB + DA)$$

$$= (DA + DB) \cdot \left(-\frac{n+1}{2n+4} \cdot (DA - DB) + k\right);$$

but $DA - DB = 2k$, and $DA + DB = l$; hence

$$al = lk \cdot \left(1 - \frac{n+1}{n+2}\right),$$

$$a = k \cdot \frac{1}{n+2},$$

$$\text{or } k = a \cdot (n+2) \text{............(2).}$$

That is, if the midship section DC is placed at such a distance k from the middle point of the construction water-line, the centre of gravity will be in the point F assigned to it.

These two equations (1 and 2) form the principal foundation of the parabolic method of construction. In the first equation, any quantity may be known by assigning values to the others; and in the second, by fixing a value for the distance of the centre of gravity before the middle, the place of the midship section will be known. Then, having by the first equation found the exponent of the parabola, any abscissa GH or KL may be calculated. Suppose, for instance, GH to be required; then in the first assigned equation $y^n = ax$, n is known; also y and x are known for a certain point B, through which the parabola passes; the value of y for this point is DB, and of x is DC. This gives

Chapman's Parabolic System.

$$a = \frac{DB^n}{DC}$$

$$= (\text{by cutting } DB = f)\, \frac{f^n}{d} \text{....(3).}$$

Now GH is easily determined in the above equation, by assigning a value to CG; if CG or any other ordinate is expressed by y', the corresponding abscissa $GH = x''$ is determined by the equation

$$x' = \frac{y'\,n}{a} \text{......(4).}$$

This equation is sufficient for calculating the areas of all the sections for the fore-body; and for those of the after-body we have the equation (3), in which, by substituting f for DA, we get the value of the parameter a' of the parabola of the after-body; and substituting this value for a in equation (4), and giving to y' any value CK, a corresponding abscissa LK is obtained. And in the same manner as many may be found as may be thought proper. It is evident that GH and LK must be subtracted from the largest ordinate DC, to give G'H and K'L, which represent the areas of the corresponding sections.

This method of first calculating the abscissas, and then subtracting them, may appear indirect, as the true lines G'H and K'L could have been obtained at once by transforming the equation of the parabolic line to another, beginning at the point D; but it would then have lost its simplicity, and the calculations would not have been easier than by this method. One thing may, however, be done, which is to substitute the area of the midship section instead of its quotient by the breadth, by which the whole areas of the other sections will be obtained, instead of the lines which represent them.

The principles of the parabolic method being now explained, it will be easily seen how very useful its application is to the comparison of all ships, whether they were constructed with or without reference to it.

Exponent of the line of sections.

By referring to equation (1), we find that the displacement, area of midship section, and the construction water-line, being known, the exponent of a parabola that coincides most nearly with the line of sections is easily found; and we shall have (putting M for the midship section) the value of

$$n = \frac{D}{lM - D} \text{........(a).}$$

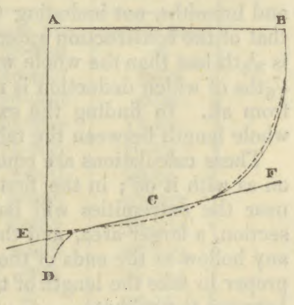
This value of n shows the degree of fulness of the ship.

The parabolic method may also be applied to show the relative fulness of the midship section, of any of the water-lines, of the displacement with respect to the water-line, and of several other elements.

Exponent of midship section.

Let ABC (fig. 23) represent a midship section, and let EF be a tangent to the curve at the point of contrary flexure C; the small area ECD not being of any importance, may be neglected. If the midship section is at all similar to those usually given to ships, a parabola may be assigned which shall pass through the points B and C, and have nearly the same area with the midship section, and also nearly coincide with the curve, so that the exponent will afford means of ascertaining its relative fulness.

Fig. 23.



Chapman's Parabolic System.

Call the breadth of the water-line AB $= \frac{1}{2}$B, the depth AE $= h$, and the area ABE $= \frac{1}{2}$M, and let m be the exponent of a parabola having the same area; then

Exponent of the midship section.

$$\frac{m}{m+1} \cdot \tfrac{1}{2}\mathrm{B} \cdot h = \tfrac{1}{2}\mathrm{M},$$

$$\text{and } m = \frac{\frac{1}{2}\mathrm{M}}{\frac{1}{2}\mathrm{B}h - \frac{1}{2}\mathrm{M}} = \frac{\mathrm{M}}{\mathrm{B}h - \mathrm{M}} \ldots\ldots\ldots(5).$$

In the same manner, the exponent may be found for the water-line, by supposing a parabola with its vertex as the greatest breadth, and passing through the points in which the water-line cuts the middle line. Suppose the exponent of this parabola $= r$, the length on the water-line $=$ L, and, as before, the breadth $=$ B; also let the area of the water-line $=$ W; then

Exponent of the water-section.

$$\frac{r}{r+1} \cdot \mathrm{L} \cdot \tfrac{1}{2}\mathrm{B} \cdot = \tfrac{1}{2}\,\mathrm{W},$$

$$\text{and } r = \frac{\mathrm{W}}{\mathrm{BL} - \mathrm{W}} \ldots\ldots\ldots(6).$$

Lastly, suppose the areas of the several water-lines, from the load water-line downwards, to decrease in the proportion of the abscissas to a parabola; and let the exponent $= s$, the depth from the water-line to the tangent of the midship section $= h$, the displacement $=$ D, and the area of the water-line $=$ W; then

Exponent of the displacement.

$$\frac{s}{s+1} \cdot \mathrm{W}h = \mathrm{D},$$

$$\text{and } s = \frac{\mathrm{D}}{h\mathrm{W} - \mathrm{D}} \ldots\ldots\ldots(7).$$

By calculating these different exponents for ships already built, and which have been found to possess good qualities, a very correct idea of their shape will be obtained, which, in making new constructions, may be referred to; and after a very short practice the constructor will be enabled to determine, not only the principal dimensions, but the outlines of the body, before a drawing is begun.

Values of these several exponents.

A collection of such calculations was begun by Chapman, and has since his time been considerably augmented. We now therefore know what the value of the exponents ought to be in the different classes of ships, for the services to which they are destined. It is always found that large ships are fuller than small ones, and in consequence have larger exponents; and that merchant-men have larger exponents than men-of-war of equal size.

The exponent of the line of sections in the Swedish navy, in ships of the line, varies from 2·5 to 2·7; of the midship section, from 5 to 3·8; of the water-line, from 6·6 to 5·9; and of the displacement, from 2·2 to 1·8; of course the larger exponent belongs to the larger class of ships.

In frigates, sloops, and brigs, they are smaller; the exponent of the line of sections varies from 2·3 to 2·1; of the midship section, from 3 to 1·9; of the water-line, from 5·2 to 3·25; and of the displacement, from 1·6 to 1·25. These exponents show that small ships have much larger dimensions in proportion to their displacements than large ones.

The above results were obtained from the displacements and breadths, not including the plank; and the length is that of the construction water-line, which, in Swedish ships, is $\frac{1}{84}$th less than the whole water-line between the rabbets, $\frac{7}{10}$ths of which deduction is made from forward, and $\frac{3}{10}$ths from aft. In finding the exponent for the water-line, its whole length between the rabbets is taken.

These calculations are equally applicable with the plank on as with it off; in the first-mentioned case, the sections near the extremities will have, relatively to the midship section, a larger area, and there will therefore be scarcely any hollow at the ends of the curves, and it will not be improper to take the length of the water-line the whole length between the rabbets.

Chapma Parabo Systen

The following tables are given as an illustration of this method, in its application to English ships.

	Length on the Water-line.	Breadth, extreme.	Depth from the Water-line to the lower edge of the Rabbet.	Displacement, including the Plank.	Area of the Load Water-section.	Area of the Midship Section.
	Feet.	Feet.	Feet.	Cub. Feet.	Sq. Feet.	Sq. Feet.
Nelson.....	203·3	53·5	23·5	165182	10027	1099
Bulwark...	180·3	49·0	19·8	105584	7706	791
Endymion	157·0	41·9	16·0	55807	5656	510

Then from the equations (a), (5), (6), and (7), the following results may be obtained:—

Applica of the s tem to E lish ship

	Value of n, the Exponent of the Line of Sections.	Value of m, the Exponent of the Midship Sections.	Value of r, the Exponent of the Water-line.	Value of s, the Exponent of the Displacement.
Nelson..........	2·836	6·9447	11·8034	2·3445
Bulwark........	2·851	4·4141	6·8273	2·2538
Endymion......	2·300	3·1795	5·1235	1·6088

From this table of exponents we may judge with certainty of the shape of the vessels. The Nelson, for instance, has a very full midship section, and an exceedingly full water-line; but she is not relatively so full towards the extremities as the Bulwark, and her displacement is not relatively much fuller than that of the Bulwark. The Bulwark has a small midship section, is full towards the extremities, and has a very large water-section in proportion to her displacement. The Endymion is a very sharp ship of her class, has a small midship section, is rather clean towards the extremities, but her water-line is not very sharp; its proportion to her displacement is very large.

The four exponents which have been described will, separately, only show the degrees of fulness in one direction; but they may be combined in such a manner as to express at the same time the longitudinal and transversal fulness; to effect which the value of the area of the midship section $= \frac{m}{m+1} \cdot \mathrm{B}h$ must be substituted in equation (1), which gives

$$\frac{n}{n+1} \cdot \frac{m}{m+1} \cdot l \cdot \mathrm{B} \cdot h = \mathrm{D} \ldots\ldots\ldots(b);$$

also, by substituting the value of W $= \frac{r}{r+1}$ BL in equation (7), we have

$$\frac{r}{r+1} \cdot \frac{s}{s+1} \cdot \mathrm{L} \cdot \mathrm{B} \cdot h = \mathrm{D} \ldots\ldots\ldots(c).$$

In these equations the products $\frac{n}{n+1} \cdot \frac{m}{m+1} \cdot \frac{r}{r+1} \cdot \frac{s}{s+1}$ show the relative fulness of the different ships in comparison to the circumscribing parallelopiped. When the construction water-line is equal to the whole water-line, as was supposed in calculating the foregoing table,

$$\frac{n}{n+1} \cdot \frac{m}{m+1} = \frac{r}{r+1} \cdot \frac{s}{s+1}$$

By this equation any error in determining the exponents may be detected; and also by using the whole equations (b) and (c), errors in the dimensions or exponents will be detected.

Methods interpola tion for finding other ele ments.

By a method of interpolation, formulæ of very easy application have been deduced; by which the depth of the centre of gravity of the displacement below the water-section, the height of the metacentre, and several other essential elements, may be approximated to without the usually long calculations; and thus most of the qualities of a ship which are determinable by calculation may be ascertained, Ch an's Pa olic S em.

compared, and altered, with very little trouble, before the construction is begun.

Ap ation of me- tho pra e.

In order to apply this method of construction to practice, nothing more is requisite than to know the limits between which the exponents generally are for the class of ships in question, the proportion between the principal dimensions, and the distance the centre of gravity should be before the middle of the load water-line. In Swedish ships of the line and frigates, the distance of the centre of gravity of the displacement before the middle of the load water-line is between $\frac{1}{70}$th and $\frac{1}{80}$th of the length, and in smaller vessels it is a little more, depending on the manner in which their stores and rigging are distributed. This distance being determined, the weight the ship is to carry, the weight of the hull, and the relative proportions of the different dimensions, or the value of the exponents, the calculations will give the areas of every section, leaving the constructor the power of giving them whatever form he may wish.

Ex ple of its lica- tio

Captain Carlsund was employed in this country in building steam-boats for the Swedish post-office service. He has given the calculations of one of these boats, which were all constructed on Chapman's parabolic system, as an example of its practical application.

Suppose the ratio of the breadth to the length to be α, and that of the breadth to the depth to be β; by substituting them in the equation (b), it will become

$$\frac{n}{n+1}\cdot\frac{m}{m+1}\cdot\alpha\cdot\beta\cdot B^3 = D.$$

The values of m and n are known, being assumed from former experience; the displacement is determined by the weight of the engines, added to the weight of the stores, &c. and an approximation to the weight of the hull. By assigning values to α and β, the value of B is obtained, and from that the values of the length and depth. The dimensions being now known, the scantling may be determined, and the true weight of the hull estimated; which, if very different from the approximation which was used, will cause a corresponding alteration in the dimensions, &c. With a steam-boat the stability is of minor importance, therefore it is not necessary to refer to equation (c).

The vessel in question was intended for two twenty-five horse-power engines, the weight of which, with the necessary stores, and the other articles, was estimated to be about 2050 cubic feet of water, and the approximation which was at first made to the hull was 1850 cubic feet, which supposed the whole displacement to be 3900 feet.

The vessel was intended to be sharp both at the midship section and at the extremities; hence n was taken $= 2·12$, and $m = 3·0$; the proportion between the length and the breadth, or α, was taken $= 5·25$; and that between the breadth and the depth, or β, $= 0·32$. By substituting this value in the equation, we have

Chapman's Parabolic System.

$$B = \sqrt[3]{\frac{3900\times 3·12\times 4}{2·12\times 3\times 5·25\times 0·32}} = 16·58.$$

$$\text{Length} = 5·25\,B = 87·04,$$
$$\text{Breadth} = 0·32\,B = 5·31.$$

By calculating the weight of the hull according to these dimensions, it was found that the approximation was too small by 175 cubic feet. By adding this quantity to the displacement, and retaining the other values, it will be found, from the above equation, that the

$$\text{Breadth} = 16·822,$$
$$\text{Length} = 5·25\times 16·882 = 88·315,$$
$$\text{Depth} = 0·32\times 16·882 = 5·383.$$

The weight of the engine, its situation, and that of its centre of gravity, must determine the place of the centre of gravity of the vessel, which was found to be about 2·25 feet before the middle of the length on the construction water-line; and consequently, from equation (2), the situation of the midship section was determined to be 9·27 feet before the middle of the construction water-line.

The stations of the other sections were determined by the room and space. The parameters for the fore and after bodies were first determined by substitution in the equation (3). In the fore-body

$$f = \frac{l}{2} - k = \frac{88·315}{2} - 9·27 = 34·887,$$

and in the after-body

$$f = \frac{l}{2} + k = 53·427.$$

The area of the midship section, from equation (5),

$$= \frac{m}{m+1}\,Bh = \tfrac{3}{4}\times 16·822\times 5·383,$$
$$= 67·912 \text{ square feet},$$

and the half area $= 33·956$.

Hence, by equation (3), the parameter of the fore-body

$$= \frac{\overline{34·887}|^{2·12}}{33·956} = 54·895;$$

and for the after-body,

$$a' = \frac{\overline{53·427}|^{2·12}}{33·956} = 135·499.$$

The calculations for the sections are contained in the following table.

For the Fore-body, $x\,\frac{y^{2·12}}{54·895}$.			
Sections.		Abscissa, or x.	Half the Midship Section, $-\,x$.
Name.	Distance from the Midship Sect. or y.		
	Feet.	Square Feet.	Square Feet.
End	34·89	33·960	·0
x	32·24	28·730	5·23
u	30·	24·660	9·30
q	24·	15·360	18·60
m	18·	8·349	25·611
h	12·	3·535	30·425
d	6·	·813	33·147
Midship section.	0·	·0	33·96

For the After-body, $x = \frac{y^{2·12}}{135·499}$.			
Sections.		Abscissa, or x.	Half the Midship Section, $-\,x$.
Name.	Distance from the Midship Sect. or y.		
	Feet.	Square Feet.	Square Feet.
End	53·43	33·960	·0
34	50·76	30·460	3·50
32	48·	27·060	6·90
28	42·	20·390	13·57
24	36·	14·700	19·26
20	30·	9·990	23·95
16	24·	6·225	27·735
12	18·	3·382	30·578
8	12·	1·432	32·528
4	6·	·329	33·631
Midship section.	0·	·0	33·96

The areas of the sections being thus determined, the construction of the draught was begun. The midship section, and one or two sections in each body, being drawn in, and their areas ascertained to agree with the tables, one or two diagonals were got in, and the rest of the sections drawn, always keeping their areas precisely equal to those given by the table. The direction of the diagonals at the extremities determined the places of the rabbets of the stem and stern-post, and from these the length of the whole load water-line was found to be 0·44 feet longer than that of the construction water-line; that is, 0·33 at the fore-end, and 0·11 at the after-end; consequently the length of the load water-line between the rabbets was equal to 88·755 feet.

As, in a ship constructed according to this method, the situation of the centre of gravity with respect to the length, and also the displacement, are known correctly, during the progress of the work much tedious arithmetical calculation is avoided; and, after a very little practice, it will be found that the forms of the different sections may with great ease be drawn to contain the requisite areas; consequently, by the general adoption of the method, an amazing saving of time and trouble would be effected.

There can be no doubt that this parabolic system offers great advantages, especially to the student of naval architecture, in the great facility with which it may be applied to institute comparisons between ships by means of the exponents. The mere repetition of the digits which number the displacement of a ship, or the area of either of her sections, will convey no idea of the form either of the body or of the section. Again, the ratio of the displacement, or of the area of the section, to that of the circumscribing parallelopiped or rectangle, will convey a scarcely more definite idea of shape; whereas the exponent of the displacement or of the section, presenting itself to us not only as an arithmetical measure of quantity, but referring us at the same time to a geometrical line, the mind becomes immediately almost as conscious of the peculiarities of the form of the body or of the section as if a drawing of either were present before the eye. A very slight attention to the comparisons which have been drawn between the Nelson, Bulwark, and Endymion, by means of their exponents, will convince the reader of the advantage which the system possesses in this respect, and of the value in which an extensive digest of ships of various forms and qualities, calculated on this principle, would be held by naval architects. At the same time, it is quite evident that even the inventor, Chapman, would not have recommended the parabolic system as a total substitute for the more rigorous applications of science, but only as accessory to them. Also, the parabola affords facilities for variations in form, which may be almost said to leave the architect at perfect liberty in his design.

General Observations on the Physiology of Timber.

As we cannot, in the space allotted to this article, enter into a particular examination of the nature and qualities of the different varieties of timber used in building a ship, we must confine ourselves to such observations on the physiology of timber in general, as may be of practical application.

Durability of the royal navy.

Of the mercantile navy.

Timber, when forming a component part of the structure of a ship, is subjected to many deteriorating influences that have no analogies in other combinations of wood-work. Although particular instances may be quoted of ships which have resisted decay for long periods, the average durability of the royal navy is reported not to exceed fifteen years. This we consider now an unfavourable statement; but, in the wear, tear, and neglect incidental to the constant services of war, even this average must be considerably lowered. The duration of the mercantile navy is stated at a higher average; but it must be remembered that the merchant-ship is not necessarily maintained in such perfect repair as the ship of war; and also, that the system of insurance enables both merchant and shipowner to freight and to sail ships, of which Lloyd's books record a most fearful and a most astounding tale; a tale which proves, that the longer average durability of the mercantile navy is in part purchased at a most sinful expenditure of human life; an expenditure which no amount of insurance can compensate.

Occasi instan durabi

The occasional instances of lengthened durability in some ships of the royal navy tend to prove, that it may be possible much to increase the average, by insuring a combination of the same causes which, perhaps accidentally in these cases, produced this effect. That this is a most important consideration is evident; for if we knew how to insure to our ships the durability recorded of the Montague, we should diminish the expense of our navy by one half; while if we could insure to them that recorded of the Royal William, we should diminish the expense to one sixth!

Classi tion o cay o ber.

The deterioration and decay of ships may be advantageously considered under several distinct heads. One may include the decay to which timber is subject, in common with all organized matter, and which may be either hastened or retarded, according as destructive or preservative influences prevail; another may include the variety of decay to which the name of "dry rot" has been applied; and another may include that decay which appears to be not only prematurely, but unnaturally induced, dependent on the injudicious combination of destructive agents with the inorganical compounds of the timber.

Decay be acc rated retard

Deter ing in ences

Prese tive i ences

That large masses of timber in combination should be more subject to the deteriorating influences which tend to accelerate decay, is what we may be led to expect from analogy. All organization of which we have any knowledge, becomes eventually decomposed by the chemical action which takes place in its constituents. During the life and health of a plant, the various components acting under the influence of their common vitality, perform their several functions in accordance to the end of their original combination; but with the cessation of life that influence ceases, and the constituents of the organized structure assert their individual existence, and resume their original affinities. Some separate, some form new compounds, and others which the vital principle had retained in harmless combination now act energetically and destructively on each other; while the original mass, under the influence of these several causes, gradually deteriorates, and is eventually decomposed. This result may be accelerated or retarded by the presence or absence of those circumstances which are favourable or unfavourable to it. Temperature, moisture, the vicinity or remoteness of agents either destructive or preservative, all have great influence in promoting or retarding decomposition, principally in as far as they promote or retard the fermentative process, which appears to be the preliminary step towards the rapid decomposition of vegetable matter. A certain degree of moisture is necessary to induce this fermentation; but when the other circumstances that are favourable to the process exist, this moisture is always to be found even in the best-seasoned timber, in which, on the authority of Count Rumford, there still remains one fourth of its weight of water. This will be readily understood when it is remembered, that a very large portion of moisture is always contained in the atmosphere, to the influence of which the timber has been exposed. While moisture to a certain extent appears essential, a continued immersion, or perfect saturation, is inimical to this vegetable fermentation. Again, a moderate temperature, not so low as to induce congelation, nor so high as to cause evaporation of the moisture, appears to be favourable to it. The unavoidable dampness of the atmosphere in ships, and the difficulty of maintaining a free circulation of air, contribute much to the process of fermentation, and consequently to the destruction of the original structure of the fermenting mass, by the distribution of its several constituents, and its consequent decomposition.

The difficulty of maintaining a circulation of pure air in those portions of the vessel below the surface of the water might be removed by adapting the openings between the timbers of the frame to this purpose. Pure air might by their means be easily supplied to the lower part of the "between decks," or even to the hold, through pipes; and the foul, heated, and therefore rarefied air, would rush from the upper part of the between decks, or of the hold, through a second series of pipes. The writer of this article proposed a plan for effecting this to the Admiralty, on his return from a cruise in the experimental squadron of 1827. The same principle is adopted now, very generally, to ventilate manufactories and other large and closely-peopled buildings.

Oxy n.

Its ect.

Dec com nces wit he felli of the ber.

The most active agent in the work of the decomposition of timber is the oxygen which it contains, whether this decomposition be rapidly induced by fermentation, or is more slowly and gradually taking place under the influence of the law which renders decay the necessary consequence of organization. The oxygen, which, during the vitality of the plant, was held in harmless combination, is set free, and immediately begins to act upon the woody fibre of the felled timber, and induces a slow combustion, the effect of which is the evolution of carbonic acid gas, and the carbonization of the wood, by which the tenacity and adhesiveness of its several parts are gradually destroyed. Timber, therefore, begins to deteriorate and to decay from the moment of its being felled; and indeed a gradual diminution of its strength may be observed during the process of its seasoning, which only ends with its total decomposition. The hastening the seasoning process is, however, advantageous, by depriving the timber of the superabundant moisture, and of the juices, which might otherwise induce an unduly rapid decomposition.

Dry t.

Dist - tive rac- teris .

Deri ion of th term Fung

The decay of timber has been frequently classed under two heads, natural decay, and decay from dry rot. Probably there is not such a marked distinction between these two decomposing principles as might be imagined. Very frequently the decomposition of timber is attended with the apparently spontaneous vegetation of parasitical fungi; and, according to common acceptation, that species of decay which is accompanied by the vegetation of these fungi has received the appellation of dry rot. The term was applied to it in consequence, probably, of the peculiarity attending it, that the decomposed wood had become a dry friable mass without fibrous tenacity. Whether the seeds of these plants are lying dormant in the juices of the timber while in a state of life and health, and the vegetative principle in them becomes active only when decomposition has furnished them a nidus, or whether they are floating in the atmosphere, and vegetate whenever favourably placed, is a point not yet established.

Gene cause f this ay.

However this may be, as in general this peculiar decay may be traced to imperfectly seasoned materials, we consider it may fairly be supposed that the seeds of the fungi are contained in a fit state for vegetation in the juices of such timber; and although it sometimes occurs and spreads among seasoned timber, it appears previously necessary that damp should have renewed and revived the vegetating principle in the seeds, and fermentation and decomposition have provided them a nidus. They then flourish and acquire strength on the sustenance which they draw from the decomposed wood; and in the same manner, and with a similar deteriorating effect as the parasitical plants which sometimes vegetate on the living tree, these destroy the dead timber, by abstracting all but the earthy particles, which are left without fibrous texture.

Preve tives.

Dryness, cleanliness, a free circulation of air, or the entire exclusion of it, appear to be the best preservatives against, or checks to, vegetable decomposition; while damp accumulations, and a vitiated atmosphere, rapidly induce it.

Tende of dec ncreas to

If the foregoing statement of the principles on which the decomposition of timber depends be correct, it is evident that its tendency is progressive, and that the decay must rapidly spread, from the accumulation of the deteriorating influences. It is also evident that the only means to check undue decay is by a removal of the inciting causes; and that the only means to prevent it, is to guard against those circumstances which are most liable to induce it, and to avoid the use of those materials in which it is most easily induced.

Precautionary measures.

Unseasoned timber should never be used, and even the most seasoned timber should only be used when in a dry state. When kilning plank was first adopted, now upwards of a century ago, the planks, after being set to the form of the body, were taken off to dry; this, however, was unnecessary, kilned plank drying almost at the mouth of the kiln. All decayed and all diseased portions of the wood should be carefully removed, and also the whole of the sap or imperfect wood, which, from being more soft and spongy in texture than the spine, absorbs moisture more easily, and, being also more filled with the vegetating principle and the vegetable juices, is more liable to fermentation, and consequently to decomposition, and to the growth of the fungi.

Influence of extraneous substances.

Iron fastenings.

Cause of their destructive effect.

We shall now consider the premature decay of timber induced by the substances which are used in connection with it. Of these the iron for fastenings has by far the most injurious influence. This is probably owing to the great affinity which exists between that metal and oxygen, so that each fastening becomes an absorbent of oxygen, either from the atmosphere or from the wood which surrounds it, and which is again supplied from the atmosphere. The surface that is first subjected to this change is converted into the brown oxyde of iron, which may be termed a supersaturated oxyde, and parts with its superabundance of oxygen to the lamina of pure iron immediately beneath it, while the surface absorbs a fresh store of oxygen from the wood; and thus the process of oxidation goes on through successive laminæ of the iron, until the whole of its metallic nature is changed, and its utility as a fastening is destroyed, while it becomes a reservoir of oxygen, which acts evidently on the woody fibre around it, and, by carbonizing it, rapidly and effectually destroys its tenacity.

Constituents of oak timber.

Of teak.

Effect of iron on teak less injurious. It therefore may be used in teak.

Action of copper on oak.

In this view of the action of iron in accelerating the decomposition of timber, we may trace the reason why its effect varies so much in different woods. Mackonochie, in his admirable Prospectus, says that oak is found to contain a much smaller proportion of oily or resinous particles than many other kinds of wood; and that, besides the lignic acid which it has in common with them, it contains an acid peculiar to itself, called the gallic acid, and that, therefore, the quantity of oxygen in oak is very considerable; that, on the contrary, in teak it is much less, while in this wood the resinous particles are so abundant as to have procured the teak-tree a place amongst the terebinthinous plants. He argues, that the iron, which cannot easily be protected before being applied as a fastening, acquires a protecting covering from the oily or resinous juices of the wood, pressed from the abraded vessels in the action of driving. This coating, which cuts off its influence on the oxygen, will be more or less perfect, in proportion to the quantities of the protecting substances contained in the wood. He states, on the authority of the experience of the shipping built in India, and used in the India trade, that the average duration of an iron-fastened teak ship is thirty years; and consequently he argues that it is a misapplication of expense to use copper fastening with teak, as the additional advantage gained is not at all commensurate with the additional expense. But with oak the circumstances are different; the action of oak on copper is not near so destructive of its metallic structure as it is on iron; and, on the other hand, the re-action of the metal on the wood is not so destructive of its ligneous fibre. The oxyde of copper, which forms almost immediately on its coming in connection with the wood, is not a supersaturated oxyde, but the portion of oxygen it has absorbed is held in strong combination; and, consequently, instead of the process of oxidation continuing from lamina to lamina, as has been described to be the case in iron, the surface oxidation becomes a natural protection of the copper from the action of the wood, and of the wood from the action of the copper, equivalent to the resinous or oily coating which supervenes in the case of iron driven into teak.

Various means of preserving timber. Mackonochie.

With this view of the process of decomposition in timber, we have an insight into the *rationale* of the various means proposed for its preservation. Several writers on timber have more or less urged the foregoing principle. Mackonochie, in his Prospectus, has adopted this theory; and though his reasoning on the causes of decomposition is not given with his usual perspicuity, his deductions as to the means of prevention are perfectly free from this objection. He recommends, that whatever iron is used for fastening, a protecting coat of paint or some other substance should be interposed between the iron and the wood, to cut off, as far as possible, the connection between the metal and the woody fibre.

Use of paint.

Seasoning timber in the light.

He also recommends that, in seasoning timber, care should be taken to expose it to the light, which will have great influence in making it give out its oxygen. But as it must re-absorb oxygen in the night, and will at least be supplied with it from the atmosphere, the only effectual means is at once to expel it, and fill up its space with some other substance; for which purpose, he says, " oil presents itself as the fittest, its use in defending timber from the action of the weather having been long acknowledged and practised." He recommends the following process as an easy means of impregnating the timber with this or any other similar substance. The wood is to be placed in a steam-tight chamber, and subjected to the action of steam, by which the air and gases will be expelled both from the chamber and the timber. Then, by condensing the steam, and repeating the process until the whole of the elastic fluids are withdrawn from the wood, and the non-elastic converted into vapour, the wood becomes freed from them, and if plunged into oil, and subjected to the atmospheric pressure, the whole interior of the wood will be filled with the oil. Mackonochie asserts that he then has (6th August 1803) in daily use a steam-chamber on the above principle, capable of containing from twenty to thirty planks forty feet long, or a proportionate quantity of timber, in which, while the planks are steaming to render them flexible, they are impregnated with teak oil. He says the oil may easily be procured from the chips and saw-dust used for the fuel of the steam-boilers; for it has been ascertained that Malabar teak contains such a quantity of oleaginous or terebinthinous matter, that the chips from the timber and plank of a ship built of it will yield, by a proper process, a sufficient quantity of tar for all its own purposes, including the rigging; and that although oak-timber does not contain so much of these substances, the chips of the fir consumed in the royal navy would be more than sufficient to supply tar to saturate the oak.

Saturation with oil.

Means of effecting this.

Oil may be procured from refuse timber.

By M. Pallas, to mineralize it.

Mr Bill, to saturate it with asphaltum.

There have been numerous proposals to impregnate timber, in a greater or less degree, with foreign substances. In 1779 a proposal was made by a M. Pallas to mineralize timber by steeping it to saturation in a solution of green vitriol, and then precipitating the green vitriol by means of lime-water. A gentleman of the name of Bill, about the year 1822, produced some samples of timber of large scantling, impregnated throughout their substance, apparently, with asphaltum. The samples thus prepared were subjected to a trial of five years' duration in the dry-rot pit at Woolwich; and we have it on the authority of Mr Knowles, the able secretary to the late committee of surveyors of the navy, that they perfectly withstood the " fungus rot," while numerous unprepared specimens were destroyed in one fifth of the above time. Sir John Barrow, whose long experience and acknowledged talent render his opinions on all naval matters extremely valuable, recommends the kreosote from the distillation of tar, which, in the shape of a gas, will, he says, penetrate every part of the largest logs, " and render the wood almost as hard as iron, so hard as not easily to be worked." Another plan, that proposed by Mr Kyan, is to soak timber in a solution of corrosive sublimate. This, on the principle advocated in this article, would be effective in all cases where the saturation was complete and permanent. Where the application is only of the nature of a surface application, there does not appear to be any reason why the corrosive sublimate should preserve the interior of the timber, or have more effect on that part than any other surface applications, excepting that it would more certainly destroy any vegetative principle which might exist in that portion near the surface to which it could penetrate.

Mr Ky with co sive sub mate.

Mr K process

The rationale of Mr Kyan's process may be best understood by the following quotation from a lecture by Dr Birkbeck. " Aware of the established affinity of corrosive sublimate for this material (albumen), he applied that substance to solutions of vegetable matter, both acetous and saccharine, on which he was then operating, and in which albumen was a constituent, with a view to preserve them in a quiescent and incorruptible state; and obtaining a confirmation of his opinions by the fact, that during a period of three years, the acetous solution openly exposed to atmospheric air had not become putrid, nor had the saccharine decoction yielded to the vinous or acetous stages of fermentation, but were in a high state of preservation, he concluded that corrosive sublimate, by combination with albumen, was a protection against the natural changes of vegetable matter....He conceived, therefore, if albumen made a part of wood, the latter would be protected by converting that albumen into a compound of protochloride of mercury and albumen; and he proceeded to immerse pieces of wood in this solution, and obtained the same result as that which he had ascertained with regard to the vegetable decoctions." The writer of this article has seen most conclusive experiments as to the beneficial effect of " Kyanization," especially on the softer woods.

Numb less no trums been pr posed.

Innumerable nostrums have been recommended as surface applications for preventing the decay of timber. Knowles, in his work on the Preservation of the Navy, gives a list of twenty-nine, besides many others the components of which were kept secret by their projectors. There does not appear to be sufficient evidence to prove the decided advantage of any of these applications; on the contrary, unless the timber to which they are applied should be thoroughly seasoned, all coatings on it which prevent the progress of the seasoning process, and confine the vegetable juices, have been proved to be injurious. If timber be already well seasoned, the principal preventives to decay appear to be ventilation and the exclusion of damp; and with unseasoned timber the same means will accelerate the process of seasoning. Those means of preventing decay by saturation with some chemical agent, and thus altering the nature of the timber by a chemical action on its constituents, appear to be the most likely to produce decided results. The physician-general of the navy, Sir William Burnett, finding that the precipitate caused by the kyanization was soluble in salt water, has lately substituted for that process saturation with the chloride of zinc; the precipitate which this forms with the albumen being unaffected by the action of the salt water. The beneficial effect of this chloride is very decided, in those specimens which the writer has had an opportunity of examining.

Sir W Burne

Time felling ber.

There has been much controversy as to the proper season for felling timber, into which we cannot devote space to enter. The argument appears to be in favour of the greater durability of winter-felled timber. In fact, the controversy appears more to have arisen from a desire to prove that spring-felled timber was not unequal to winter-felled, than for the purpose of eliciting truth; the bark being more easily detached and more valuable from off a spring-felled than from off a winter-felled tree.

Laying Off.

General observations and definitions.—Laying off is delineating the form of a ship according to its actual dimensions, in order to supply the workmen with the exact shape and proper positions of the principal pieces of timber which compose the structure. If the floor be sufficiently spacious, the ship may be laid off in one length; if otherwise, the operation must be performed in two or more lengths, according to circumstances.

The principal plans of a ship are the sheer, body, and half-breadth plans.

1*st*, The sheer plan is a projection on a vertical longitudinal plane, dividing a ship into two equal parts. Plate CCCCL. fig. 24.

2*d*, The body plan is a projection, on an athwartship plane, of transverse vertical sections of the ship, which sections are square to the keel. Fig. 25.

3*d*, The half-breadth plan is a projection, on a horizontal plane, of various sections of the ship. Fig. 26.

The principal lines employed, as well in the construction of a draught, as in laying off a ship, are water-lines, level lines, diagonal lines, and buttock and bow lines.

1*st*, Water-lines, in the sheer plan, are straight lines drawn parallel to the surface of the water. In the half-breadth plan, the water-lines show the boundaries of the sections of the ship, at the corresponding heights in the sheer and body plans. Figs. 24, 25, 26.

2*d*, Level lines are similar to water-lines, except that they are drawn parallel to the keel instead of to the water. To avoid confusion, the level lines are omitted in the sheer draught, but they are drawn in Plates CCCCLI. and CCCCLII.

3*d*, Diagonal lines show the boundaries of various sections formed by planes which are oblique to the vertical longitudinal plane, and which intersect that plane in straight lines parallel to the keel. Plate CCCCL. figs. 25 and 26.

4*th*, Buttock and bow lines are the boundaries of vertical sections of the ship, parallel to the vertical longitudinal plane. See B. L., figs. 24, 25, 26.

The main-breadth line is the boundary of the widest part of the ship in each of the three plans. Plate CCCCL.

The top-breadth or top-timber line, in the sheer plan, is a line drawn to the sheer of the ship, fore and aft, at the height of the under side of the gunwale amidships; and the top-side line is a sheer line drawn above the top-timber line, at the extreme height of the side of the ship. Plate CCCCL.

The cutting-down line is a curve in the sheer plan which corresponds to the upper surface of the throats of the floors amidships, and to the under side of the keelson. Plate CCCCL.

Fore and after bodies. These combined constitute the whole of the ship. They are supposed to be separated by an imaginary athwartship section, at the widest part of the ship, called the midship section, or dead-flat.

Midship body, as sometimes used, applies to an indefinite length of the middle part of the length of a ship, including a portion of the fore and after bodies.

Square and cant bodies may be considered as subdivisions of the fore and after bodies. There is a square fore-body, a square after-body, a cant fore-body, and a cant after-body. In the square body the sides of the timbers are athwartship vertical planes, whereas in the cant body the sides of the timbers, although vertical, are not athwartship planes.

Laying Off.

Moulding and siding.

Moulding and Siding. These terms are nearly synonymous with thickness and breadth; observing that the moulding of a piece is the dimension of the side on which the mould is applied for determining its shape or curvature. For instance, the moulding of a beam is its depth or thickness; its siding is its fore and aft dimension, or breadth.

Room and space.

Room and space is a certain distance determined by the siding of two adjacent timbers, together with the openings between them; or it is the distance apart of the joints of the frame, as from A to B in the disposition of the timbers, or one half the distance apart of the stations B, D, F, &c. in the sheer plan. Plate CCCCL. fig. 24.

Shift.

Shift. This, in its general sense, refers to a certain arrangement among the component parts of a ship. Thus we speak of a shift of plank, a shift of dead-wood, meaning thereby the disposition of the buts of the timber or plank, both with respect to strength and economy. In a more limited sense, "shift" means the distance apart of two neighbouring buts or scarphs.

Bevellings.

The bevelling of a timber is the angle contained between two of its adjacent sides. Bevellings are either acute angles, right angles, or obtuse angles. These three separate cases are denominated under bevellings, square, and standing bevellings.

Sirmarks.

Sirmarks are certain stations marked on the moulds of the timbers at which the bevellings are applied. These sirmarks are denoted in the body plan by the various diagonals.

Description of the draught, consisting of the sheer, body, and half-breadth plans.—The principal dimensions of a ship are length, breadth, and depth. Connected with and dependent on these three dimensions, are three plans, named the sheer, half-breadth, and body plans. These combined constitute what is termed the draught of a ship. We purpose to describe them separately. Plate CCCCL.

Sheer plan.

1*st*, The sheer plan or elevation (fig. 24) is the representation of an imaginary longitudinal section, dividing the ship into two equal parts, by a vertical plane passing through the middle of the keel, stem, and stern-post. This section is bounded by the fore part of the knee of the head, under side of the keel or false keel, aft side of the rudder, rake of the stern, and the sheer of the upper part of the top-side.

Perpendiculars.

Besides this plan being a section of the ship amidships, showing the sheer of the decks, cutting-down line, stations of the masts, &c., on it are also projected, in lines perpendicular to the aforesaid longitudinal section, the ports, cat-head, head-rails, side counter-timber, quarter-gallery, main-breadth line, channels, dead-eyes, &c. From all this we see that the chief use of the sheer plan is to obtain heights and lengths; heights measured from the upper edge of the rabbet of the keel, and lengths measured from the after or the fore perpendicular. These perpendiculars, which define the length of the ship, are drawn in most ships of war at the ends of the lower or gun deck; the foremost perpendicular at the aft side of the rabbet of the stem, the aftermost at the foreside of the rabbet of the stern-post.

Profile.

Occasionally the interior fittings and accommodations are shown on the sheer plan, as the beams, magazines, store-rooms, well, pumps, capstans, cabins, and other minutiæ; but as these produce confusion by multiplying lines, it is usual to represent the interior economy of the ship on a separate plan, called the "profile," or plan of the inboard works.

Half-breadth plan.

2*d*, The half-breadth plan (fig. 26) principally shows the form of the ship, 1*st*, when cut by water-lines; 2*d*, by level lines; and, 3*d*, by diagonal lines. As before observed, the planes of these diagonal sections intersect the longitudinal plane of the ship, in straight lines parallel to the keel. Besides the above, the form of the decks, main-breadth and top-breadth lines, may be also delineated on the half-breadth plan; together with the projection of the planes of the fore and after cant timbers, which will be more particularly explained in the sequel.

Body plan.

3*d*, The body plan (fig. 25) is simply a representation of vertical transverse sections, before, at, and abaft the widest transverse section, which is termed "dead flat," and usually denoted by the symbol ⊕.

The sections in the body plan in the fore-body are distinguished by letters, A, B, C, &c., those in the after-body by figures, 1, 2, 3, &c., corresponding with the same letters and figures in the sheer and half-breadth plans. It must be understood, that the sections in the body on the right of the middle line represent the starboard fore-body, whilst those on the left of the middle line represent the larboard after-body, of the ship.

It is thus seen, that from the aforesaid three plans we may derive correct ideas of the form of a ship, which form is obtained

From the sheer plan,	by vertical fore and aft sections parallel to the vertical longitudinal plane, as seen by the buttock and bow lines;
From the body plan,	by athwartship vertical sections, square to the keel, and at right angles to the vertical longitudinal plane;
From the half-breadth plan,	1*st*, by water-lines, or by planes parallel to the water; 2*d*, by level lines, or by planes parallel to the keel; 3*d*, by diagonal lines, or by planes inclined at any angle to the horizon.

The reader will also perceive from the preceding remarks, that

The sheer plan	is a projection	on a vertical longitudinal plane;
The body plan		on a vertical athwartship plane;
The half-breadth plan		on a horizontal plane.

As before remarked, the three above-described plans constitute the draught of a ship. We shall presently see their mutual dependence on each other, so that any two being given, the third may be obtained.

Profile. **Disposition.** **Midship section.** **Scheme of scantlings.**

Besides the sheer draught, it is customary to furnish the architect with a profile of the inboard works before explained; the "disposition," or the appearance of the timbers which constitute the frame, showing the heads and heels, and general arrangement of the futtocks; the midship section, on which is described the moulding, or athwartship size of the timbers, the thickness of the exterior and interior planking, the connection of the beams to the side, the dimensions of the water-ways, shelf-pieces, the description and fastening of the knees, &c. These, together with a scheme of scantlings, which is a document containing the dimensions, and other particulars, of the principal pieces which enter into the construction of the fabric, constitute all the preparatory information required by the builder.

After these general observations, we shall now enter more in detail into the description of the draught of a ship; but as laying off and practical building are so intimately connected, that a perfect knowledge of the one cannot be attained without some acquaintance with the other, it becomes previously necessary to describe, in general terms, the method in which the timbers of a ship are combined and disposed, both in the square and cant bodies.

This constitutes another division of our subject.

Frame of a ship.

The timbers of a ship are combined together in assemblages which are technically called "frames;" these are put together in a certain predetermined order, depending on a variety of circumstances, as the size and form of the ship to be built, the nature and dimensions of the timber to be used, the skill and judgment of the architect employed. We will suppose each frame to consist of a floor crossing the dead-wood, a first futtock stepping against the dead-wood, a second futtock on the head of the floor, a third futtock on the head of the first futtock, a fourth futtock on the head of the second futtock, and, lastly, a top-timber on the head of the third futtock. The above arrangement accords with the old system of building.

Old system. **Short-ti ber fra**

An economical modification of the plan was introduced of late years, by diminishing the length, and therefore by increasing the number, of the timbers. Thus the long floors are abolished, and their place is substituted by shorter floors, called cross timbers. To the sides of these cross timbers, giving scarph to and projecting beyond them, are bolted and dowelled pieces, called half floors. The first futtock will then but on the head of the cross timber, the second futtock on the head of the half floor, the third futtock on the head of the first, the fourth on the head of the second, the fifth on the head of the third, the sixth on the head of the fourth, and the top-timber on the head of the fifth. Occasionally lengthening pieces are added to the upper timbers, when required by the conversion. See figs. 34, 35, 36.

Figure 49, Plate CCCCLVII., represents a disposition with the buts of the frame arranged like those of a shift of plank, there being three timbers between every two buts, while in the usual disposition there is only one timber between every two buts.

Joints. **Single timber.**

By reference to the disposition of the frame, Plate CCCCLIV., it is seen that the timbers are not in contact sideways, but are kept apart a certain distance; although, for the sake of simplicity in laying off, we suppose them to touch each other from the keel to the top-side. This imaginary junction of the futtocks of a frame is called the joint. The joints of the frames are, with one exception, equidistant. This exception is seen in fig. 24, Plate CCCCL., in which the distance between the joints 3 and (2) is greater than between the other joints. This variation is for the purpose of introducing an additional timber, called the "single timber," so that there will be five timbers in the space 3 (2), whereas there are only four timbers between the other joints. Hence the opening in question is called the five-fourth opening; and one frame, instead of consisting, like all the others, of two adjacent timbers, will consist of an assemblage of three timbers. The reason of the introduction of the single timber is, because the position of the various futtocks is reversed in the fore and after bodies, *i. e.* those which in the fore-body are on the fore side of the joint, are placed in the after-body on the aft side of the joint. Hence, were it not for the single timber breaking the shift of the heads and heels, we should have a series of two buts together, as two first-futtock heads, and so on. The timbers being square to the keel, the joints will obviously be represented in the sheer and half-breadth plans by straight lines square to the keel.

Square body. **Cant bo**

As before explained, these joints and their corresponding frames are distinguished in the fore-body by letters, as A, B, C, D, &c. and in the after-body by figures, as 1, 2, 3, 4, &c. Thus it is seen that the sides of the timbers already described are athwartship vertical planes. This arrangement, however, is departed from at the two extremities of the ship; for if the sides of the frames were athwartship, timber of much larger scantling would be required, which would be more costly, more liable to decay from converting older trees, and would be still farther objectionable, from the fastenings, which ought to be square to the curve, cutting the timbers more obliquely. To obviate these inconveniences, the timbers, in technical language, are "canted."

Square cant bod

It has been before explained, that the sides of square timbers are vertical planes; so also are those of cant timbers. Again, the intersection of the plane of the square timber with the vertical longitudinal plane of the ship, is a vertical straight line: the same remark is applicable to the cant-timber. Further, the plane of the square timber is at right angles to this longitudinal plane, whereas that of the cant timber is oblique to this plane. The subject of square and cant timbers has been explained by the following familiar illustration. Imagine the before-named vertical athwartship plane to be fixed at its intersection with the vertical longitudinal plane, but still allowed to revolve on the vertical line of intersection as an axis. It may be considered as a door on its hinges. When the door is wide open, in other words, when the plane stands athwartships, it represents a square timber; when the door is partially closed, or allowed to revolve on its hinges, it represents a cant timber. This imaginary revolution, of course, takes place forward in the fore-body and aft in the after-body. Thus, in the half-breadth plan, Plate CCCCL., AB, drawn perpendicular to the middle line of the ship, represents the joint of a square frame; but if it is made to revolve forward round the point A, till it comes into the position A*b*, it then represents the joint of a cant frame.

The draught of a ship.

We have now to explain the manner of drawing the various lines and sections of a ship, and of transferring them from one plan to another. For this purpose it will be convenient to imagine the draught complete, and in a general way to retrace the steps by which the completion was effected, by explaining the adaptation and correspondence of the three plans with each other. Below the upper edge of the rabbet of the keel are drawn the depth of the rabbet and the under sides of the main and false keels. At a distance apart, equal to the length of the ship, are drawn the foremost and aftermost perpendiculars, at right angles to the keel, and respectively intersecting the aft part of the rabbet of the stem, and the fore part of the rabbet of the stern-post, at the height of the lower deck. The stem and stern-post, together with their respective rabbets, are likewise delineated. From the calculation of the weight of the ship when fully equipped, as already explained, is determined the position of the upper or load water-line; the other water-lines are drawn at pleasure parallel to, and generally equidistant from, the load water-line. They are severally marked No. 1, 2, 3, 4, &c. (Plate CCCCL.), observing that they are characterized by the same figures in the body and half-breadth as in the sheer plan.

Keel.

Perpendiculars.

Stem and stern-post.

Load water-line.

Sheer of the decks.

The load water-line being drawn in the sheer draught, the height of the lower deck may be determined. It is to be observed, that a deck is delineated by three lines, the upper two of which are parallel to each other, and represent the thickness of the deck at the middle; the third or lower line denotes the under surface of the deck at the side of the ship. Supposing the height of the deck determined amidships, forward and aft; let these heights be set above the load water-line, and through the three spots thus obtained draw a segment of a circle; this curve defines the deck at the middle. To obtain the deck at the side, proceed as follows. Draw a straight line, equal in length to the breadth of the ship amidships, to the interior of the timbers. Perpendicular to and at the middle of this line, set off the round-up of the beam, through which point and the extremities of the line draw the segment of a circle, which will represent the round-up of all the beams. Draw a tangent to this curve at its middle point, which will evidently be parallel to the first-named line, or chord of the arc. Now, to obtain the round-down of the deck at any particular station, take the half-breadth of the ship at that station, and set off this half-breadth on the tangent from the middle of the curve. Next take the perpendicular distance (at right angles to the tangent) of the curve from the point last obtained, and set it off on the sheer plan at the corresponding station below the under side of the deck at the middle; the spot thus obtained is the deck at the side. By proceeding in a similar manner at other stations we obtain several spots through which a fair curve must be drawn, and thus is determined the under surface of the deck, or the upper surface of the beam at the side of the ship. In like manner are the other decks delineated, their height and round-up being known. At present, however, only the lower deck can be decided. Before the upper deck, quarter-deck and forecastle, and round-house, are drawn, it will be necessary to draw, in the sheer draught, the midship and side counter-timbers. We here remind the reader that we are alluding to a two-decked ship, whereas the sheer draught (Plate CCCCL.) represents a frigate, which has one fighting deck less than a line-of-battle ship.

Wing-transom.

As the heels of the stern or counter-timbers rest on and are connected to the wing-transom, this transom may be considered as the foundation of the stern. To draw the wing-transom, set up in the sheer plan, from the upper edge of the rabbet of the keel, the height of its intersection at the middle line of the ship with the fore part of the rabbet of the stern-post. At this point draw a horizontal line, below which draw a second horizontal line, at a distance from the former equal to the round-down of the transom. On the upper horizontal line set off the round-forward of the transom, which square down to the second horizontal line. Next join the last-named point and the point of intersection of the upper surface of the transom, with the fore part of the rabbet, and we thus obtain the after upper edge of the transom. It is to be understood that the method just described for drawing the wing-transom is only an approximation to truth: thus we have supposed the after upper edge of the transom a straight line, whereas in reality its projection is a curve; but as this description is sufficiently accurate for our present purpose, we shall reserve any further remarks on the subject until we explain the method of laying off the transoms.

Having drawn a line to represent the after upper edge of the wing-transom, the fore and after extremities of this line will be respectively the terminations of the after parts of the lower ends of the midship and side counter-timbers; but before these timbers are described, it will be necessary to make a few observations on the stern of a ship.

The stern.

If we imagine the stern to be cut by a vertical fore and aft plane, the after boundary of this section, above the wing-transom, will consist of the hollows of the lower and upper counters, and a straight line from the upper knuckle to the top of the side. Moreover, the stern has two curvatures, a round-up and a round-aft. The round-up is variable, whereas the round-aft (above the upper knuckle) is constant. The round-up of the stern gradually increases from the wing-transom to the taffrail; that is, the right aft rails, which include the tuck-rail, the lower counter, upper counter, foot-space, and breast-rails, have more and more curvature as they ascend. The round-aft of the stern, from the upper knuckle to the taffrail, is the same in equal breadths; in fact, the stern is a portion of a cylinder, and therefore all sections square to its axis, or square to the rake, which is parallel to its axis, are portions of the same circle.

Counter-timbers.

We may now proceed to draw in the midship counter-timber. The stations of the upper and lower knuckles being determined, draw a circular arc to the hollow of the upper counter; and from the lower knuckle to the intersection of the upper edge of the wing-transom with the fore part of the rabbet of the stern-post draw another curve to the hollow of the lower counter. From the upper knuckle draw a straight line to the rake of the stern, and we thus complete the projection of the midship counter-timber.

Side counter-timber.

To draw in the side counter-timber in the sheer plan. At the height of the upper knuckle of the midship counter-timber draw a horizontal line; at the distance of the round-down of the upper counter below this line draw another horizontal line, on which set off the round-forward of the upper counter square to the rake. The point thus obtained will be the upper knuckle at the side. In like manner is

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obtained the lower knuckle at the side. From the two knuckles draw in the hollow of the upper counter, and from the lower knuckle to the fore part of the after edge of the wing-transom draw in a curve for the hollow of the lower counter.

Now if the top-side had no "tumbling home," the side counter-timber above the upper knuckle would be parallel to the midship counter-timber; and further, in proportion as the "tumbling home" is great or small, so will the heads of these timbers approximate to or recede from each other.

To obtain a point for the head of the side counter-timber, it will be first necessary to draw the round-aft of the stern. Strike a straight line at pleasure, the length of which is equal to the breadth of the stern at the lower knuckle. At the middle of this line erect a perpendicular, and on it set off the round-aft of the stern; through this last point, and the extremities of the line, draw a circular arc, from which we may obtain the round-aft of the stern, square to its rake, at any breadth. For instance, to procure the round-aft at the head of the side counter-timber, set off the half breadth of the ship at that height from the middle of the chord of the arc; then take the distance of this point (square to the chord) from the circular arc; this distance is the round-aft required, which, when set off square to the midship counter-timber, determines the aft side of the side counter-timber at its head. We have now to obtain spots for drawing in this timber between the head and the upper knuckle.

Stern.

As before remarked, the stern above the upper knuckle is cylindrical, and as all sections of a cylinder parallel to its axis are bounded by straight lines, while those sections which are oblique to its axis are bounded by curves, it follows, that in the sheer plan the midship counter-timber, as explained above, is a straight line, while the side counter-timber is a curve.

Further, as all sections of a cylinder made by a plane square to its axis are circles, while those sections which are oblique to its axis are ellipses, it follows, that in the half-breadth plan the round-aft of a plane, which in the sheer plan is at right angles to the rake of the stern amidships, will be circular, while the round-aft in the half-breadth plan of all other planes will be elliptical.

Round-aft.

Bearing this in mind, we proceed to show the manner of obtaining the elliptical round-aft of the level line Q at the height of the upper knuckle *a* at the sides (Plate CCCCLIII. fig. 31). In the sheer plan, from the point *a* draw *ab* at right angles to the midship counter-timber produced. Project the point *a* in the sheer plan to the middle line of the half-breadth plan, as *e*. From *e* draw *ef* at right angles to the middle line, and on *ef* set off the half breadth of the ship at the lower knuckle. Draw *eg* equal to *ab*, and through *g* and *f* draw a circular arc *ghf*, the radius of which arc will be equal to half the diameter of the cylinder; then will *ghf* be the round-aft of the stern square to its rake. Again, in the half-breadth plan draw any number of lines W, X, parallel to the middle line, intersecting the round-aft *ghf* in the points *h* and *i*. Take the horizontal distances of *h* and *i* from *ef*, and set these distances off on the line *ab* from the point *a*. Through the points thus obtained on *ab* in the sheer plan, draw lines parallel to the rake of the stern. Square down the points of intersection of the last-named lines, with the level line Q, to the corresponding lines W and X in the half-breadth plan. Lastly, through the intersections thus obtained draw a curve, which will represent the elliptical round-aft of the stern when cut horizontally. Further, as all parallel sections of a cylinder are similar curves, we infer that the round-aft just obtained will serve for the round-aft of any number of level lines drawn above the upper knuckle.

Therefore draw level lines above the upper knuckle, at a distance of from two to three feet apart, both in the sheer and body plans. Run off these level lines in the half-breadth plan. Square down the intersections of each of these lines in the sheer plan, with the midship counter-timber, to the middle line of the half-breadth plan. From these points draw the horizontal round-aft of the stern, and the intersections of this round-aft with the corresponding level lines will be the terminations of the said level lines. Square up these terminations to the respective level lines in the sheer plan, and through these spots draw a curve, which will be the projection of the after edge of the side counter-timber.

Side co- ter-timbe

To represent the projection of the side counter-timber in the body plan, take the distances square from the middle line in the half-breadth plan of the termination of each level line, and transfer these distances to the corresponding level lines in the body plan; through the spots so obtained pass a curve, which will represent the required projection of the side counter-timber. (Plate CCCCLIII. fig. 33.)

Decks.

Following the previous directions, the decks above the lower deck may now be drawn.

Ports.

The joints of the frames are drawn perpendicular to the keel. The previous explanation on the frame-timbers of a ship renders any further remarks on this subject unnecessary. The ports are drawn to the sheer of the ship. Their number, size, and distance apart, of course, depend on the determined armament.

Breadth-lines.

The main-breadth, top-breadth, top-side, and other lines, have been already explained; and with respect to the channels, head-rails, and other details, our limits preclude the possibility of entering into a description. We must therefore conclude our account at present of the sheer plan by referring to Plate CCCCL., and proceed to a brief description of the body plan. Fig. 25 represents the body plan. A horizontal line is drawn for the upper edge of the keel. On this line three perpendiculars are raised, at a distance apart equal to half the moulded breadth of the ship. The middle of these three lines represents the middle line of the ship, or rather the projection of the vertical longitudinal plane which divides the ship into two equal parts. The other two lines are the boundaries of the ship at the widest part, or dead-flat, ⊕. The curves A, B, C, &c. in the fore-body, and 1, 2, 3, &c. in the after-body, represent vertical transverse sections of the ship, at the corresponding joints A, B, C, &c. 1, 2, 3, &c. in the sheer plan. It is to be understood that these sections correspond to the exterior surface of the timbers, on the supposition that the plank of the bottom and top-side is not yet on the ship.

Body pl

Buttock lines.

Independent of the joints of the frame, many other lines in the body plan originate in the sheer plan, as port-sill lines, top-breadth, top-side, water-lines, &c. We shall presently describe the manner of transferring them from the sheer to the body plan. But there are other lines which may be said to originate in the body plan. Among this class may be mentioned buttock, bow, and diagonal lines. Buttock lines are vertical lines drawn at discretion at any distance from and parallel to the middle line. They are marked Nos. 1, 2, 3, &c. Plate CCCCLII. The position of the diagonal lines drawn in the body plan is not, however, arbitrary, because it has reference to two considerations, the length of the timbers, and the station of the ribbands and harpins: thus those marked floor-head, first futtock-head, second futtock-head, &c. show the lengths of the floors and futtocks, together with the heights of their heads and heels above the keel; while those marked first sirmark, second sirmark, third sirmark, &c. show the heights and situations of the various harpins and ribbands, which are placed between the heads of the respective timbers, in order to give support to the ship whilst in frame. Fig. 30.

Diagona

Ribbands and harpins.

Half-breadth plan.

The half-breadth plan is in most draughts placed below the sheer plan, the stations being squared down to its middle line. (Plate CCCCL.). Occasionally, however, the upper edge of the keel in the sheer plan answers to the middle line of the half-breadth plan, as in Plates CCCCLI., CCCCLII., and CCCCLIII. This is generally the case in laying off, because the dimensions of the mould-loft floor would not admit of any other arrangement.

From the description of the draught we proceed to explain the manner of transferring the various lines from one plan to another.

Dia als.

To run off the diagonals in the half-breadth plan. From the point of intersection of the diagonal with the middle line in the body plan, take the distances of the intersection of every timber with the said diagonal, which distances set off on the corresponding timbers in the half-breadth plan. Through the points thus obtained pass a curve, which will represent a vertical projection of the diagonal on the half-breadth plan, not in its original position, but after it is supposed to revolve until it comes into a horizontal position. The axis of revolution is a fore and aft line parallel to the keel, being the intersection of the diagonal plane with the vertical longitudinal plane of the ship. It remains to explain the method of ending the diagonals; but before the process can be clearly understood, it will be necessary to enter into a brief explanation of the rabbets of the stem and stern-post.

Ra ets of the em, &c.

The upper part of the rabbet of the stem, and also of the stern-post, is an equilateral triangle, whose sides are equal to the thickness of the bottom plank, the middle of the rabbet being half the distance between the fore and after edges. But at the lower part of the stem, although the fore part of the rabbet remains fixed, yet the middle and the after edges vary considerably from their relative positions at the upper part.

This variation is technically termed the "opening of the rabbet," and it arises from the alteration of the form of the body. Thus, if we conceive the bow to be of the same shape above and below, no alteration would be required in the form of the rabbet. Again, if the bow were so sharp near the keel that its horizontal section becomes a fore and aft straight line, then the ends of the bottom plank should be cut off square, and therefore in the sheer plan the middle of the rabbet would coincide with the fore edge. Hence we see that the middle of the rabbet approximates to or recedes from the fore edge, according to the sharpness or fulness of the lower part of the bow. In general, it will be sufficiently accurate for all practical purposes to place the middle of the rabbet at the lower part one third its breadth from the fore edge, from which point it gradually recedes from the fore edge till it arrives at the upper end of the stem, where, as before observed, it is midway between the fore and after edges.

The same remarks obviously apply to the rabbets of the stern-post and keel; observing, that with respect to the keel, the rabbet amidships is an equilateral triangle, the middle of which is equidistant between its upper and lower edges, whereas forward and abaft, the projection of the middle of the rabbet of the keel, in the sheer plan, with respect to the lower edge of the rabbet, partakes of a similar variation, as before described with respect to the rabbet of the stem. In general it should be understood, that that form of rabbet is to be adopted which most conduces to its utility as a security of the wooden ends, and the efficiency of their caulking, so that there shall be no tendency to set off the buts of the plank.

End the diag als.

For determining the endings of the diagonals, it is further necessary to observe, that the half siding of the stem and stern-post must be drawn in the body plan, together with the depths of their respective rabbets; observing, that with respect to the stem, it is usual to make it of a parallel siding from the head to the lower side of the lower cheek, in order to afford greater support to the bowsprit and knee of the head. From the lower cheek downwards it gradually tapers to the siding of the keel. The stern-post either tapers the whole of its length, or is of a parallel siding from the head to the lower side of the deck-transom, from whence it tapers to the heel. From our preceding remarks, it will be perceived, that in the half-breadth plan the upper diagonals will terminate at the aft part of the rabbet of the stem, and the lower diagonals at the middle of the rabbet. Hence there will be an intermediate point depending on the comparative fulness and sharpness of the bow, at which one diagonal will terminate both at the middle and at the after part of the rabbet; or rather this one diagonal will break in fair with both the middle and after part of the rabbet.

To determine the endings, we proceed thus: In the body plan take the heights of the intersections of the diagonal with the outside of the stem, and with the inside of the rabbet; transfer these heights to the sheer plan, to the after side and to the inside of the rabbet; square down these two spots to the middle line of the half-breadth plan, at which points raise two perpendiculars; along the diagonal in the body plan take the distances from the middle line to where the diagonal intersects the inside of the rabbet and outside of the stem, and set these distances off on the corresponding perpendiculars in the half-breadth plan; thus will be obtained two points, one of which will be the termination of the diagonal according to the form of the body, as before explained.

Or, in the half-breadth plan, with the fore part of the rabbet as a centre, and the after part of the rabbet as a radius, describe a portion of a circle, and let the diagonal at its termination be a tangent to this circle. The after ends of those diagonals which are below the wing-transom terminate in the rabbet of the stern-post, in a similar manner to the fore ends in the rabbet of the stem.

The termination of those diagonals which cross the wing-transom is thus explained. In the body plan, take the distance square to the middle line of the intersection of the diagonal with the margin. Set this distance off in the half-breadth plan, square to the middle line, to intersect the margin. Through the spots thus obtained draw a perpendicular to the middle line, on which perpendicular set off the diagonal distance of the intersection of the diagonal with the margin in the body plan. This gives the termination required.

Water and level lines.

The foregoing remarks will serve to elucidate the plan of terminating water-lines, and also all level lines which are below the wing-transom; excepting that the distances in the latter cases are taken horizontally instead of diagonally.

To run off diagonals in the sheer plan.

To run off the diagonals in the sheer plan: In the body plan, take the perpendicular heights, that is, the heights square to the upper edge of the keel, of the intersection of the diagonal with each of the timbers, and transfer these heights to the corresponding timbers in the sheer plan. Through the points thus obtained draw a curve, which will be the line required.

These lines terminate forward at the aft side of the rabbet of the stem, and aft at the fore side of the rabbet of the post, at the respective heights of their intersection in the body plan, with the sides of the stem and stern-post.

These lines are chiefly required in the sheer plan, when making a disposition of the timbers of the frame; as by their means we show the heights above the keel, of the floor-heads, first futtock-heads, &c.

The horizontal ribbands in the half-breadth plan.

To run off the horizontal ribbands in the half-breadth plan. Having run off the diagonal planes, as just explained, in their true form, it will be necessary to obtain their vertical projections in the half-breadth plan, without imagining them, as before, to revolve into a horizontal position. The diagonals, when projected according to this second method, are called "horizontal ribbands."

Observe the points of intersection of the diagonal in the body plan with each timber. Take the horizontal distance

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of each of these points from the middle line, and transfer it on the corresponding timber in the half-breadth plan. Through the points thus obtained draw a curve which will terminate both forward and abaft on the same lines as the corresponding diagonal, only observing that the distances of the terminations must be taken in the body plan horizontally instead of diagonally.

Water and level lines in the half-breadth plan.

To run off level lines and water lines in the half-breadth plan. Take the horizontal distances, from the middle line of the ship, of the intersection of each timber with the level or water line in the body plan, and set off these distances from the middle line of the half-breadth plan on the corresponding timbers. Through the points thus obtained pass a curve.

The terminations of these lines below the wing-transom have been already explained.

To terminate the after end of a level line above the wing-transom. From the sheer plan square down the intersections of the level line with the aft part of the midship and side counter-timbers, to the middle line of the half-breadth plan. From the foremost of the two points thus obtained, erect a perpendicular to the middle line, and the point where the round-aft of the stern drawn from the aftermost point intersects the perpendicular, will be the termination of the level line.

Without further explanation, this method will serve for the terminations of the top-breadth, top-side, port-sill, and other similar lines. The fore ends of these lines may terminate in the half-breadth of the stem from the middle line.

Buttock and bow lines in the sheer plan.

To run off buttock and bow lines in the sheer plan. In the body and half-breadth plans, buttock and bow lines are straight lines parallel to the middle line. To transfer them from the body to the sheer plan, proceed thus: in the body plan, from the upper edge of the keel, take the heights of their intersections with each timber, and set off these heights on the corresponding timbers in the sheer plan. Through the spots thus obtained pass a curve. Those lines which do not cross the wing-transom may terminate in the sheer plan, at the main-breadth line. Those which cross the wing-transom terminate at the margin as follows. Square up the intersection of the buttock-line with the margin of the wing-transom in the half-breadth plan, to the margin in the sheer plan. The spot thus obtained determines the ending of the buttock-line.

Main-breadth line.

To run off the main-breadth line in the sheer and half-breadth plans. In the body plan this line is a curve passing through each timber, at its widest part. It is transferred to the sheer plan by levelling in its intersection with each timber, to the corresponding timbers; and it is drawn in the half-breadth plan in a manner similar to that before described with respect to water-lines.

We now suppose the draught is complete, and that due precautions have been taken to make the various curves in the three plans perfectly fair. We proceed to explain the method of laying off the more important parts of a ship.

Transferring to the floor.

It will be unnecessary to allude to the manner of transferring the sheer and body plans from the paper on which they are first drawn to a small scale, to the mould-loft, on which they are to be delineated the full size of the ship. The process will be sufficiently obvious to any intelligent person. We will therefore suppose the sheer and body plans transferred to the floor of the mould-loft. This being done, the next operation is to fair the body, by horizontal, vertical, and oblique sections, which is effected by running off in the half-breadth plan, according to our previous description, level lines, buttock-lines, and diagonal lines.

Fairing the body.

Proof timbers.

It should be understood, that, forward and aft, it is necessary to run off a few vertical sections nearer together than the other sections. This is done on account of the sudden curvature in the bow and buttock of a ship. These sections, which are called "proof timbers," may be placed according to discretion; observing, however, that it is essential to have one near the end of the wing-transom.

Laying

Joints o the fram

When the body is perfectly fair on the floor, it becomes necessary to get in all the alternate timbers, or rather joints of the frames, which have been omitted. In the half-breadth plan, bisect the spaces between every joint already laid off, and strike in the new joints, which, like the others, will be square to the middle line. Then in the half-breadth plan take the distances from the middle line, of the intersections of these joints with each of the level lines and diagonals, and transfer these distances to the corresponding level lines and diagonals in the body plan. Thus will be obtained a series of spots through which curves must be drawn to represent the new joints, when all the moulding edges in the body plan will be complete.

Moulds

Supposing the body plan complete, the moulds may be made for the timbers in the square body. With respect to the floors, it is customary for one large mould to contain them all, the fore and after bodies being placed on its opposite sides. This mould, for lightness and convenience, is made of battens; it is connected at the middle line by a pair of hinges, so that when not in use it may be shut together, and thus occupy only one half the space. In trimming a floor, after the spots are obtained from the mould for its curvature, it is sometimes customary to apply the adjacent first futtock-mould through them. With respect to the futtocks, for the sake of illustration, let us imagine one frame of the ship (as starboard, K), instead of consisting of a floor, first futtock, second futtock, third futtock, fourth futtock, and top-timber, to consist simply of two long timbers, each extending from the dead-wood to the top of the side, one on either side of the joint. Were we to make a mould to K in the body plan, it is obvious that it would give the form of both these imaginary long timbers. The only difference in the application of the mould would be, that in moulding the foremost of these timbers the after side of the mould would be uppermost, whereas in moulding the after timber, the fore side of the mould would be uppermost. The reverse would obviously be the case in moulding the larboard timbers. Now, bearing this principle in mind, the moulds are made for the various futtocks, conforming in their length to the respective diagonals which denote the stations of their heads and heels. The scantling of the timbers is marked on the moulds, together with the stations of the ribbands and bevelling spots. As each edge of a mould may be used, one mould answers for two timbers, and their opposites. Where rigid economy is of importance, one mould may serve for several futtocks, in which case the various joints are inked on the surface of the mould, and are bored through the mould to the timber in order to obtain its curvature. This method, however, is not to be generally recommended, because a set of moulds will, with care, convert for several ships in succession.

Bevellir

After the moulds are made, it is customary to take the bevellings of the square body. This subject will, however, be explained generally under the head of cant-timbers, to which we now direct the reader's attention.

Laying the cant timbers.

We have already explained that the plane of a cant-timber is vertical, and inclined at a certain angle to the longitudinal plane of the ship; its projection, therefore, in the half-breadth plan, will be a straight line inclined to the middle line.

In the disposition of the cant-timbers, strength and economy should be considered; hence the propriety of diminishing their curvature and bevelling as much as possible. No particular rule can be laid down for their number and disposition, as these must depend on the form of the bow and buttock of the ship. As a general rule, they should be placed as square as possible to the body, and be equally spaced on the main-breadth and middle lines; their sidings, together with the openings between them, or, in other words, their "room and space," should assimilate as near as may be to the square body. The hawse-pieces should be so situated that they may not be too much wounded by the hawse-holes; and in order that the knight-heads may not be injudiciously weakened by the bowsprit, their heads should be separated from the stem, at least in large ships, by a timber of from six to eight inches siding.

It should be remarked, that in the square body every other joint only is laid off, the intermediate joints being drawn in after the laying off may be said to be complete. But in the cant-bodies every joint is laid off, each joint, as in the square body, serving to mould the adjacent timbers on its fore and after sides. Still, if the opening between the timbers of a cant-frame should be very great, it would be more accurate to strike in the openings on the half-breadth plan, and to lay off each timber independent of the other, that is to say, the after edge of the foremost, and the fore edge of the aftermost timber.

Supposing the disposition of the fore and after cant-bodies completed as in the half-breadth plans (Plates CCCCLI. and CCCCLII.), in which the joints of the cant-frames are marked *c*, we proceed to lay them off in the body plan. This is generally done by one of two methods; either by horizontal ribbands, or by level lines. We must here remind the reader, that the square timbers in the body plan, as A, B, C, &c., 1, 2, 3, &c., are not only projections of the same timbers in the sheer plan, but they are absolutely the real shape of the said timbers, on the supposition that the ship was cut asunder athwartships at those stations. Now, if we conceive a vertical section of the bow to be made, not athwartships, but in the direction of the plane of a cant-timber, as W, Plate CCCCLI. fig. 27, and if we project this section to the body plan, this projection will not be the shape of the cant-timber. But if keeping the plane of the cant-timber W fixed at its vertical intersection with the longitudinal plane, we make it revolve round the said intersection as an axis until it comes athwartships, and if in its new position we project it from the sheer plan into the body plan, then, as in the square body, we not only obtain a projection, but also the true form of the timber, to which a mould may be made for trimming it. We shall now explain the manner of performing this ingenious process, selecting as an example the cant-timber W in the fore body.

To lay off cant-timbers by horizontal ribbands. Observe the intersection of the cant-timber, marked W, with the upper horizontal ribband in the half-breadth plan, Plate CCCCLI.; take the nearest or perpendicular distance of this point from the middle line; set this distance off horizontally from the middle line of the body plan, so as just to intersect the corresponding diagonal. In like manner, obtain similar spots from the remaining horizontal ribbands in the half-breadth plan on all the other diagonals in the body plan, and if through the spots so obtained a curve were drawn, this curve would be the projection, not the true shape, of the cant-timber. Next through all the above-named spots on the diagonals in the body plan, draw horizontal lines. In the half-breadth plan, take the distances along the cant-timber from where it intersects the middle line to its intersection with each of the horizontal ribbands. Transfer these distances to the body plan, by setting them off from the middle line, on each of the corresponding horizontal lines before named. Lastly, through the spots so obtained pass a curve, which curve will be the absolute shape of the cant-timber, which has thus been made to revolve round the point W in the half-breadth plan, from its original position, which was oblique to the middle line, until it came into an athwartship position, or square to the middle line.

We have thus delineated the form of the cant-timber at and below the upper diagonal. To obtain its form at the top-side, proceed thus. In the half-breadth plan, square up the intersection of the cant-timber with the main-breadth line, to the corresponding main-breadth line in the sheer plan. Transfer the height so obtained to the middle line of the body plan, through which point draw a level line. In the half-breadth plan, take the distance in the direction of the cant-timber, from its intersection with the middle line to its intersection with the main-breadth line, and set off the same distance from the middle line of the body plan, along the level line just drawn. Proceed in like manner with respect to the top-breadth, top-side, port-sill, or any other similar lines, and we thus procure a series of spots through which the cant-timber may be continued from below.

Ending the timbers.

To obtain the ending of the timber. Draw in the bearding line or the half thickness of the dead-wood in the half-breadth plan, parallel to the middle line. Square up the intersection of the cant-timber with this bearding line, to the bearding line in the sheer plan. Level in this height to the middle line of the body plan, where a horizontal line must be drawn, on which line set off from the half-breadth plan the distance between the intersection of the cant-timber with the middle line, and its intersection with the bearding line. The spot thus obtained determines the ending of the timber.

Bevelling edges.

Having laid off the moulding edge of W, we proceed to lay off its bevelling edges. Parallel to and on either side of the joint W, draw two lines *ac*, *bd*, to represent the sidings of the adjacent timbers. The side extremities of these lines terminate like the joint at the top-breadth line; their midship extremities are bounded by a small line *ab* drawn at right angles to the joint W at its intersection with the middle line.

In our former description we supposed the joint of the timber to revolve round the point W, until it, the joint, came into an athwartship position. Now, instead of imagining the joint only to be thus circumstanced, let us suppose the whole cant-frame to revolve round the point W; in which case the bevelling edges *ac*, *bd*, will become athwartship lines, and *ab* will become a fore and aft line, and may be regarded as the middle line, or rather a small part of the middle line, of the ship. Hence, in laying off the two bevelling edges *ac*, *bd*, we proceed as was before described for the joint, with this exception, that we take the cant distances along *ac*, *bd*, from the points *a* and *b*, instead of, as before, from the point W, at the middle line.

Bevelling of cant-timbers.

The bevelling edges are delineated, as just explained, in the body plan, in which plan they fall without, coincide with, or fall within, the joint; and these three conditions determine whether the timber has a standing, square, or under bevelling. Therefore, across a board the breadth of which is equal to the siding of the timber, draw a line square to its edges. In the body plan, at the various bevelling spots, as sirmarks, port-sills, heads, &c. take the nearest distances of the joint from the bevelling edges, and set these distances on the right-hand side of the board, either above or below the square line, according as the bevellings are standing or under. Then join the points so obtained, and the intersection of the square line, with the left-hand side of the board. The angles formed by the left-hand side of the board, and the various lines across the board, denote the respective bevellings at the corresponding stations in the body plan, which bevellings will be applied square to the curve of the timber.

Heels of cant-timbers.

For trimming and cutting off the heel two bevellings are necessary. The bevelling against the dead-wood is simply the angle formed in the half-breadth plan by the direction of the timber and a fore and aft line, and is therefore taken by placing the stock of a bevel to the cant of the timber, and the tongue to the bearding line.

To obtain the bevelling for cutting off the heel against the stepping. Square up from the half-breadth plan to the

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sheer plan, the intersection of the joint of the cant-timber with the bearding line. From this point in the sheer plan erect a perpendicular to the keel. Place the stock of the bevel to this perpendicular, and the tongue to the direction of the stepping line, and the required bevelling is obtained.

Laying off by level lines.

To lay off the cant-timbers by level lines. The reader will observe that two processes were necessary in laying off cant-timbers by the horizontal ribbands; for, first, we had to take the square distances of the intersection of the timber with each horizontal ribband from the middle line in the half-breadth plan, and transfer these distances to the corresponding diagonals in the body plan; and, secondly, we had to take the oblique or cant distances of the timber with the same horizontal ribbands in the half-breadth plan, and transfer them to the body plan. But the method of laying off these timbers by level lines is far more simple, only one process being required. Thus, to lay off the joint of W, take the cant distances from the middle line in the half-breadth plan to the intersection of the joint with each level line, and transfer these distances from the middle line of the body plan, along each of the corresponding level lines. A curve through the spots thus obtained gives the true form of the timber.

In considering these two methods of laying off cant-timbers, the reader will remark, that the difference between them consists in this particular, viz. in the first method, or by horizontal ribbands, the heights in the body plan along which the cant distances are set off, are procured from the half-breadth plan; whereas in the second method, or by level lines, these heights are already given in the body plan.

But it may be naturally asked, which is the preferable method? To this we reply, if the student can rely on the fidelity of his labours, let him by all means lay off the cant-bodies by level lines: if, however, he mistrusts the accuracy of his work, let him adopt the plan by horizontal ribbands. The reason of this opinion is, that as the level lines cut the body obliquely, any inaccuracy is more magnified by them than by the diagonals, which cut the body nearly at right angles. With this explanation, we leave the choice of these plans to the discretion of the student.

Bevelling edges.

The bevelling edges are laid off by level lines in the same manner as the joint, except, as in the former method, the cant distances are taken from the points *a* and *b*, instead of from the point W. The bevellings of the timber are taken as explained in the former method.

Cant-timbers in the sheer plan.

To obtain the projection of the cant-timbers in the sheer plan. Square up the intersections of the timber with any of the lines except diagonals, in the half-breadth plan. Diagonals are excepted, because in the half-breadth plan they are not in their natural position, but are supposed to revolve into a horizontal position before they are projected into this plan. Through the spots thus obtained pass a curve, and we obtain the projection required.

This operation is necessary for a variety of purposes. Thus the projection of the fashion-pieces into the sheer plan, shows the boundary of the ends of the transoms. (Plates CCCCLII. and CCCCLIII.) A like projection of the other cant-timbers in the fore and after cant-bodies, shows the arrangement of the heads and heels of the cant-timbers, and their disposition with respect to the bow and after ports.

To lay off the transoms.

To lay off the transoms. As the ends of the transoms are bounded by the fashion-pieces, it becomes necessary to obtain the projection of the fashion-pieces in the sheer and body plans. This is done as previously described with respect to any other cant-timbers. In Plate CCCCLII. the transoms are projected into the half-breadth plan; but as this creates confusion from the multiplicity of lines, it is customary to lay off the transoms by themselves, and to show both sides of the ship. With this view Plate CCCCLIII. is drawn, where fig. 32 represents the plan of the transoms in which the square timbers 29, 31, the buttock-lines 1, 2, 3, 4, 5, the middle line, the bearding of the post, the fashion-pieces, and the wing-transom, are transferred from the half-breadth plan.

Layin

In the sheer plan, where the wing-transom intersects the fore part of the rabbet, a line is drawn at right angles to the keel. This line is called the perpendicular to the transoms. A corresponding line is drawn in the plan of the transoms.

Transoms may generally be divided into four kinds. 1*st*, Those which have a round-up and a sheer: 2*d*, those which have a round-up and no sheer: 3*d*, those which have neither a round-up nor a sheer, their upper and lower sides being level both athwartships and fore and aft; they are called horizontal transoms: and, 4*th*, those which are square to the stern-post, or rather as square to the body as they can be drawn. These are called cant-transoms; their upper and lower sides are planes.

The deck-transom must necessarily have the round-up and sheer of the deck. We have supposed the wing and filling transoms also to have a round-up and sheer to them, although they are sometimes designed, particularly in small ships, without any sheer. It is customary to distinguish the transoms under the deck-transom as No. 1, 2, 3, &c. They are delineated in fig. 31 as horizontal transoms; occasionally, however, they are canted, as AB, Plate CCCCLII. fig. 29.

Laying
horizon
transom

From the nature of horizontal transoms, as previously explained, they will be represented in the sheer and body plans by level lines. (Figs. 31 and 33.) This being done, we have next to make a horizontal section of the ship, at the upper side of each of these transoms, which will of course give the curves to which the moulds are to be made. As the after part of the transoms is terminated either by the fore side of the rabbet, or by the bearding line of the stern-post, in the sheer plan take the distance from the intersection of the upper side of the transom with the fore part of the rabbet, or with the bearding line, to the perpendicular of the transoms. Set this distance off in the plan of the transoms, on each bearding line square from the perpendicular to the transoms, then by joining these two points we obtain the after part of the transom amidships. Again, in the sheer plan, observe the intersection of the upper edge of the transom with each buttock-line. Take the distances of these intersections from the perpendicular to the transoms; transfer the said distances to the plan of the transoms, by setting them off from the perpendicular to the transoms on the corresponding buttock-lines. A curve line passing through these spots will give the form of the upper after-edge of the transom. The accuracy of this curve may be tested thus. In the body plan, take the distances from the middle line of the intersection of the upper side of the horizontal transom with each square timber, transfer these distances from the middle line on each square timber in the plan of the transoms; the spots so obtained ought to correspond with the curve drawn by means of the buttock-lines.

Transo
with a
round-
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To lay off a transom which has a round-up and a sheer, it should be understood that the mould given to the workmen for trimming the transom to its round-up is generally a circular arc, applied square to the sheer; and that the mould for trimming it to its round-aft is applied flat upon and bent round its upper surface.

In the sheer plan, at the height of the intersection of the middle of the transom with the fore part of the rabbet of the post, draw a line to the sheer of the transom. Continue this sheer line until it meets the perpendicular to the transoms, at which point draw a line downwards at right angles to the sheer line. Fig. 31.

In the body plan, at the height of the upper side of the transom amidships, draw a level line; draw also a circular arc to the round-down of the transom, square to the sheer, the before-named level line being a tangent to this arc;

at each buttock-line take the distances of the level line from the arc, and set them off in the sheer plan, upon the line drawn square to the sheer of the transom, below the point of intersection of the square and sheer lines. From these points draw lines parallel to the sheer, and where they cut the corresponding buttock-lines, draw a curve which will represent the round-down of the transom below the sheer. To transfer this curve to the body plan, level in its intersection with each buttock-line in the sheer plan to the corresponding buttock-lines in the body plan; through the points thus obtained pass a curve. To delineate the curve in the plan of the transoms to which the mould is to be made, proceed thus. In the sheer plan, observe the points of intersection of the sheer-lines with the buttock-lines; take the distances of these points in the direction of the sheer to the line drawn at right angles with the sheer. Transfer these distances to the plan of the transoms by setting them off on each buttock-line, from the perpendicular to the transoms. Through the points thus obtained pass a curve, which will represent the mould for the upper after-edge of the transom. This curve may be corrected, by means of the square timbers, on the principle before explained with respect to the horizontal transoms. We may here remark, that, strictly speaking, the buttock-lines in fig. 32 should have been expanded, by taking their distances from the middle line in the body plan round the curve of the transom, and transferring them to the plan of the transoms. But as the variation would be very trifling, this operation is unnecessary in practice.

La g off a c -tran- soms

To lay off a cant-transom. In the sheer plan, from the perpendicular to the transoms, take the distances along the upper side of the transom to the intersection of the upper side with each buttock-line and with the bearding line. Set these distances off in the plan of the transoms, on the corresponding buttock and bearding lines, from the perpendicular to the transoms. A curve through these spots will give the form of the transom.

To test the accuracy of this curve, in the sheer plan project the heights of the intersections of the upper sides of the transom with the square timbers and buttock-lines, to the corresponding timbers and buttock-lines in the body plan. A curve passed through the spots thus obtained will represent the transom in the body plan. Next, in the sheer plan, from the perpendicular to the transoms take the cant distances of the intersections of the transom with the square timbers and with the fashion-piece. Set off these distances in the plan of the transoms, from the perpendicular to the transoms, and through the spots draw lines parallel to the said perpendicular In the body plan take the horizontal distances from the middle line, to the intersections of the transoms with each square timber and square fashion-piece. Lastly, in the plan of the transoms set off these distances from the middle line on the lines just drawn, parallel to the perpendicular of the transoms. The spots thus obtained should correspond with the curve previously drawn by means of the buttock-lines.

Bev ngs of t tran- soms

The bevellings of the transoms may be taken in the sheer plan from the buttock-lines, by placing the stock of the bevel in the direction of the upper surface of the transom, and the tongue in the direction of the buttock-line. In this case the stock of the bevel must, when applied, be placed in a fore and aft direction.

If it be thought more desirable to set off the bevellings square to the curve, it will first be necessary to lay off the under sides of the transoms, as before described with respect to their upper sides. This being done, in the plan of the transoms take the shortest distance apart of the upper and lower sides of the transom, at any assigned station. This distance denotes how much the transom is under a square in its depth, and therefore determines the bevelling at the assigned station.

Margin of the wing-transom.

With respect to the wing-transom, it must be observed, that the margin is of a parallel depth all round. The bevelling of the margin conforms to the direction of the fore side of the rabbet of the post. Below the margin the bevellings are taken as before described.

Moulds to the transoms.

Moulds may be made to the after lower edges of the transoms, which moulds are applied on the under surfaces, through the spots obtained from the bevellings.

Laying off the side counter-timber.

We shall next proceed to lay off the side counter-timbers. We have already explained the manner of obtaining the projection of the after edge of the side counter-timber in the sheer and body plans. The fore edge is drawn in the sheer plan by setting off from the after edge the intended size or moulding of the timber. To draw the fore edge in the body plan, square down from the sheer plan the points where it cuts the various level lines, to the corresponding level lines in the half-breadth plan; take the half-breadths of the ship at the points thus obtained, and transfer these half-breadths to the body plan on the corresponding level lines. Hence we obtain the projection of the fore edge of the side counter-timber in the body plan.

Now it is evident that the lines in the sheer plan representing the fore and after edges of the side counter-timber do not give its true form, and that, on account of the tumbling home of the side, a mould made to the above lines would be shorter than the timber itself. Hence it becomes necessary to expand the timber, by making it revolve on a horizontal axis at the heel until it becomes vertical. This process is thus performed. In the body plan draw a straight line, about three fourths of an inch from the upper and lower part of the fore edge of the side counter-timber, as seen in fig. 33, Plate CCCCLIII. This straight line represents the upper side of the mould; its lower end terminates on the level line of the wing-transom at the side; it is marked, in figs. 31 and 33, "base." Having all the level lines marked on this line, imagine it to revolve round its lower end until it comes into a vertical position; mark in the level lines in their new situation, and transfer them to the sheer plan, in which plan the intersections of the edges of the side counter-timber with the original level lines are to be squared up by perpendicular lines to the new level lines. Through the points thus obtained draw curves for the fore and after edges of the side counter-timber in their expanded or vertical position. To these curves the mould must be made.

Next, in the body plan, take the distances along the various level lines, from the straight line representing the mould, to the fore and after edges of the timber. In the sheer plan let the distances just taken from the body plan be marked upon the fore and after edges of the mould at the new or expanded level lines. When the mould is applied on the timber, these distances or spilings are set off in the direction of the tumbling home. After the outside of the timber is completed, the inside may conform to the scantling of the top-side.

We may observe, that instead of the spilings being marked on the mould, brackets are sometimes nailed on the mould, corresponding to the spilings. These brackets are shown in fig. 31, marked *b*. In this case, when the outside of the side counter-timber is completed, the under edge of each bracket exactly conforms to the timber. For the sake of illustration, brackets are also shown in fig. 29.

Bevellings.

To take the bevellings of the side-counter timber from the half-breadth plan, place the stock of the bevel to a fore and aft line, and the tongue to the horizontal round-aft of the various level lines. In applying these bevellings, the stock is placed on the mould to the level lines, and the tongue is placed in the direction of the tumbling home.

We have thus described some of the principal operations in laying off. We have endeavoured rather to illustrate the general principles than the details of the subject; and

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although in this short treatise many things are necessarily omitted which are of importance, as illustrative examples of the art of laying off, it will be found to embrace all those points which are likely to occur in the ship-building of the present day, or at least render them comparatively easy.

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Ship-building.

We now come to the consideration of the branch of our subject to which the term "ship-building" may be correctly applied; that is, the mechanical construction of the fabric of a ship. We have already, in the preliminary remarks to the "Laying Off," described generally the relative position of the principal timbers which compose the frame-work of the hull, and that are necessary to give the contour of the body. Technically speaking, it is usual only to apply the term timbers to the frame-timbers of a ship. We shall, however, for the sake of perspicuity and brevity of description, adopt the term as one of more general application, and use it to designate the larger pieces of wood-work which enter into the construction of the hull. Previously to any detail, we shall mention severally the various internal timbers used as supports and ties to the frame, and the combinations of external and internal plank by which it is covered. This is necessary in order to render the subsequent descriptions intelligible to those unacquainted with the technical names used in ship-building. We must also refer our readers to the plates which are intended to illustrate this part of our article, for much information that may be more easily obtained from them than from description.

Definitions.

The apron is fayed (or fitted) to the after side of the stem, and is intended to give shift to its scarphs; the lower end scarphs to the dead-wood. The keelson is an internal longitudinal range of timbers, situated immediately over the keel, and fayed to the inside of the throats of the floors, its use being to give shift to the scarphs of the keel, and to secure the frames down to the dead-wood. The foremost end of the keelson scarphs to the stemson, which is intended to give shift to the "boxing scarph," or connexion between the stem and keel. The after end of the keelson formerly scarphed to the sternson, a timber which, in a similar manner aft, strengthens the connexion between the keel and stern-post. The keelson is now generally rounded off short of the heel of the sternson, and latterly the boxing scarph of the stem has been discontinued. The additional keelsons, sometimes also called sister-keelsons, are timbers brought on the inside of the frame on each side of the keelson, to receive and to diffuse the weight of the main-mast. Timbers which cross the stemson or keelson forward, for the purpose of connecting the two sides of the ship, are called hooks. Those which are placed to receive the ends of the decks are called deck-hooks. Timbers which for a similar purpose cross the sternson or keelson aft, are called crutches. These hooks and crutches are frequently combinations of timber, or of timber and iron. They are then formed of two half hooks called ekeings, and the middle or connecting piece. Timbers which are fayed to the inside of the frame, or upon the inside plank, solely for the purpose of supporting the frame, are called riders. Timbers which in a square stern fay to the fronts of the transoms, and run forward to strengthen the connexion between the stern and the ship's side, are called sleepers. The two sides of the ship are prevented from collapsing by transverse timbers called beams, which are generally connected at their ends to the ship's side by knees either of wood or iron. The beams are spaced, first with reference to the mast-holes, to the hatchways, ladderways, or passages from deck to deck, and other arrangements connected with the economy of the ship, and then in reference to the ports, that they may afford support to the artillery.

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Those beams which do not extend from one side of the ship to the other are called half-beams; they are placed in intervals between the beams that would otherwise be too devoid of support for the plank of the deck, which is laid on the upper surface of the beams, and called the flat of the deck. Timbers worked round the interior of the ship for the purpose of receiving the beams of the several decks, are called shelves to these decks; and those timbers which are worked upon the ends of the beams, and also round the interior of the ship, are called water-ways; thus, gun-deck shelf, gun-deck water-way, or upper deck shelf, upper deck water-way. Chocks, internally, are timbers brought under the ends of the beams, or under the shelf that is immediately beneath the beams, to support them, and to receive the bolts of the knees which connect their ends with the ship's side. A chock is a name applied very generally to any piece of timber filling an interval, or supplying a deficiency in any of the combinations, either of timber, or of timber and iron. Bits are timbers projecting through the decks, either vertically or slightly inclined, and are used for facilitating the management of the ropes for the rigging. The riding-bits are for securing the cable when the ship is riding at anchor. Standards, generally, now, are timbers used for supports, as to the bits. On the old system of building, standards were sometimes placed where they could only act as ties, as the standard to the stern. There were also standard-knees on the decks, both to support and tie the ship's sides.

The plank, both external and internal, is of various thicknesses: a thick strake, or a combination of several thick strakes, being worked wherever it has been supposed that the frame required particular support; as internally, over the heads and heels of the timbers; both externally and internally between the ranges of ports; and internally, to support the connexion of the beams with the side.

Of the internal planking, the lowest strake or combination of strakes in the hold is called the limber-strake. A limber is a passage for water, of which there is one throughout the length of the ship on each side of the keelson, in order that any leakage may find its way to the pumps; and it is from this that the limber-strake takes its name. A strake of planking is a range of planks abutting against each other, and extending, excepting in particular cases to be afterwards mentioned, the whole length of the ship.

The whole of the plank in the hold is called ceiling. Those strakes which come over the heads and heels of the timbers are worked thicker than the general thickness of the ceiling, and are distinguished as the thick strakes over the several heads. The strakes under the ends of the beams of the different decks, and down to the ports of the deck below, if there be any ports, are called the clamps of the decks to the beams of which they are supports; as the gun-deck clamps, middle-deck clamps. The strakes which work up to the cills of the ports of the several decks are called the spirketing of those decks, as gun-deck spirketing, upper-deck spirketing. The upper strakes of planks, or assemblages of external planks, are called the sheer strakes. The strakes between the several ranges of ports, beginning from under the upper-deck ports of a three-decked ship, are called the channel-wale, the middle-wale, and the main-wale. The strake immediately above the main-wale is called the black strake. The strakes below the main-wale diminish from the thickness of the main-wale to the thickness of the plank of the bottom, and are therefore called the diminishing strakes. The lowest strake of the plank of the bottom, that of which the edge is in the rabbet of the keel, is called the garboard. In merchant-ships the rabbet is generally worked out of the middle of the side of the keel, and not, as in ships of war, at the upper part of the side. Several methods of working this garboard, and the lower strakes of the bottom, have been lately adopted, both in the royal and in the mercantile shipping. One of these plans, see fig. 37, Plate CCCCLIV., called "Lang's safety keel," from the inventor, Mr Lang, the master shipwright of Woolwich yard, has, we believe, been very extensively applied to the keels and garboards of steam-boats; and several of Her Majesty's ships have been built with their garboards so worked. A represents the keelson, B the floor-timber, C the keel, D the outer keel, E the false keel, F, F solid pieces continued fore and aft the vessel, as substitutes for the chocks on the floors and the planking of the bottom.

The pieces of timber, either secured or placed to receive the heels of the several masts, are called steps, as the main, fore, or mizen step. The heel of the bowsprit is also, in small ships, sometimes on a step. In general, the bowsprit steps on a frame-work, called the bowsprit partners. The frame-work of timber which is formed round the mast-holes in each deck is called mast-partners. Partners, generally, are the principal timbers in a framing formed for the support of any thing passing through a deck, as the masts and capstans. Carlings are pieces of timber forming a part of the framing for a deck, lying in a fore and aft direction, and from beam to beam, to receive the half beams, to aid in supporting the deck, and for various other purposes. Ledges are pieces also forming a part of the framing of a deck, generally smaller than carlings, and which are placed athwartships in the same direction as the beams. Coamings are pieces of timber generally faying on carlings, and raised higher than the flat of the deck, forming the fore and aft boundaries to openings in it, as hatch or ladder ways. Head-ledges in the same manner form the athwartship boundaries to these several openings.

The knee of the head, which has been already incidentally noticed in the laying off, is a prolongation of the fore part of the ship, principally of use as a security for the bowsprit, which is firmly lashed to it by portions of the rigging, called the gammoning and the bob stays. The cheeks are knees fayed on each side of the knee of the head, and also against the bows, in the direction of the sheer, in order to afford support to the knee of the head.

We do not profess that this is a perfect list of the components of the hull of a ship. We have merely enumerated some of the more important pieces, or combinations, of timber, the names of which may occur again in our further remarks. It would be impossible, in an article so limited in extent as the present, to enter much into the detail of practical building. We shall content ourselves with endeavouring to illustrate some few general principles, which may guide the practical builder in his arrangements.

There are several very voluminous works explanatory of the detail of practical ship-building. By far the most perfect information on the practice, as it exists in Her Majesty's yards, will be found in the very excellent plates to Fincham's Outline of Ship-Building. We believe the most modern work on the construction of the mercantile navy is Hedderwick's Treatise on Naval Architecture, which contains very minute details of the practical building in the merchants' yards.

Dis rbing forc

We shall now consider the most important disturbing forces which are in action, either to injure or to destroy the several combinations of the hull of a ship. Some of these forces are inherent to the form of the body, while others are only brought into action when the body is in motion. In the theoretical portion of this article it has been explained, that when the ship is at rest on still water, the total weight of the vessel is equal to the upward pressure of the water; but it does not necessarily follow, that the weight of every portion of the vessel shall be equal to the upward pressure of that portion of water which is immediately beneath it. On the contrary, the shape of the body is such, that these weights and pressures are very unequal. We will suppose the vessel to be divided by transverse vertical sections into a number of laminæ of equal thickness, which will all be perpendicular to the vertical longitudinal section. It is evident that the after laminæ comprised in the overhanging stern above water, and the fore laminæ comprised in all the projecting head, also above water, cannot be supported by any upward pressure from the fluid, but their weight must be wholly sustained by their connexion with the supported part of the ship. The laminæ towards each extremity immediately contiguous to these can evidently derive a very small portion of their support from the water; but as their stations in both the fore and the after bodies approach towards the middle of the ship's length, a greater proportionate bulk is immersed, and the upward pressure of the water is increased; so that at some certain station from the middle of the length in each body, the upward pressure will equal the weight of the superincumbent lamina, and all the laminæ comprising that portion of the body between these two stations will be subjected to an excess of pressure above their weight, tending to force them upwards, which upward pressure will be the greatest at the lamina having the greatest transverse area of section.

Now, as we know that the total pressure upwards is equal to the total weight of the vessel, this excess of upward pressure, to which the midship part of the length of the body is subjected, must be just equal to the excess of weight over the upward pressure in the parts of the vessel before and abaft those laminæ at which we have represented the pressure and weight to be in equilibrio.

A ship floating at rest may be considered as a beam loaded at each extremity with a weight, and supported at two points in its length, which are at some distance on each side of its centre, while the part between its points of support is subjected to a force acting upwards equal to the sum of these two weights. A beam thus acted upon would have a tendency to assume a curved shape; and it would gradually assume such a form, as the effect of the weights and forces overcame the rigidity of its particles. This is precisely the effect of the action on the ship; and the upward curvature, when it does ensue, is what is technically called "hogging." As long as the fastenings remain unaffected from the continued operation of the disturbing forces, and the abutments of the several timbers and plank composing the fabric also maintain their close contact, this curvature will not take place; but when these become partially deranged, the upward pressure, and the downward gravitation of the several portions of the body, can no longer be considered as tendencies only to deterioration of the fabric, but as active agents in the work of destruction.

Hogging.

Sagging.

It does not necessarily follow, from all that has been said, that the hogging will give a regular curvature to the form: on the contrary, the various actions of the weight and pressure will produce varied effects. Thus, before the introduction of the additional keelsons, the body frequently "sagged," the contrary or opposite curvature to hogging, under the weight of the main-mast.

A corresponding action to that described as hogging, takes place in relation to the breadth of the vessel, especially on account of the weight of the ordnance; so that the central portion of the body is subjected to an upward pressure forcing it above the water, and the outer portions are strongly acted upon by their unopposed gravity immersing them beneath it. The effects of this action will be modified by the form of the vessel; longitudinally it produces the upward curvature that we have described, and transversely it either tends to a separation of the sides both above and below throughout their extent, or, if the "tumbling home" be great, a separation at the main breadth and below it, and a collapsing of the sides above it.

Horizontal pressure of the water.

Another force tending to alter the form of the ship when she is at rest, arises from the horizontal pressure of the fluid on the surface below the load water-section, which tends to reduce the dimensions below that plane, and therefore to add to the hogging.

Though these are the disturbing forces when the ship is at rest, their action is not confined to that state; they are also in operation when she is in motion. Other injurious effects are produced by, and belong only to, a state of motion.

Pitching and rolling.

If the surface of the sea be very uneven, so that the ship's passage may be over its undulations, her support becomes variable, and the opposing forces of upward pressure and gravitation will have a tendency to produce a corresponding undulation in the body.

Force of the waves.

When the ship is on a wind, the lee side is subjected to a series of shocks from the waves, the violence of which may be easily imagined, from the effect they sometimes produce in destroying the bulwarks, tearing away the channels, and washing away the boats, &c. The lee side is also subjected to an excess of hydrostatic pressure over that upon the weather side, resulting from the accumulation of the waves as they rise against the obstruction offered by it to their free passage. These forces tend in part to produce lateral curvature. Also in this inclined position the forces which, when she is upright, tend to produce hogging, now partly contribute to produce lateral curvature. By experiments made on Her Majesty's ship Genoa, in the year 1823, by Mr Moorsom, formerly a member of the late School of Naval Architecture, he ascertained that this lateral curvature amounted to one inch and a half on each tack, making an alteration of form to the extent of three inches, from being on one tack to being on the other.

Tension of the rigging.

The strain from the tension of the rigging on the weather side when the ship is much inclined, is so great as frequently to cause working in the top-sides, and sometimes even to break the timbers on which the channels are placed.

Taking the ground.

Ships also, especially those designed for the service of commerce, are liable, either from intention or from accident, to take the ground. This contingency must be provided against, as has been already mentioned, in the laying off.

These are the principal disturbing forces to which a ship is subjected. It must be remembered that they are in almost constant activity to destroy the connexion between the several parts of the fabric; and that whatever "working" may be produced by their operation, tends most materially to increase their effect; because the disruption of the close connexion between the several parts admits an increased momentum in their action on each other, and the destruction proceeds with an accelerated progression; while the admission of damp, and the unavoidable accumulation of dirt, soon generate fermentation and decay. To make a ship strong, is at the same time to make her durable, both in reference to the wear and tear of service, and the decay of materials. But there is one very important consideration which should be remembered in the construction of all fabrics with so perishable a material as timber; it is, that all strength beyond that which is necessary to insure durability to the fabric equal to the durability of the material, is a waste both of labour and material; or, in other words, if a ship, built at an expense of L.40,000, will last twelve years, it would be false economy to expend L.60,000 in building one to last fifteen years.

If, by any means, the durability of wood should be much increased, it would be also necessary to increase the strength of the ships built of it, that the durability of the construction might equal the durability of the material.

Hogging as it affects the structure.

We see from this outline, that the forces which cause the hogging, which are the most important disturbing influences, commence their action at the moment of launching of the ship, and are thenceforward in constant operation. This curvature can only take place by the compression of the materials composing the lower parts of the body, and by the elongation of those composing the upper parts. We therefore have to determine the divisional line separating these two actions, and to form the combinations above and below this line, to offer opposition in accordance to the different directions of the strains to which they will be subjected. Dupin, in his able paper on Seppings' Diagonal System, fixes this line of inaction at about the surface of the water. According to the accepted theory of the strength of bodies, it would be situated lower than this in large ships; but the horizontal pressure of the water, already mentioned, makes the case of a body supported on a fluid an exception, and the station assumed by Dupin must approximate nearly to the correct position.

The portion of the ship about the surface of the water must therefore be considered in the light of a foundation to the fabric, and should be strengthened, not only to resist the inequalities of the strains to which it will be itself subjected, especially when the ship is in motion, but also to constitute it a firm basis, from which to extend supports to those portions of the hull both above and below it, that will be subjected to yet greater disturbing forces than itself.

In order to resist the tendency to hogging, the object of the ship-builder should be to form an incompressible mass below this line of inaction, and to render the body rigid and inextensible above it; hence the immense advantage gained from Sir Robert Seppings' plan of filling in the openings in the lower part of the frame, and especially of the plan which he introduced of filling them with cement that so far exceeds any timber in hardness. The various abutments of this part of the body should be as closely fayed as possible. In the dead-wood the buts of the shifts should all be cut off square to the joints, and the abutting surfaces multiplied by the interposition of dowels in these joints, the abutments formed by which are certain, and hence the advantage of dowelling the kelson, rather than scoring it over the floors. In this part of the body the length of the scarphs is not of so much importance as the close abutment of the lips, to insure which the scarphs should be keyed. The keel scarphs are an exception to these remarks, as they require additional and different security, from being external openings.

The tendency of the hogging will be to alter the angles formed by the post and the stem with the keel; therefore it is necessary to strengthen the connexions of these timbers by every means which will oppose this tendency, as elongating all the shifts, hooking all the scarphs, and judiciously distributing and supporting all the fastenings. Hence the advantage of a dead-wood knee, as adding most considerably to the strength of the connexion abaft, and enabling a more regular and advantageous application of the bolts to be made. This object of strengthening the connexion of the post and stem with the keel, is therefore the consideration to be attended to in shifting the after shifts of the after dead-wood and the sternson, and in shifting the fore dead-wood with the stem, apron, and stemson, and also in disposing the fastenings which pass through these timbers. The old plan of running the keelson aft to scarph with the sternson added materially to the tie. Another important support to the stern in line-of-battle ships, is a carling brought up under several of the after beams of the gun-deck, and secured to them; its after end being connected to the head of the sternson by side-plate knees.

There is more necessity for attention to the support of the stern than to that of the bows, because, when a ship is under weigh, the after part beneath the water, as it has been already explained, is deprived of much of the pressure to which it was subjected when at anchor, and therefore the effect of the gravitation is less opposed. Hence also the "cambering," or curving outwards, of the stern-post. The cambering of the post might, however, be greatly prevented, by a tie-bolt connecting it with several of the after beams of the lowest deck, among which the strain would be diffused by the carlings between them. This might now be done even in line-of-battle ships, as they carry their orlop-beams right aft.

Since compression is the action to which the lower part of the body is subjected, we see the evident inutility of sacrificing economy in order to obtain length of shift for the plank of the bottom, or, indeed, of making any great sacrifice of plank for this purpose below the surface of the water, excepting for the foremost and aftermost shifts, at the bluff of the bow, and under the buttock.

The deck below the water, that is, the orlop, in ships of the line, and the lower deck in frigates, though near the neutral line, are below it; and therefore the action to which they are subjected is compression, to resist which the ranges of carlings should be maintained from one extremity of the vessel to the other, and all their abutments should fit as closely as they can be got in place.

We have mentioned the keel scarphs as an exception to our general remarks. They are usually in England vertical scarphs, with coaks raised in the lip-ends of the scarphs, to fit into mortices sunk for their reception in their but-ends. These coaks serve as a stop to the caulking, and, in connexion with the scarph-bolts, are well devised, in the event of the curvature of the keel, to enable the scarph to partake of it, and to prevent leakage. In France, and generally in the foreign yards, the scarphs of the keel are horizontal. Very lately the horizontal scarphs have been adopted in the English service. We consider the vertical scarph much to be preferred, for the reasons above stated.

In those parts of the ship situated above the line of inaction, every means should be taken to multiply longitudinal ties. Since, in order to resist compression in the lower parts of the body, the openings are filled in, and form a solid mass; to produce the opposite effect, that is, to enable the frame to resist extension, it should be chain-bolted together towards the upper parts of the body, wherever the continuous range of bolts can be placed not to interfere with the in and out fastenings; as opposite the openings between the shelf and water-way of the several decks just above the scuppers. This plan has been pursued in several of the modern ships. The shifts of the different walcs, spirketings, and clamps, should be long, the regular shift of the buts most carefully maintained, and the buts of the inside assemblages made to give shift to the buts of those outside. Sir Robert Seppings' plan of supporting the fastenings, and compensating for the weakness of the buts in some of the principal assemblages of plank, by dowels into the timbers in the strakes immediately above and below the buts, is of great utility. Also the plan of connecting several strakes together by tie-bolts placed opposite the openings between the timbers in the frame, where they could not interfere with any fastening, was admirably adapted to diffuse strength, and to prevent longitudinal working of the planks, or the sliding of one edge past another, from any partial weakness. These might advantageously be much more extensively applied than was contemplated in the instructions issued by Sir Robert; indeed, to all the internal assemblages of plank in which they can be driven.

The ank-
ing.

Plank is either worked in parallel strakes, when it is called "straight-edged," or in combinations of two strakes, so that every alternate seam is parallel. There are two methods of working these combinations, one of which is called "anchor-stock," and the other "top and but." The difference in their appearance will be best seen by a reference to Plate CCCCLVIII., fig. 43. The difference in the intention is, that in the method of working two strakes anchor-stock, the but of one strake always occurs opposite to the widest part of the other strake, and there is consequently the least possible sudden interruption of longitudinal fibre arising from the abutment; therefore this disposition of plank is used where strength is especially desirable. In top and but strakes the intention is, by having a wide end and a narrow end in each plank, to approximate to the growth of the tree, and to diminish the difficulty of procuring the plank.

The shift of plank is the manner of arranging the buts of the several strakes. In the ships of the royal navy the buts recur with intervals of three whole strakes between. In merchant-ships there are often not more than two whole strakes between the recurrence of the buts. The regularity of the shift of plank is far more carefully maintained in English building-yards than in those abroad.

The fastening of the plank is either "single," by which is meant one fastening in each strake through each timber of the frame which it crosses; "double," or two fastenings in each timber; and "double and single," meaning alternations of the double fastening in one timber with the single fastening in the next.

This fastening consists generally either of nails or treenails, excepting at the buts, which are secured by bolts. Several other bolts are driven in each shift of plank as additional security. These additional fastenings are far more plentifully diffused in the royal yards than in those of private builders. Whatever system of securing the plank may be determined upon, great care should be taken to guard against a repetition of fastening, which will otherwise occur from the various bolts that will come through the bottom as securities to the riders, shelves, water-ways, knees, and bolts connected with the service of the guns. These bolts should evidently, for economy, and also for the sake of avoiding unnecessarily wounding the timbers, supply the place of the regular fastenings of the plank.

Before copper sheathing was introduced, iron was used for fastening. Since then, either bolt-nails cast of a mixture of zinc, copper, and grain tin, technically called "metal," or pure copper bolts, are used in addition to the treenails. Experiments are now being made in Holland to protect iron bolts, used for fastening the plank on ships' bottoms, from the galvanic action induced by the copper. The bolts are punched within the wood, and covered with a cement made of equal parts of lignum vitæ saw-dust, smiths' ashes, and "minium." In France also several ships' bottoms have lately been iron-fastened, with Roman cement over the bolts; they were then felted and sheathed, the sheathing being secured with copper nails, and the bottom afterwards coppered. This inquiry as to the possibility of applying iron for the fastening of ships in connexion with the copper sheathing, is of great importance, as, independently of the difference in the expense of the two metals, the difference in their tenacity is as 995 to 546, or copper is only about $\frac{11}{20}$ths of the strength of iron, or little more than one half.

The plank in the royal yards is not usually permanently fastened for some time after it is trimmed and brought on to the bottom of a ship, but is temporarily secured by Blake's screws, and allowed to season and shrink. About one strake in eight or ten is left out for the purpose of making good the shrinkage and refaying the strakes. Without this precaution there would be such an alteration of edge as would throw the holes made for the temporary securities out of the ranges of the strakes; but this precaution being taken, it is very seldom that the alteration of edge is such as to require new holes, especially as the iron screw eye-bolts used for this temporary fastening are of much smaller diameter than the permanent treenail fastening, and therefore the holes for the screws will make good holes through the plank for the treenails.

Temporary fastening.

This method of securing the planks in a temporary manner is of immense advantage in enabling them to be brought into close contact with the timbers, in the saving of bolt-fastenings, and in causing a good and regular seam to be given for the caulking.

The circumference of the bottom being much larger at the midship part than towards the extremities, that is, at the bow and buttock, the lines for the strakes of plank must

Sny. **Hang.**

close, and the strakes taper as they recede from midships. They also acquire an upward curve, called "sny," which renders it difficult to work the plank. When the sny becomes too great, a strake is ended short of the rest, and this is termed a "stealer," as it diminishes the sny for the succeeding strakes. Under the buttock it is often necessary to work some of the after plank wider at the after end, which has the same effect of diminishing the sny of the following strakes. "Hang" is the exact reverse of "sny." It mostly occurs in working plank on the inner surface of the timbers, and outside above the main breadth.

The various plans for fastening the plank and for securing the buts will be most easily understood by a reference to Plate CCCCLVIII. fig. 43.

Caulking. When the plank is worked and fastened, the seams, or the intervals between the edges of the strakes, are filled with oakum, or "caulked," with such care and force, that the oakum, while undisturbed, is almost as hard as the plank itself. If the openings between the strakes were of parallel width throughout the thickness of the plank, it would be impossible to make the caulking sufficiently compact to resist the water. The inner part of the edges of contiguous strakes should be in contact throughout their length, and from this contact the edges should gradually recede from each other to the outer surface of the plank, so that at a thickness of about ten inches they would be about $\frac{10}{16}$ths of an inch apart; that is, about $\frac{1}{16}$th of an inch seam for every inch in thickness of plank. The practice in the royal yards is to allow a double thread for every inch in thickness of plank, and an additional double thread for every five inches; besides which, one, or sometimes two, threads of spun-yarn are driven in as a bottom to the oakum. In the merchant-yards on the Thames, and where the larger merchant-ships are built, the caulking is nearly the same as in the government establishments. But in the smaller ships built at the outports, the oakum is seldom "bottomed" home to the inner edge of the seam, the consequence of which is, that the uncovered edges of the planks decay, and the second caulking drives the oakum through, after which the seams cannot long be kept tight.

It is the generally received opinion, that however the French may have excelled us in designing the body of a ship, our practical building has always been incomparably superior to theirs. In so far as the skill of the workman is involved in this opinion, we believe it to be strictly correct.

The workmanship of English mechanics is probably unrivalled, certainly not surpassed by that of any other mechanics in the world, either in solidity or in neatness of execution; but we cannot in justice urge the claim of superiority further.

However weak the French prizes taken during the last century may have been from defective workmanship, the materials were in several instances much more judiciously combined for the purpose of obtaining strength than in the contemporary ships in our service. Indeed it was not until after Sir Robert Seppings became surveyor of the navy, that the absurdity of having the sheer of the ship and the sheer of the ports different from each other, was discontinued. The effect of this difference in their sheer was, that the assemblages of thick strakes brought round the sides for the purpose of strengthening them, were actually cut off from being crossed by the sheer of the ports. In the majority of the French and Spanish ships taken at so early a period as the middle of the last century, the sheer of the ports was the same as the sheer of the ship, consequently the whole strength of the thick strakes was preserved. The shelf was also originally copied from the French; and though they have now discontinued it, it was at the period of its introduction an important improvement. Also we have only followed them in the adoption of iron knees for the security of our beam-ends. In making these animadversions, we speak wholly of the past. For many years British ships have been unequalled for strength, as well as for perfection, of workmanship.

It has become almost a fashion to decry the improvements introduced by Sir Robert Seppings. It would be well, perhaps, to remember the complaints continually made, of the weakness of the ships before he became surveyor of the navy, and to contrast the fleets of England at that time with the fleets which he left in the service when he relinquished the surveyorship. There is no doubt that many of his plans were imperfect, and are susceptible of great improvement. No change ever yet was made, or ever will be made, that was not and will not be susceptible of yet further improvement.

Decks. We have already mentioned the decks which are situated below the line of non-action; those above it must all be considered as most valuable longitudinal ties. Their sheer has been most properly much diminished within these last twenty years. It is evident, that for rigidity, decks without any sheer would be advantageous. The sheer was probably given them to facilitate the run of water to the scuppers, and may perhaps be desirable for this purpose; but certainly, as strength is lost by their curvature, the sheer of the decks should be as little as possible. It may be objected, that perfectly straight decks would be injurious, or at least very unsightly, in the event of hogging taking place. The objection is not valid; strength must not be sacrificed in order to prepare for the occurrence of a contingency which we are endeavouring to prevent, and which evidently may be prevented for a great length of time, since the various improvements introduced during the last five-and-twenty years have certainly almost wholly prevented the weakness in ships, which was before such a source of constant complaints.

Fastenin decks. The only consideration, in fastening decks, is to preserve their contact with the beams, and to withstand the action of caulking: more than enough to effect this object is useless, and therefore the numerous bolts introduced with the system of diagonal decks were unnecessary. It may probably be proper to observe, that the harder the material used for the flat of decks, the greater should the quantity of fastening be, as there will be less yielding of the edge to the caulking; and although it is usual to allow more seam for caulking planks of a hard than of a soft material, the caulking will bring far more strain on the fastenings of the harder than on those of the softer; besides which, strictly speaking, though it is not practically expedient, seam should depend upon thickness alone. It may not be improper to mention here, that the quantity of fastening must increase with the thickness of the plank, whether of deck or bottom, which is to be secured; for the set of the oakum in caulking will have the greater mechanical effect the thicker the edge.

Diagona deck. The diagonal deck, whatever advantage it might have been presumed to possess in other respects, was certainly a great loss of strength in as far as longitudinal tie was involved, and, we consider, has been most judiciously discontinued. The rapid deterioration arising from the wear occurring across the fibre of the wood, with the additional inconvenience, that the partial wear along the working passage of the deck, by crossing every strake, involves the shifting the whole flat, is alone a strong argument against any alteration in the system of laying the strakes of deck fore and aft. Mackonochie proposed to lay decks in three layers, one diagonally from starboard to larboard, another diagonally from larboard to starboard, and an upper layer fore and aft. He also proposed a somewhat similar system for the outside plank, from the garboard to the wales. Merchant-vessels have been built in America, and boats and steam-vessels in this country, on this system of layers of planks laid diagonally.

Sir Robert Seppings was apparently aware of the important tie which a deck is to a ship, as he retained some of the midship-binding strakes, and introduced dowels to render their connexion with the beams and with the extremities of the vessel more perfect and more unyielding than could be effected by the old plan of scoring down, with its attendant evils from the shrinkage of the materials and neglect of workmanship.

The aftermost and the foremost beams of each deck might be advantageously made to afford support to the projecting bows, and especially to the raking sterns of the modern ships, by connecting the bow and stern timbers to them at each deck by long tie-bolts passing through several beams, clenched on the aft side of the aftermost forward, and on the fore side of the foremost of them aft. These beams should have several ranges of carlings let down between them, to diffuse the strain. This would be far preferable to forelocking the bolt on the fore side of each beam; first, because, generally speaking, the strain would only fall upon one beam, that which was most closely forelocked; and, secondly, because by experiment we find that the size of the bolt being the same, the forelock would give way, or the bolt break at the forelock-holes, under about one half the strain which the clench would withstand.

Several Dutch ships have been built with a round-up to the decks in the direction of the length; the keels of the same vessels were built to sag or curve downwards towards the midships of the length, and the fore and after extremities were so constructed that the longitudinal vertical section should form an elongated ellipse. Only steam-boats have, we believe, ever been built on this plan.

Bea

The beams which support the deck have a curve upwards, in the direction of their length, to the middle of the ship, called the "round-up." This is for the purpose of strength, and for the convenience of the run of water to the scuppers. Beams are single piece, two, three, or four piece (Plate CCCCLIV., figs. 39, 40, 41, 42), according to the number of pieces of timber which are combined to form them. The several pieces are scarphed together, and coaked and bolted, the scarphs being always vertical. Hooked scarphs, with keys of hard wood or iron driven in, to bring the buts in close contact, have been lately introduced with much advantage in great additional neatness of appearance, great reduction of weight, and consequently of materials and expense, by Mr Edye, the master-shipwright of Pembroke yard, fig. 38.

Iron pli- ed t hip- buil g.

It is rather surprising, that in the very general application of iron for ship-building, the wooden beams which occupy so much space between deck and deck, and so materially contribute to the height of the vessel above the water, have not either been superseded by beams of iron, or at least by wood beams of much less moulding, to which the necessary rigidity might be given by iron plates at their sides. An objection to beams wholly of iron would arise from the great expansion and contraction of that metal under variations in its temperature.

The beams of ships are supported at each end, and the strain to which they are subjected is a downward pressure; consequently the upper part of the beam must compress, and the lower fibre elongate, before there can be any alteration in the curvature. It is desirable therefore that the fibre of the wood towards the lower part of the beam should not be wounded, and that, whether for the purpose of securing the beam, or of security to the beam, no incision should be made, excepting in the upper, or compressed, ranges of the fibre, which may be cut through, according to Du Hamel's experiments, one half, and according to Professor Barlow's, five eighths, of their depth, without impairing the strength. Nay, if the carling or material to be inserted in the score be of harder texture than that which is removed, the strength is increased.

Connexion of beam-ends to ship's side.

The connexion of the ends of the beams to the sides of the ship has afforded scope for the display of much ingenuity. We have in our plates (CCCCLV. and CCCCLVIII.) given sketches of those plans which have been adopted in the navy of England, and also of several taken from foreign works or observed in foreign yards. There are three things to be considered in the connexion of the beam with the side: that it shall act as a shore to prevent the sides from collapsing; as a tie to prevent their falling apart; and be perfectly rigid, that there may be no working.

That the beam may be an effective shore, nothing more is necessary than that the abutment of the end against the ship's side may be perfect. In order to constitute it a tie between the two sides, it is generally dowelled to the upper surface of the shelf, and the under surface of the water-way is dowelled to it. These dowels connect it therefore with the fastenings of the shelf and water-way, which pass through the side. There is also in the ships of the royal navy a plank called a side-binding strake, scored down over and into the beam-ends, at some distance from the side, and bolted through the side between the beams. The scoring into the beams connects the in and out fastening of this strake with the longitudinal tie of the beam. There are also the various bolts forming that part of the fastening of the beam-ends, whether in the knees or in the chocks, which passes in and out through the ship's side.

It will be very easily conceived, from the short outline which we gave of the disturbing forces acting on a ship, that the strain on the ends of the beams to destroy the rigidity of their connexion with the side must be very great when the ship is under sail either on a wind or before it, that is, either inclined or rolling.

Forces to which they are subjected.

The principal action of these forces is to alter the vertical angles made by the beam and the ship's side; and it will be seen that the action is alternately to decrease and to increase the angles made by the beam and the part of the side below it, or, what is the same thing, alternately to increase and decrease the angles made by the beam and the ship's side above it. Now the first of these actions takes place on the lee side; the gravitation of the weather side, and all connected with it, of the deck and every thing upon it, as well as the upward pressure of the water, all tend to diminish the angle made by the beam and the ship's side below it, and increase the angle made between them above it. The contrary effect is produced on the weather side, the angle above the beam being closed, and that below opened.

Beams considered as levers.

In investigating the nature of the action of these forces, we shall find that in each case the beam may be considered as a lever. The power being supposed to be applied at the opposite end of the beam to that at which the forces under investigation act, the weight being the fastening applied to prevent alteration in the angle formed by the beam and the ship's side, and its action being supposed to take place at the point in which it should be applied to produce the most advantageous effect.

Effect on lee-beam arm.

On weather-beam arm.

The lever is of the first order, that is, with the power and weight on opposite sides of the centre of motion or fulcrum, when its effect on the lee arm is considered; and it is of the second order, that is, with the power and weight on the same side of the fulcrum, when its effect on the weather arm is considered.

The object in securing the beam-ends in each case should be to diminish the effect of the power and increase that of the weight. We lessen the effect of the power by diminishing the distance between the point at which it acts and the fulcrum, and we increase the effect of the weight by increasing the distance between the point at which it acts and the fulcrum. In the lever of the first order, that is, when we are considering the action on the lee arm, this is accomplished by bringing the support of the under side of the beam, the midship side of which support is the fulcrum of the lever, as far from the ship's side as it can be extended consistently with the accommodation of the decks; and by having the weight, that is, the security to keep down the beam-end, as close to the end of the beam, and consequently to the ship's side, as it can be placed.

In the lever of the second order, that is, when we are considering the action on the weather arm, the effect of the power is diminished by increasing the distance between the fulcrum and the weight. The fulcrum, in this case, is the support of the lower side of the extreme end of the beam; the weight is the strength of the knee, or whatever connexion is intended to tie it to the ship's side, and maintain the angle invariable which is formed by them. The effect of this weight is increased by approaching it to the point at which the power is supposed to act. Therefore, in order to resist the action on the weather arm of the beam, the fulcrum, which, as we have said, is the support of the extreme end of the beam, that is, the edge of the clamp or shelf which fays to the timbers, should be most firmly connected to them; and the weight, which is the downward tie, should be extended as far from the side as it may be consistently.

The difference of the action to which the two arms are subjected, points out therefore at once the principle which should guide us in all plans for connecting the beams to the side, and it may not be useless to recapitulate our conclusions.

The action on the lee arm requires the extreme end of the beam to be closely tied down, either to the clamp or the shelf, as the case may be, and which is necessarily presumed to be firmly connected to the ship's side. This action also requires the centre of motion to be extended far from the side, in order to diminish the effect of the power. Therefore, the downward fastening close to the ship's side, and the upward support far removed from it, is that which is necessary in this case.

The action on the weather arm requires an exactly different disposition of the securities. The extreme end of the beam is here the centre of motion, and is the part which ought to be supported; and it is the downward tie which should be as far extended from the side as may be consistently.

It may be urged against these views, first, that if working be presumed to take place in the lee-beam arm, round the midship or outer edge of the shelf, the distance between this fulcrum and the fastenings which keep the beam-end down will cause greater motion in that end, and greater strain on the fastening; and, secondly, that if the weather-beam arm be presumed to work from the side or inner edge of the clamp or shelf, the distance between this point and the fastening intended to keep the beam down, will cause an increased strain on that fastening.

These objections are both true, but they do not embrace the correct view to be taken. The object is how to dispose the fastenings in the best possible manner, in order to prevent working. And this is attained in each case by extending the distance between the weight and the fulcrum.

Shelf and clamp as securities of the beam-end.

In the system of building the ships of the royal navy, introduced by Sir Robert Seppings, the shelf was brought upon the clamp (*m*, Plate CCCCLV.); it is now worked home to the timbers (*i*, *k*, *l*), and its front is therefore less extended from the side. One joint, that between the clamp and shelf, is avoided by this method, but security to the beam-end is lost by it. An arm of the iron knee, which has superseded Sir Robert Seppings' forked knee, is extended under the beam to compensate for this diminution in the width of the shelf; but unless the rigidity of this arm be such that the fulcrum in the case of the lee-beam arm, and the weight in the case of the weather-beam arm, be removed from the ship's side a distance at least equal to the diminution in the extension of the front of the shelf from the ship's side, the object is not attained.

Plate-b

One of the most perfect securities for a beam-end, in point of principle, and combining at the same time simplicity of workmanship, which is another important requisite, especially in all iron work, is the plate-bolt (*a*), frequently adopted for round-house beams, and for the lower decks of frigates. The extreme end of the beam is tied downward by bolts, and supported by the shelf, and the extended downward fastening is by a dog-plate. These securities, and the upward support afforded by the chock to that plate, are, according to the foregoing reasoning, correctly applied, but are insufficient in amount of security for the beams of principal decks, as the downward tie depends wholly on the clench of the dog-plate.

Strap.

Probably a strap passing round the beam, as shown in fig. 44, Plate CCCCLVIII., might be an advantageous and simple modification of the above plan. For easiness of execution, and smallness of expense, it would be better if the strap was merely bent over, and scored into the top part of the beam, and the ends brought down and fastened on the sides of the chock, which would then require to be only of the same siding as the beam. In this case there could be no in and out fastening through the strap; the only in and out bolts would be those through the chock. The fastenings of the strap might be screws, as in the French knees (Plate CCCCLVIII. figs. 45, 46), which we shall describe. The disadvantage attending this sort of strap would be, that to obtain an equal degree of downward security for the weather-beam arm, the chock must be more extended from the ship's side than if the ends of the strap were brought in front of the chock, and took their own in and out fastening.

Advantages of the choc

The extension of the security from the side of the ship by means of a chock, is preferable to gaining the same breadth by bringing a shelf on to the clamp with a chock under it, in so far as extending the support to the beam is involved; because the chock presents "end-grain," in which there is comparatively but little shrinkage, to receive the downward pressure of the weather-beam arm. A well secured and firmly supported clamp is sufficient to resist the downward pressure of the weather-beam arm; and if this clamp be of a sufficient thickness to receive the up and down bolts through the water-ways and beam-end, that is all that is indispensable, and this would be little, if any, addition to the thickness of clamp already usually worked. We therefore doubt much whether the shelf might not be advantageously discontinued, and substituted by a clamp with chocks under the beams, stepping on the projecting edge of the spirketing. We shall speak of the support to this clamp when we consider the short stuff between the ports. Of course this change presupposes a maximum of advantage to be derived from all the other combinations for strengthening the side.

Object a to choc

An objection is urged against chocks, which is, that they occupy space against the ship's side; but they afford security to the beam-ends which cannot be well obtained without them; and it is questionable whether the foundation of the objection is correct, because the continuous breadth of shelf should also be considered, and that effectually prevents a man's standing erect close to the ship's side, while the obstruction from the chocks is only partial, with intervals between.

Rober plate-k

Roberts' plate-knee (*d*, Plate CCCCLV.) is a very strong method of fastening, as a preventive to any alteration of the angle formed by the beam and the side, provided the in and out security of the chock to the side is sufficient to resist the strain that is brought on it. These knee-plates, together with up and down bolts in the beam-ends, fulfil all the requisites for a correct mode of fastening, unless it may be the objection against the chock which we have stated. The great objection which has been urged to their use arises from the fore and aft bolts through the beam, which, it is said, are liable to split the beam-end.

All fore and aft bolts through the beam-end, as they do not pass through the fulcrum round which the beam would work, are nearly equally liable to this objection, whether they occur in the same range of fibre or not, because when motion ensues they must all act to split the beam-end. But we have already said we do not consider this line of argument should be urged. The occurrence of working should not be presupposed in determining securities to prevent it, because such a course would frequently militate against the application of the most advantageously disposed preventives to motion; not however that we are arguing in favour of fore and aft bolts through beam-ends ranking among these; on the contrary, we think they should be avoided.

The foregoing observations embrace the main outline of the principles which should be kept in view in connecting the two sides of the ship by means of the beams.

Ho

The bows, as we have already said, are connected by timbers called hooks. It is important to remember that the hooks above and those below the surface of the water are subjected to an opposite strain. The tendency of the pressure of the water on the bow is to make the sides collapse, and therefore the hooks below the water's surface should not only act as ties to the bow while the ship is grounded, as, for instance, when in dock, but should be formed more especially to resist the pressure of the water when she is afloat. Those hooks which are above the surface of the water act principally as ties, the rake of the bow and the gravitation of its parts tending to separate the two sides of the ship. These observations are of little importance when the hooks are of wood; but when they are formed partly of wood and partly of iron, they materially affect the application of the iron plate. Below water it should evidently be brought as close to the inner surface of the bows as possible, and therefore on the fore side of the hook. It should also be secured to the wooden ekeings, independently of the bolts which secure the hook to the bows. Very slight consideration will suffice to prove, that by these means the utmost advantage is obtained from the materials employed, to resist the pressure, while at the same time they form a sufficient tie to support the sides of the bows when the ship is in dock, before launching, or aground. In made hooks above the water, the iron plate should be on the aft side, as far from the bow, and as straight as may be, that it may be a more effective tie.

We shall now pass to the several systems of strengthening the sides, and of preventing the hogging, which have been successively introduced.

Vertic riders.

In the system of building which was superseded by that termed the diagonal system, the whole of the interior surface of the frame was planked, and a series of internal frames worked upon this planking, agreeing in direction with the timbers of the ship (Plate CCCCLVI. fig. 47). They appear principally to have been intended to support the frame in the event of the ship's grounding, as they could add no longitudinal strength to the fabric. There were about eight "bends" of the "riders" in three-decked ships, and six bends in two-deckers. There were other timbers running up to the top-sides, called breadth, middle, and top riders. These were more closely spaced than the bends in the lower parts of the body, and were placed in a diagonal direction evidently only to avoid the ports. The beams were secured to the side by hanging and lodging knees of wood: they rested on the clamp, there being no shelf. The water-way was merely a thicker strake of deck gouged out, or "chined down," as it is technically called, from the front of the spirketing, to the same thickness as the flat of the deck. This chining down is for the protection of the water-way seam, by keeping it above the run of the water. There were different methods of shifting the bends of riders in the hold, several of which we have introduced in the plate.

An enormous quantity of timber was thus massed together, having the appearance of great strength; but in fact, from its weight, injudicious combination, disposition, and fastening, much of it was, if not injurious, at least useless. The riders in the hold were no doubt originally necessarily introduced when ships were "grounded" for repairs; but that necessity has now ceased to exist. In the earliest drawings representing them there are "pointers," or shores, extending from them at the bilge of one side, to the gun-deck at the opposite side of the middle line, which we shall presently refer to.

The system we have described was partially superseded by single riders in the hold, scarphing to chocks under the orlop-beams, and running down to give shift to the floor-heads. The top-sides were supported by standard knees brought on the deck over the beams; and the beams were secured by Roberts' plate-knees brought on the sides of chocks under the beams.

The idea of diagonal trussing was not novel at the time the system of Sir Robert Seppings was first proposed: It may even be observed in Plate CCCCXLVI. in the vessel of the fifteenth century, under repair. In the plates of a Dutch work of the date of 1697, there are diagonal pointers in an athwartship direction from the floor-heads on one side, to the quarters of the upper-deck beam of a two-decker on the other. Sir Walter Raleigh also mentions this mode of strengthening ships; and the Dutch author, Van Yk, gives the drawing as a representation of the English system of building at the date of the publication of his work. Somewhat similar also were those afterwards proposed by Mr Snodgrass, the surveyor of shipping to the East India Company, though his were to step upon the keelson and extend to the clamps of the lowest gun-deck, and were therefore less judiciously placed to resist the strain in grounding than those represented in the Dutch work. Diagonal trussing between the keelson and the gun-deck beams along the vertical longitudinal section of the ship, had also been proposed, and partial experiments of various diagonal supports or shores made, both abroad and in England; but until the introduction of the diagonal riders and trusses by Sir Robert Seppings, there had been no permanent results from these experiments.

We quote the following description of the system from a paper communicated by the inventor to the Royal Society, and which is printed in the Philosophical Transactions for 1814.

Diagonal frame.

"An accurate conception of the state of a ship's hold may be formed by referring to the longitudinal section (fig. 48), which is termed the Jesuit's perspective, or bird's-eye view of the internal part of one side of a seventy-four-gun ship in a complete state, with fillings in the openings between the timbers of the frames, instead of the planking over them.

"In this state the diagonal timbers are introduced, intersecting the timbers of the frame at about the angle of forty-five degrees, and so disposed as that the direction in the fore is contrary to that in the after part of the ship (as may be seen in the engraving), and their distance asunder from six to seven feet or more; their upper ends abutting against the horizontal hoop or shelf-piece of the gun-deck beams, and the lower ends against the limber strakes, except in the midships, where they come against two pieces of timber placed on each side of the keelson (called additional keelsons), for the purpose of taking off the partial pressure of the main-mast, which always causes a sagging down of the keel, and sometimes to an alarming degree. These pieces of timber are nearly as square as the keelson, and fixed at such a distance from it, that the main step may rest upon them. They may be of oak or pitch-pine, and as long as can be conveniently procured. Pieces of timber are next placed in a fore and aft direction, over the joints of the frame-timbers, at the floor and first futtock-heads; their ends in close contact with, and coaked or dowelled to, the sides of the diagonal timbers. In this state the frame-work in the hold presents various compartments, each representing the figure of a rhomboid.

"A truss-timber is then introduced into each rhomboid, with an inclination opposite to that of the diagonal timbers, thereby dividing it into two parts. The truss-pieces so introduced into the rhomboid, are to the diagonal frame what the key-stone is to the arch; for no weight or pressure on the fabric can alter its position in a longitudinal direction, till compression takes place at the abutments, and extension of the various ties.

"This arch-like property of the diagonal frame not only opposes an alteration of position in a longitudinal direction, but also resists external pressure on the bottom, either from grounding or any other cause, because no impression can be made in its figure in these directions, without forcing the several parts of which it is composed into a shorter space.

"The beams are disposed in the new system nearly as usual, except that in midships, where a ship necessarily requires the greatest security, two additional beams have been introduced.

"The beams of the several decks are attached to the ship's side in the following manner.

"1*st*, By shelf-pieces or internal hoops, distinguished by the letter E. These shelf-pieces are composed of several lengths of timber, scarphed or joined together by coaks or circular dowels, so as to form a kind of internal hoop, extending from the hooks forward, to the transoms abaft—(in the plate the transoms are not shown, as we have chosen the perfected application of Sir Robert Seppings' system, after the adoption of the circular stern into the service),—to the under side of which, as well as the under parts of the beams, they are securely coaked, and being then firmly bolted to the side, instead of becoming a mere local fixture of the beam to the ship's exterior frame, as knees were, they are one continued and general security. The shelf-piece is also a tie to the top-side in a fore and aft direction, co-operating with the trussed frame, as already explained.

"2*dly*, By chocks, represented in Plate CCCCLV. (*m*, *o*), which are placed under all the shelf-pieces in wake of the beams, except the orlop, in such a manner as to receive the up and down arm of the iron knees. The lower ends of those under the gun-deck shelf-piece step on the ends of the orlop-beams; and those of the several decks above, step on the projecting part of the spirketing below. The chocks, particularly those between the orlop and gun decks, admit of their being driven into their respective places very tightly, thereby acting like pillars. Another advantage attending them is their great tendency to stiffen the ship's side, and to prevent the beam-ends from playing on the fastenings when the ship is rolling, or straining under a press of sail.

"The curved iron-plate knees for securing the orlop-beams, and the iron forked knees of the other decks, are described in (*n*) and (*m*), Plate CCCCLV.

"The tendency of the ship to stretch or draw asunder in her upper works being by no means obviated by the short planks on the inside between the ports, a truss piece of plank is substituted in lieu of them, which being well secured at the abutments, very materially aids the trussed frame, and gives great stiffness, thereby opposing the inclination to arch or hog aloft."

These various alterations from the old system of building had the effect of very greatly increasing the strength of the ships of the royal navy. Among so many changes, it is not improbable that erroneous conclusions may have been drawn as to the relative importance of each. We incline much to the opinion that this has been the case to a very great degree, and that a part hitherto considered as quite subordinate, and now wholly discontinued as useless, was one principal cause of the increase of strength which enabled ships to preserve their sheer. This we shall presently endeavour to prove.

The diagonal frame.

The lower ranges of riders and trusses, which were brought on the upper surfaces of the floors and first futtocks, could have but little effect in preventing arching beyond that which arose from the additional resistance they offered to compression, and the additional rigidity they gave to the structure in the event of grounding, or of being ashore. They certainly served as a firm base upon which to erect a series of riders with diagonal trusses, which were more advantageously placed to afford efficient support to the extremities of the body. Yet these upper riders only extended to the securities of the gun-deck, and therefore not very far above the line of non-action. Presuming, however, that this second series of riders was of considerable utility, a firm base for them might probably have been obtained without so much incumbrance to the hold, and consequently without the objection being urged against it, which was made to the diagonal riders, of diminishing the stowage. According to the estimates made by Sir Robert Seppings, the actual cubical contents of the diagonal frame were less than those of the ceiling which it superseded.

Trussing between the ports.

The trussing between the ports has been discontinued in Her Majesty's ships. We cannot but regret the change, as we consider this was the most advantageous innovation connected with the diagonal system, and one in which the benefit was unaccompanied with compensating inconveniences.

In investigating the reasons on which we found this opinion, we shall merely describe the manner in which we consider this trussing must have acted, to prevent any alteration of form in the upper parts of the ship.

We commence, then, with the gun-deck of a three-decker. The gun-deck, from its proximity to the line of inaction, from the support of the trussed frame, which extended to its shelf, and from the wales, may be assumed, at least in a new ship, as a most firm base on which to raise a series of supports. At some point on the upper edge of the gun-deck spirketing, a shore, that is, the truss, firmly cleated at its heel, extended upwards and aft, in the after-body of the ship, to the lower edge of the middle-deck clamp, where it was securely cleated; immediately above the head of this shore a second was fixed on the upper edge of the middle-deck spirketing, and extended upwards to the lower edge of the main-deck clamp, where it was secured; and immediately over the head of this shore a third was secured, on the edge of the main-deck spirketing, and extended upwards to the lower edge of the quarter-deck clamp, where it was finally secured: so that a point in the range of securities to the quarter-deck was continuously and firmly shored up from a point in the most rigid and unalterable part of the ship; and, in the same manner, a series of points along the range of securities to the quarter-deck became shored up from the same foundation. This is in the after-body. In the fore-body a corresponding system of shoring ran in an opposite direction forward, and in a similar manner supported the range of securities of the forecastle, while each intervening deck partook of the same advantage.

Radiating as these shores did in opposite directions from the most rigid part of the ship as their base, while they afforded a series of points of support to the principal longitudinal ties, they formed with them a system of triangles; and the triangle is a figure which admits of no alteration of form; for as long as the sides remain the same, the angles are invariable. It might almost be said to be impossible, therefore, for the range of quarter-deck and forecastle securities, by which we mean the clamp, shelf, and water-way, to drop at the extremities, excepting in so far as the compressibility of the materials would admit.

To adapt another, and perhaps a stronger, view of this system of trussing, we may consider the whole top-sides of a ship, with the securities of the gun-deck as a base, to be a series of horizontal ranges of materials, supported by alternations of firmly secured triangles, so placed, that the bases of the superior ranges of these triangles derive firm support from the triangles of the inferior ranges. Considering the unalterability of form of the triangle, and the advantage of the pressure being brought upon the end grain, in which there is comparatively little shrinkage, this is certainly a mode of constructing a top-side which must be possessed of great rigidity. In fact, if there was an error in the system of trussing the top-sides adopted by Sir Robert Seppings, it was, that he did not extend it to the extremities, even round the bow and stern, and also apply a similar system to the short stuff outside between the ports.

The advantages to be derived from triangular combinations of the timber composing the hull of a ship are yet but imperfectly appreciated. We have no doubt that great improvement in ship-building is to be effected by these means, unless, indeed, timber should be superseded by iron, and the stupendous and costly line-of-battle ship be destined to give place to small but powerfully armed steamboats. An iron sailing vessel is being built in Scotland, of between five and six hundred tons burthen. It seems also not improbable that the introduction of so destructive a missile as the hollow shot into naval warfare, will render it expedient to diminish the aggregate loss from their effect, by lessening the size and increasing the number of the vessels used in naval battles. This is, however, as yet merely speculative.

Fill in the en- ings

Another important part of the diagonal system, as it is described in the foregoing account given by Sir Robert Seppings, was the making the bottom a solid mass, by filling in the openings between the frame-timbers. This we have already mentioned as most effective in resisting alteration in form. It possessed a more important advantage, in the immense additional safety it assured to the vessel in the event of grounding, or of starting a but of the plank. The introduction of the system of solid bottoms into the mercantile navy, which Mr Ballingall has so long and so strenuously urged, would be an incalculable advantage, not to the merchant or ship-owner, for the system of insurance is their refuge, but to a class of men of equal value to England with either merchant or ship-owner—seamen, whose lives are often most cruelly sacrificed to the present immunity from pecuniary loss which marine insurance guarantees to their employers.

We are no friends to the system of marine insurance. We doubt much whether the evils which have resulted from it, in the loss of human life, and its attendant miseries to survivors, the system of gambling which it encourages among all classes of commercial men engaged in it, and the fraud and crime which it often occasions, do not more than counterbalance its advantages, which, after all, may be summed up in this, that in the event of shipwreck, the merchant and ship-owner are indemnified for a loss which, in a majority of cases, would not have occurred had it not been for the recklessness and carelessness engendered by the very knowledge that this indemnification was to be purchased. We here advance no unsupported opinion: the Report of the committee of the House of Commons on shipwrecks says, "The system of marine insurance, though affording the means of protecting individuals from excessive loss, has nevertheless a tendency, by transferring the pecuniary responsibility for such losses from the owners of ships to the underwriter who insures them, to induce less care in the construction of ships, less efficiency in their equipment, and less security for their adequate management at sea; in as much as the risk of such loss to the ship-owners can be covered by a fixed premium of insurance, which, being charged on the freight, and then recharged on the goods conveyed, fixes the real responsibility and real loss ultimately on the public; as all the parties actually engaged in the transaction can insure themselves from any participation in such loss, by the aid of marine insurance." This, too, is from the Report of a committee composed principally of merchants, of ship-owners, and of ship-builders. But to return to our more immediate subject, though we can hardly call this a digression, connected as it is with the progress of the science we are writing on.

Modern diagonal supports, and system of building.

The system of wooden riders, longitudinal pieces, and trusses (Plate CCCCLVI. fig. 48), is now discontinued in Her Majesty's ships, and is superseded by a modification of the iron riders or braces, which were formerly only proposed by Sir Robert Seppings for frigates and the smaller classes of vessels. In the recent adaptation of these braces to line-of-battle ships, there are several material differences from the original plan. The ceiling, with its thick strakes over the heads and heels of the timbers, is restored, excepting that the planking between these thick strakes is laid diagonally, as shown in Plate CCCCLVII. fig. 49. There are also two ranges of iron riders; the lower range is brought upon the inside of the timbers of the frame, and the ceiling worked upon and scored over them. The upper ends of this range of riders extend forward in the fore-body and aft in the after-body, and the heads run high enough to turn out upon the orlop clamps, and bolt through them. The riders of the upper range give long shift to those of the lower range, and their direction crosses that of the lower range at right angles. Both ranges are very securely bolted through the bottom.

It will have been evident from the foregoing remarks, that we do not consider the hold as an advantageous situation for any great expenditure, either of workmanship or materials, simply for the purpose of preventing the alteration in the form of a ship.

After having obtained the greatest degree of incompressibility compatible with the materials used, the next object, in this part of the body, should be to insure adequate local strength to resist the strain of taking the ground; and we assume it for granted, that it is for this purpose the thick strakes at the heads and heels of the timbers have been restored, and also that the lower tier of iron riders is worked. The placing the ceiling diagonally between the several assemblages of thick strakes, was probably with an idea that it would act as a trussing; but, according to the views of the action of the disturbing forces which we have taken in this part of our article, it can have little, if any, effect in preventing alteration in form, beyond that of ceiling worked in the ordinary and less costly manner, and is inferior in other respects.

In the upper range of riders the iron bars are placed with their upper ends extending inwards from the extremities of the ship, offering a series of very effective ties, or braces, to connect the unsupported extremities of the vessel to the midship, or supported part, and to the firm basis of the zone about the surface of the water. This series of braces is unquestionably advantageous, and is also correct in principle, as affording support to the extremities of the vessel, by connecting them with the most unalterable part of the fabric, and to that portion which is abundantly supported by the external fluid. We think it probable that the additional strength resulting to the lower part of the vessel from the lower range is scarcely adequate to the additional expense incurred by working them, with all the accessory fastening and fitting. This method which we have described of strengthening the floor, has not near the rigidity to resist damage from grounding, of the system that it has superseded, which certainly did, according to the intention of the inventor, partake of the nature of an inverted arch, or rather dome. It has, however, one, and that too a very considerable advantage, over the wooden diagonal system, as it offers a fair surface for stowage.

The system of iron diagonal riders which we have described is that adopted in line-of-battle ships. There are several variations from this system, in its adaptation to the smaller classes of vessels. The general features are however the same. The modifications all tend more or less to simplify it in its details. There are, however, some instances in which the iron bars have their upper ends extending outwards, towards the extremities of the vessel, probably in order to assimilate them to trusses; but this is evidently, next to the vertical, the least advantageous position they could be placed in.

Stern.

Circular stern.

Of all the modern innovations in ship-building, the alteration from the square termination to the round in the sterns of ships was received with most general reluctance, so wedded is the eye to the forms it has been habituated to gaze upon; yet it may be fairly questioned whether, if cannon had been used for naval warfare when ships were first built, a square stern would have ever been constructed, and also whether the curvilinear termination to a body, every outline of which presents curves to the eye, is not more consistent with the requirements of a correct taste. Be these questions answered as they may, it is certain that the alteration was attended with a great local increase of strength in a part which had always previously been considered the most imperfectly combined in the whole hull. This was in consequence of the various changes in the timbering which were required to maintain the angles in the contour of the square stern. (Plate CCCCLIX.) First, the ends of the transoms were very insecurely connected with the sides of the ship; then the connexion between the counter-timbers and the transoms was equally insecure; and, lastly, the planking along the sides had no connexion with, and consequently formed no tie to, that on the stern. In the round stern, the timbers of the frame continue to give shift to each other, and to be firmly connected together all round the curve of the stern; the various internal supports are uninterrupted; and the principal planking, being continued from side to side, binds the whole together, and makes the stern little inferior to the broadside in local strength.

The object for which the circular stern was introduced was not so much increased strength in mechanical structure, as increased strength in defence from attack. Most of the modifications of the round stern which have been introduced to preserve the appearance of the square form, and yet obtain the same increase of means of defence or of aggression, have been considerable improvements in point of mechanical construction on the old square stern, but they are certainly inferior to the circular stern in strength. This is partly in consequence of the great rake given to them, which also diminishes the advantage that was the object of the original alteration; the increase of the means of attack or defence, as the explosion from the muzzle of the gun will scarcely clear the ship's side.

The great extent to which this rake is now carried is exemplified by comparing the rake of the stern of the Queen, an English first-rate, which is three feet nine inches in ten feet, with the rake of the stern of the Achille, a French line-of-battle ship, which is only two feet two inches in ten feet. We quite grant the beauty of appearance arising from the rake of the stern; but beauty of appearance is not an essential for a ship of war. In fact, we believe that the stern adapted for a ship of war is yet to be designed, and that sterns will eventually be towers of strength, nearly vertical from the counter to the taffrail.

The three modifications of ships' sterns of which we have been speaking will perhaps be more clearly understood by an examination of Plate CCCCLIX.

Bows.

The drawings (Plate CCCCL.) which we have selected for exemplifying the various plans, sections, and lines connected with the draught and the laying off, are those of the Vindictive, a frigate having an important improvement in the form of the bow above water, introduced by Mr Blake, the master-shipwright of Portsmouth yard, by which her battery for chase is very considerably increased in strength and efficiency. These advantages are gained without the loss of any strength, and without the addition of cost, in building; so that it is highly to be desired that this ship should have a fair trial at sea. The stern of this ship is a modification of the circular formed stern, also from the design of the same gentleman.

We shall now proceed to notice some of the peculiarities observable in the French practice of ship-building. The characteristic difference in their system from our own, which would strike an observer accustomed to English ship-building, would evidently be a less expenditure of material.

Frenc ship-b ing.

The French have retained the old system of frames and filling timbers. Frequently the frames are close jointed throughout their height, and the filling frames put up as single timbers, as is shown in fig. 50, Plate CCCCLVIII. The filling timbers are also frequently of fir. Both frames and filling timbers are chain-bolted. There is no shelf under the beams, only a thick clamp, and a wide chock worked upon the short stuff, and up to the beam (Plate CCCCLVIII. fig. 45). There are generally three side binding strakes faced one inch on, and scored one inch over the beams, and bolted together by in and out bolts passing through the water-way, which is also faced and scored in the same manner. These bolts are secured with nuts and screws at the points, on the outside plank.

Water way.

The water-way is not always scored over the beams, but is sometimes brought plain on their ends (fig. 46). The bolts of the binding strakes, which are then also merely brought on to the beams, secure its lower edge; and in both cases it has in and out bolts through the ship's side, to secure its upper edge.

Beam

The method of connecting the beam-ends with the ship's side, which appears to be most generally adopted in the French ships at present, consists of a chock under the beam (fig. 45), securely bolted through the ship's side, the points of the bolts being set up with a nut and screw. The beam-end hooks over the head of this chock. A plate-knee similar in shape to that known in the English service as Roberts' knee is brought on each side against the chock and beam; but these knees, instead of having a short arm against the ship's side for taking in and out fastenings, themselves form the bolt, each knee having an arm which is driven through the side by means of a shoulder worked in the knee, similar to the shoulder of a dog-bolt. The outer end is secured by a nut and screw. The security of the plate-knees to the beam and chock consists only of three screws in each arm, and one screw in the diagonal brace. These screws are not above five inches long. Thus the security of either knee is completely unconnected with that on the opposite side of the beam.

Plank

The wales, diminishing stuff, and plank of the bottom, are all treenail-fastened, the buts are secured with two bolt-nails in the timber on which the but is placed, and a through-bolt is driven in the timber next the but. In some instances the plank is nail-fastened, but whether with nails or treenails it is double fastened. The treenails are not caulked on the ceiling, but wedged with conical wedges. Most of the principal bolts, as those of the water-ways and chocks, under the beams, are set up outside with a nut and screw; and great care is taken to omit the fastening of the wales and outside planking, wherever these bolts can be advantageously made to answer as fastenings for them.

There is no regular system observed in shifting the buts of the plank, as there is in the English service; but the planks are worked to their full length, without reference to the shift: the only rule which appears to be observed is, that

La hing.

there shall be about two feet shift between the buts of following strakes.

Rather an interesting experiment as to the possibility of diminishing the scantling of the timber, to any great extent, which is used for building large ships, is in progress in the French navy. The Surveillante, a large frigate, was built wholly of small timber, about ten years ago, and as yet the reports on the system are favourable.

The following is an outline of the plan on which she was built.

Sm tim-
ber

The keel, stem, and stern-post are formed of various pieces of timber combined as in the section, Plate CCCCLVIII. fig. 51.

The several lengths of the centre piece, or core, are scarphed together, while the side or strengthening pieces only but with plain buts; care being taken that the buts and scarphs give good shift to each other.

There are in this system no other frames than those which form the sides of ports, and the timbers composing these frames are bolted together, without leaving any opening between them, that is, close jointed. The spaces between the frames are filled in with single timbers, or rather with a frame-work of timber fitted together in the manner shown in fig. 52.

The cant-bodies are framed as in the ordinary method, the after-body timbered round to the post without transoms or fashion-pieces.

From the main-deck upwards the scantlings of the frames are not different from those of a ship of a similar size built in the usual manner; but below this line there is a very considerable reduction. This reduction commences at the lower edge of the gun-deck clamps, and there a couple of thick strakes are worked up to the lower edge of these gun-deck clamps, to form an abutment for a series of internal timbers, brought on the inner surface of the timbers of the frame, and crossing them at an angle of 45°, the upper ends being placed forward in the fore-body, and aft in the after-body. These timbers but at their heels on the heads of a series of internal floor-timbers, brought on the upper surfaces of the floors of the frame. These internal floors are laid athwartships. The openings between the timbers of this internal diagonal frame are filled in with wedge-fillings, so that the whole hold presents one smooth surface for stowage.

Wherever there is an athwartship bulk-head, there is a system of riders worked on the inner surface of this diagonal frame, but taking a vertical direction. The timbers of these bends of riders are not wrought side by side, but one series of timbers is worked on the inner surface of the other, and the bolts pass in and out through both, and through the bottom. These riders run up to the lower deck, and a beam is so disposed with respect to each bend of riders, as to be secured to their heads, and form a part of the system. The bulk-heads which necessarily fill in the space between the beam and the riders run diagonally up on either side the middle from a midship pillar to the beam and riders. Each bulk-head is water-tight.

On Launching.

La hing.

Ships are generally built on blocks which are laid at a declivity of about $\frac{5}{8}$ths of an inch to a foot. This is for the facility of launching them. The inclined plane or sliding plank on which they are launched has rather more inclination, or about $\frac{7}{8}$ths of an inch to the foot for large ships, and a slight increase on this for smaller vessels. This inclination will, however, in some measure depend upon the depth of water into which the ship is to be launched.

While a ship is in the progress of being built, her weight is partly supported by her keel on the blocks, and partly by shores. In order to launch her, the weight must be taken off these supports, and transferred to a moveable base; and a platform must be erected for the moveable base to slide on. This platform must not only be laid at the necessary inclination, but must be of sufficient height to enable the ship to be water-borne, and to preserve her from striking the ground when she arrives at the end of the ways.

Launching.

For this purpose, an inclined plane, *a*, *a* (Plate CCCCLVIII. figs. 53, 54), purposely left unplaned to diminish the adhesion, is laid on each side the keel, and at about one sixth the breadth of the vessel distant from it, and firmly secured on blocks fastened in the slipway. This inclined plane is called the sliding plank. A long timber, called a bilgeway, *b*, *b*, with a smooth under surface, is laid upon this plane; and upon this timber, as a base, a temporary frame-work of shores, *c*, *c*, called "poppets," is erected to reach from the bilgeway to the ship. The upper part of this frame-work abuts against a plank, *d*, temporarily fastened to the bottom of the ship, and firmly cleated by cleats, *e*, *e*, also temporarily secured to the bottom. When it is all in place, and the sliding-plank and under side of the bilgeway finally greased with tallow, soft soap, and oil, the whole framing is set close up to the bottom, and down on the sliding plank, by wedges, *f*, *f*, technically called slivers, by which means the ship's weight is brought upon the "launch."

When the launch is thus fitted, the ship may be said to have three keels, two of which are temporary, and are secured under her bilge. In consequence of this width of support, all the shores may safely be taken away. This being done, the blocks on which the ship was built, excepting a few, according to the size of the ship, under the foremost end of the keel, are gradually taken from under her as the tide rises, and her weight is then transferred to the two temporary keels, or the launch; the bottom of which launch is formed by the bilgeways, resting on well-greased inclined planes. The only preventive now to the launching of the ship is a short shore, called a dog-shore (*g*), on each side, with its heel firmly cleated on the immoveable platform or sliding plank, and its head abutting against a cleat (*h*), secured to the bilgeway, or base of the moveable part of the launch. Consequently, when this shore is removed, the weight of the ship forces her down the inclined plane to the water. To prevent her running out of her straight course, two ribbands are secured on the sliding plank, and strongly shored. Should the ship not move when the dog-shore is knocked down, the blocks remaining under the fore part of her keel must be consecutively removed, until her weight overcomes the adhesion, or until the action of a screw against her fore foot forces her off.

French method of launching.

Fig. 55 (Plate CCCCLIII.) will give an idea of a method of fitting the launch which is practised in the French yards. It must be observed, that the plan requires a firm foundation to the slipway, and therefore it is not generally applicable.

The two pieces (*a*, *a*) which are shown in the figure as being secured to the ship's bottom, are the only pieces which need be prepared for each ship; the whole of the remainder will be available for every launch. These pieces were, in the launch fitted to the bottom of a fifty-gun frigate, seven inches thick on their outer edges at the midship bend, and were in length one third that of the ship.

A space scarcely more than half an inch was left between them and the baulk-timber, which was placed beneath them (*b*, *b*), as it was not intended that the ship should bear on these baulk-timbers in launching; they are only to support her in the event of her heeling over. The ship was intended to launch wholly on the sliding plank (*c*), which was fitted under the keel. This sliding plank was, in the case in question, about four inches thick. The groundways were of baulk-timber, laid about four feet apart, extending across the slip; between these groundways stacks of blocks were built, so that the sliding plank was supported along its whole

Launching.

length with scarcely greater intervals than about fifteen inches between the supports. The slip was cut from out of the solid rock.

Launching without subsequent docking.

Fig. 56 (Plate CCCCLIII.) represents a section of a method of launching a ship which has been coppered on the slip, and which therefore need not be afterwards docked for that purpose. This method of fitting the launch avoids the necessity of docking to remove the launch, by not having any part secured to the ship. The two sides of the cradle are prevented from being forced apart when the weight of the ship is brought on them, by chains passing under the keel. Each portion of frame-work composing the launch has two of these chains attached to it, and brought under the keel to a bolt *a*, which passes slackly through one of the poppets, and is secured by a strong fore-lock *b*, with an iron handle *c* reaching to the ports, at which, when the ship is afloat, it may be drawn out of the bolt; the chain then draws the bolt *a*, and in falling trips the cradle from under the bottom. There should be at least two chains on each side secured to the fore-poppets, two on each side to the after-poppets, and two on each side to the stopping-up (fig. 54); and this is only for the launch of a small ship. The number will necessarily increase with the weight of the vessel.

Launchi

Experi- ments o fastenin

We close this article with some most valuable tables of experiments. The first is compiled from one in Moseley's Illustrations of Mechanics, the other three we have been kindly favoured with by Mr Parsons, a member of the late School of Naval Architecture, and formerly belonging to Her Majesty's dock-yard service. These experiments, with a number of others on various securities, were most carefully made by this gentleman; and we regret much that he has not yet made them public to the world, as we are not aware of any similar information being accessible to naval architects or to engineers.

" *Table of the Tenacities of different Substances, and the Resistances which they oppose to direct Compression.*

Substances Experimented on.	Tenacity, in Tons, per Square Inch.	Name of the Experimenter.	Crushing Force, in Tons, per Square Inch.	Name of the Experimenter.
Wrought iron,				
in bars, Russian (mean)	27	Lamé.		
— English (mean)	25½	—		
— hammered	30	Brunel.		
rolled in sheets and cut lengthways	14	Mitis.		
ditto cut crosswise	18	—		
Cast iron, quality No. 1	6 to 7¾	Hodgkinson.	38 to 41	Hodgkinson.
— — No. 2	6 to 8	—	37 to 48	—
— — No. 3*	6 to 9¾	—	51 to 65	—
Copper, cast	8½	Rennie.	52	Rennie.
— hammered	15	—	46	—
— sheet	21	Kingston.		
— wire	27⅓	—		
Ash, specific gravity, ·6	8	Barlow.		
Teak, — ·9	7	—		
Oak, — ·92	5	—	1·7	—
Oak, — ·77	4	—		
Fir, — ·6	5	—		
Mahogany, — ·637	3½	—		
Elm	6		·57	—
Pine, American	6		·73	—
Deal, white	6		·86	—

* " The strongest quality of cast iron is a Scotch iron known as the Devon hot-blast, No. 3; its tenacity is 9¾ tons per square inch, and its resistance to compression 65 tons."

" *Table of the Adhesion of Iron and Copper Bolts driven into sound Oak with the usual Drift,*† *not clenched, and subjected to a direct Strain, as in fig. 57.*

Diameter of the Bolt.	Number of the Experiment.	Iron.				Copper.			
		Length of the Bolt driven into the Wood.							
		Four Inches.		Six Inches.		Four Inches.		Six Inches.	
Inches.		Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
¼...	1	1	13	...		0	18½	...	
	2	2	0	...		0	18	...	
	3	2	2	...		0	19	...	
	4	1	13	...		0	18	...	
⅜...	1	2	6	2	12	1	7	2	2
	2	2	4	2	11	1	8	2	2
	3	2	4	2	16	1	10	2	2
	4	2	0	2	10	1	13	2	0
½...	1	3	2	3	12	2	10	2	15
	2	3	4	4	0	1	17	3	10
	3	3	0	4	0	2	2	3	1
	4	2	10	4	0	2	5	2	15
⅝...	1	3	2	5	5	3	0	4	5
	2	3	0	4	8	3	6	3	18
	3	3	1	4	8	3	6	3	15
	4	3	1	5	0	2	9	3	5
¾...	1	3	3	6	0	3	10	5	5
	2	3	2	6	0	3	10	5	5
	3	3	10	5	0	3	10	5	8
	4	3	10	6	0	3	18	4	18
⅞...	1	4	10	6	2	4	0	4	13
	2	5	12	5	10	4	0	4	13
	3	3	10	6	11	4	5	4	19
	4	4	10	6	4	4	2	4	19
1...	1	5	0	7	2	4	2	5	19
	2	4	7	8	1	4	8	5	0
	3	4	11	6	5	3	15	6	5
	4	4	0	7	0	4	10	5	0

† Drift is an allowance made to insure sufficient tightness in a fastening; it is therefore the quantity by which the diameter of a fastening exceeds the diameter of the hole bored for its reception.

“ In Riga fir the adhesion was on an average about one third of that in oak, and in good sound Canada elm it was about three fourths of that in oak.

“ *Table of the Strength of Clenches and of Forelocks, as securities to Iron and Copper Bolts, driven six inches, without Drift, into sound Oak, either clenched or forelocked on Rings, and subjected to a direct Strain, as in fig.* 57.

Diameter of the Bolt.	Number of the Experiment.	Iron.				Copper.			
		Clench.		Forelock.		Clench.		Forelock.	
Inch.		Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
¼…	1	1	16	0	16	1	0	0	8
	2	1	13	0	14	0	19	0	8
	3	1	9	0	20	1	0	0	7
	4	1	9	0	18	1	0	0	6
⅜…	1	3	0	1	15	2	10	1	4
	2	3	0	1	8	2	10	1	0
	3	2	16	1	9	2	5	1	2
	4	2	15	1	14	2	9	1	4
½…	1	4	15	2	11	3	10	1	18
	2	4	10	2	15	3	15	1	18
	3	4	5	2	10	4	0	2	4
	4	4	12	2	12	4	10	1	16
⅝…	1	5	18	3	15	6	0	2	13
	2	6	8	3	6	5	15	2	10
	3	6	8	3	0	6	5	2	16
	4	6	0	3	7	5	10	2	10
¾…	1	7	10	3	10	7	0	…	
	2	7	10	3	15	7	0	…	
	3	8	0	3	10	7	5	…	
	4	8	15	3	15	7	8	…	
⅞…	1	11	11	5	1	7	16	…	
	2	11	15	5	10	7	16	…	
	3	8	11	4	6	7	12	…	
	4	8	6	4	15	7	5	…	
1…	1	12	0	5	18	7	1	…	
	2	12	3	6	18	7	1	…	
	3	11	3	5	12	7	14	…	
	4	11	1	5	2	8	14	…	

“ In the experiments on the clenches, the clenches always gave way; but with the forelocks it as frequently occurred that the forelock was cut off as that the bolt broke; and in the cases of the bolt breaking, it was invariably across the forelock hole. According to the tables, the security of a forelock is about half that of a clench.

“ It appears an anomaly that the strength of a clench on copper should be equal to that of one on iron. But, in consequence of the greater ductility of copper, a better clench is formed on it than on iron. Generally the thickness of the fractured clench in the copper was double that in the iron. With rings of the usual width for the clenches, the wood will break away under the ring, and the ring be imbedded for two or more inches before the clench will give way.

“With the inch copper bolts, all the rings under the clenches turned up into the shape of the frustum of a cone, and allowed the clench to slip through at the weights specified.

“ Experiments with ring-bolts were made to ascertain the strength of the rings in comparison with the clenches. The rings were of the usual size, viz. the iron of the ring one eighth inch less in diameter than that of the bolt. It was found that the rings always carried away the clenches, but that they were drawn into the form of a link with perfectly straight sides. The rings bore, before any change of form took place, not quite one half the weight which tore off the clenches. It appears that the rings are well proportioned to the strength of the clenches.

“ *Table of the Transverse Strength of Treenails of English Oak used as fastening for Planks of three and of six inches in thickness, and subjected to a Strain, as shown to be applied in fig.* 58.

Number of the Experiment.	Diameter of the Treenails.															
	1 Inch.				1¼ Inch.				1½ Inch.				1¾ Inch.			
	Thickness of the Plank.															
	3 In.		6 In.		3 In.		6 In.		3 In.		6 In.		3 In.		6 In.	
	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.
1	1	8	1	7	1	14	2	8	2	0	3	12	3	0	5	10
2	1	7	1	15	2	2	2	2	2	6	2	10	2	10	3	13
3	1	2	1	8	1	17	2	19	2	15	2	10	4	0	4	0
4	1	5½	1	8	2	2	2	2	2	4	3	12	2	8	3	8
5	2	12	1	3	2	2	1	15	2	18	2	5	3	10	4	0
6	2	2	1	7	2	9	2	10	2	6	2	5	3	10	5	8
7	2	4	1	10	2	8	2	10	3	7	2	5	3	5	3	12
8	1	6	2	3	2	7	2	0	2	5	3	0	3	5	3	13
9	1	8	1	8	2	12	2	10	3	0	4	0	4	6	4	13
10	1	2	2	3	2	10	2	15	3	0	4	10	3	8	4	0
11	2	0	2	0	2	7	2	0	3	9	2	18	4	0	3	8
12	1	8	1	7	2	10	2	0	4	2	3	0	4	10	5	0
13	1	16	2	8	2	17	2	0	3	2	3	18	4	2	5	5
Average	1	11	1	13	2	6	2	6	2	16	3	2	3	10	4	6

“ In all these experiments on treenails, when the treenails were evidently good, they gave way gradually. In some of the rejected experiments, however, the treenails certainly did break off suddenly, but then they were evidently on examination either bad or over-seasoned treenails. It is no uncommon remark in caulking down the bottom of a vessel, that the caulkers break off the treenails by caulking, and that they hear them crack or break off suddenly. Now I do not believe that this cracking of the treenails takes place so frequently as it is supposed. What the men hear is the starting of the plank on the different fastenings. It has been asserted that the treenails made from the Sussex oak are much stronger than those made from the New Forest timber, or any other English oak. To ascertain the truth of this assertion, some experiments were made with Sussex and New Forest treenails of all sizes; and the result was, that there was not the least difference in them, the New Forest were on experiment quite as strong as the Sussex.

“ In the experiments on treenails, the plank generally moved about half an inch previous to the fracture of the treenail.”

(B. Z.)

SHIPSTON-ON-STOUR, a town of the hundred of Oswaldslow, in the county of Worcester, but detached from it, and surrounded by Gloucestershire. It is eighty-three miles from London, has little trade except what arises from its great sheep-fairs. It has a large market on Friday. The population amounted in 1801 to 1293, in 1811 to 1377, in 1821 to 1562, and in 1831 to 1632.

Ship-Money was an imposition charged upon the ports, towns, cities, boroughs, and counties of England, in the reign of King Charles I., by writs, commonly called ship-writs, under the great seal of England, in the years 1635 and 1636, for the providing and furnishing of certain ships for the king's service, which was declared to be contrary to the laws and statutes of this realm, the petition of right, and the liberty of the subject, by statute 17 Car. I. c. 14.

SHIRAZ, or SHIRAUZ, a large city of Persia, the capita' of the province of Fars, and, at different periods, of the whole kingdom. According to Fraser, the city of Shiraz is situated in the midst of a brown, barren plain, without a village or any living thing, to relieve it. There were, when he visited the place, only one or two gardens on the wide expanse, which resembled black spots in the desert. He adds, that a nearer view does not present any more favourable impression, the aspect of its mud-walls, surrounded with ruins and broken ground, impressing the most gloomy ideas. Kinneir, on the other hand, gives a different account of its

Shiraz.

appearance, which, he says, is pleasing rather than grand, the city being surrounded with many beautiful gardens. The season of the year when Shiraz was visited by the former traveller seems, however, to have been unfavourable for the display of vegetable beauty; and he accordingly observes, that at this time the richer and irrigated spots were burnt up; and to this circumstance may be traced the discrepancy in the accounts of these two writers. All travellers, however, agree in their account of the interior of the city, which has an extremely mean appearance; the houses are small, and the streets narrow and filthy.[1] Every thing within the town marks the total neglect of even the attempt at improvement. The bazaars and maidans or colleges are falling into ruins; the streets are choked with dirt, and with heaps of ruins from decaying houses; their inmates squalid and insolent, crawling forth in a state of rags and wretchedness, which, Sir R. Porter says, no pen can describe. The impure state of the water brought into the city affords one among many gross instances of public neglect, more especially considering the abundant supply of this pure element with which the city was furnished in ancient times, and the facility with which the spring at the tomb of Sadi, or the limpid rills of the Rocknabad, might again be introduced and distributed for the supply of the city. The town has six gates, and is divided into twelve districts or parishes, in which there are fifteen considerable mosques, besides many others of inferior note, eleven colleges, fourteen bazaars, thirteen caravanserais, and twenty-six mumniums or baths.

Of the mosques, the Mesjed Ali, built in the khalifat of Abbas, is the most ancient, and the Mesjed No the largest. It was converted from a palace to a mosque by Attabek Shah, whose son was lying in a dangerous illness, and who, consulting one of the priests, was answered, that for the recovery of his son he must devote to the Almighty that which of all his worldly goods he valued most. The Mesjed Jumeh is likewise an ancient structure; and there are six others of an older date than the time of Kerim Khan. Of the modern mosques the Mesjed Vakeel, the only one built by this prince, is the most beautiful. Of the colleges, one of the earliest was founded by Imaum Kouli Khan. Kerim Khan began a college which he never finished; and another was founded by Haushem, father of Hajee Ibrahim, the vizir of the late king. The great bazaar, or market-place, was built by Kerim Khan, and forms a contrast to the mean appearance of the other parts of the city. It is about a quarter of a mile in length, made of yellow burnt brick, and arched at the top, with numerous sky-lights, which, with its doors and windows, always admit of sufficient light and air, whilst the sun and the rain are completely excluded. The bazaar is allotted to the different traders in the city, all of whom have their separate quarter, in which their shops are extended adiacent to each other on both sides of the building.

Of the caravanserais, the one built by Imaum Kouli Khan, and now in ruins, is the most ancient. There is another old structure, which was restored from a state of great decay, and assumed the name of its second founder, Ali Khan. There are five others; one for the dressers of sheep-skins for caps, another for dyers, and one for Hindoos. Three other caravanserais were added by Kerim Khan, and two others have been since erected. The ark or citadel, in which the governor of Fars resides, is a fortified square of eighty yards. The royal palace within is far from being an elegant structure; and some of its finest ornamental pillars were removed by Aga Mahommed Khan to adorn his palace at Teheran.

The environs of Shiraz, in its ancient splendour, have furnished a theme for poets, and have been celebrated by Hafiz, the favourite bard of Persia, who was a native of this city, and who is buried in a small garden about half a mile from the town. A monument was erected to his memory by Kerim Khan; it is placed in the court of a pleasure-house which was much frequented by the poet; the building has a small court before it and another behind, and in the centre is an open vestibule, supported by four marble columns, opening on each side into neat apartments. The tomb is placed in the back court, at the foot of one of the cypress trees which he planted with his own hands. It consists of a block of white marble in the form of a coffin, exquisitely carved. One of the poet's odes is inscribed on the marble, and the letters appear as if they had been sculptured with the finest pen, rather than carved with a chisel. Sir R. K. Porter, who visited this tomb ten years after Morier, gives a melancholy account of the decay which has taken place in the interval, from neglect: the spot is no longer held sacred, being covered with promiscuous graves; the trees are gone, and the stone itself, already defaced, will not, unless it be secured from profane hands, long remain the memorial of departed genius. The population of Shiraz has been variously estimated at from 40,000 to 10,000. M. Morier, who was at some pains to make an accurate estimate, says 19,000. The commerce of the city is of some extent, and has been increasing of late years. The principal trade is with Bushire, through whose ports is brought into the country a supply of foreign produce and manufactures, such as sugar, pepper, cinnamon, chintz, glass, hardware, piece-goods, &c. These articles are exported to Yezd and Ispahan, and the manufactures of these cities received in return. The prosperity of Shiraz decayed after the death of Kerim Khan; its commerce was diverted into other channels, and its numerous manufactures perished for want of purchasers. Two, however, have survived, and are prosecuted with diligence and success; one is making glass for windows, bottles, and goblets, which are sold all over the kingdom; the second is the formation of sword-blades and daggers, which are deemed excellent for general use. In the hills which bound the plain of Shiraz, was formerly produced a wine which is celebrated over all the east. Long. 52. 44. E. Lat. 29. 36. N.

SHIRE is a Saxon word signifying a division; but a county, *comitatus*, of the same import, is plainly derived from *comes*, the count of the Franks; that is, the earl or alderman, as the Saxons called him, of the shire, to whom the government of it was intrusted. This he usually exercised by his deputy, still called in Latin *vice-comes*, and in English the sheriff, shrieve, or shire-reeve, signifying the officer of the shire; upon whom, in process of time, the civil administration of it totally devolved. In some counties there is an intermediate division between the shire and the hundred; as lathes in Kent and rapes in Sussex, each of them containing about three or four hundred a piece. These had formerly their lathe-reeves and rape-reeves, acting in subordination to the shire-reeve. Where a county is divided into three of these intermediate jurisdictions, they are called trythings, which were anciently governed by a trything-reeve. These trythings still subsist in the large county of York, where, by an easy corruption, they are denominated *ridings;* namely, the north, the east, and the west ridings.

SHIRT, a loose garment, commonly of linen or cotton, worn next the body. Shirts were not worn by the Jews, Greeks, or Romans, but their place was supplied by thin *tunicæ* of wool. The want of linen among the ancients made frequent washings and ablutions necessary.

SHIRVAN, or SCHIRVAN, a province in the north of Persia, now claimed by Russia. It is the largest and most important division of the Southern Caucasus. It extends along the Caspian, 200 miles from the mouth of the Cyrus, to the little river Rubas; and forms a large triangular peninsula, the point of which stretches into the Caspian. From its form it varies extremely in breadth, which, at the extremity of the peninsula on the Rubas, is scarcely sixteen miles; near Kuba it amounts to forty; from the mouth of the Ata it is above fifty; while in the interior part it amounts to 160. It has the Caspian to the east; Daghestan to the north; the Kur and the plains of Mogam to the south and south-west, being separated by the river Kur from the provinces of Ghilan and Azerbijan; and the kingdom of Georgia to the north-west. The northern part of this province consists of a plain, which is formed by the mountains that extend toward the sea near Derbend, and which, gradually receding behind that city, approach again in a circular form near the sea at the mouth of the river Ata. Numerous streams, issuing from the mountains, greatly contribute to fertilize this plain, and, at the same time, to secure it against the access of an invading army. They branch off in various directions, and being generally mountain-streams, are uncommonly rapid, though they are shallow, with a wide channel, and a rough and sandy bed. The plain is interspersed with small woods and clumps of bushes, and the villages are surrounded with orchards, vineyards, and plantations of mulberries. The second division of Schirvan extends on one side along the coast from the Ata to the plains watered by the Kur; and on the other it is bounded by the higher range of mountains, which run in a south-east course through the province. The length of this district is about eighty miles; but as the coast projects considerably, the breadth varies. The higher portions of the country are here the most fertile; the part towards the sea is barren, being devoid of water; and to the north of Baku is a desert tract of about fifty miles. The plain along the left of the Kur is about 140 miles in length, and from forty to fifty in breadth. The district is in a great degree surrounded with mountains, and, being exposed to frequent inundations, is overgrown with rushes to a considerable distance. The most elevated division of Schirvan is that which extends from the Rubas to Lesgestan. This tract varies much in breadth, and is intersected by narrow valleys, in many of which are small lakes, which continue filled even in the greatest heat of summer. This province is abundantly watered by streams, which fall, some into the Caspian, and others into the Kur. The most considerable are the Samur, Deli, Sagaite, and Persagat. This province was annexed to Persia in the year 1500, and continued subject to that empire till the decline of the Sefi dynasty, when the native princes, taking advantage of the weakness of Persia, re-established their independence. Of late, however, the Russians have obtained possession of the sea-coast, though the interior is still in the hands of the native chiefs. The principal towns are Schamachi, the capital, and Baku.

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[1] Narrative of a Journey into Khorassan, p. 94; Geographical Memoir of the Persian Empire, p. 62.

SHOAD, among miners, denotes a train of metallic stones, serving to direct them in the discovery of mines.

Shoad-Stones, a term used by the miners of Cornwall and other parts of this kingdom, to express such loose masses of stone as are usually found about the entrances into mines, sometimes running in a straight course from the load or vein of ore to the surface of the earth.

SHOAL, in the sea-language, denotes a place where the water is shallow; and likewise a great quantity of fishes, such as a *shoal of herrings*.

SHOAL-WATER BAY, on the east coast of New Holland, visited by Captain Flinders in 1802. Long. of Aken's island at its entrance, 150. 15. E. Lat. 22. 21. S.

SHOE, a small island in the Pacific Ocean, near the coast of Waygoo. Long. 130. 53. E. Lat. 0. 1. S.

Shoe, a covering for the foot, usually of leather. Shoes among the Jews were made of leather, linen, rush, or wood; those of soldiers were sometimes of brass or iron. They were tied with thongs, which passed under the soles of the feet. To put off their shoes was an act of veneration; it was also a sign of mourning and humiliation. To bear one's shoes, or to untie the latchets of them, was considered as the meanest kind of service.

Among the Greeks, shoes of various kinds were used. Sandals were worn by women of distinction. The Lacedæmonians wore red shoes. The Grecian shoes generally reached to the middle of the leg. The Romans used two kinds of shoes; the *calceus*, which covered the whole foot, somewhat like our shoes, and was tied above with latchets or strings; and the *solea* or slipper, which covered only the sole of the foot, and was fastened with leathern thongs. The calceus was always worn along with the toga when a person went abroad; slippers were put on during a journey and at feasts, but it was reckoned effeminate to appear in public with them. Black shoes were worn by the citizens of ordinary rank, and white ones by the women. Red shoes were sometimes worn by the ladies, and purple ones by the coxcombs of the other sex. Red shoes were put on by the chief magistrates of Rome on days of ceremony and triumphs. The shoes of senators, patricians, and their children, had a crescent upon them, which served for a buckle; and these were called *calcei lunati*. Slaves wore no shoes; and hence they were called *cretati*, from their dusty feet. Phocion also and Cato of Utica went without shoes. The toes of the Roman shoes were turned up in the point; and hence they were called *calcei rostrati*.

In the ninth and tenth centuries the greatest princes of Europe wore wooden shoes, or the upper part of leather and the sole of wood. In the reign of William Rufus, a great beau, Robert, surnamed the horned, used shoes with long sharp points, stuffed with tow, and twisted like a ram's horn. It is said that the clergy, being highly offended, declaimed with great vehemence against the long-pointed shoes. The points, however, continued to increase till, in the reign of Richard II., they were of so enormous a length that they were tied to the knees with chains, sometimes of gold, sometimes of silver. The upper parts of these shoes were in Chaucer's time cut in imitation of a church window. The long-pointed shoes were called crackowes, and continued in fashion for three centuries, in spite of the bulls of popes, the decrees of councils, and the declamations of the clergy. At length the parliament of England interposed by an act passed in the year 1463, prohibited the use of shoes or boots with pikes exceeding two inches in length, and forbade all shoemakers from making shoes or boots with longer pikes, under severe penalties. But even this was not sufficient. It was necessary to denounce the dreadful sentence of excommunication against all who wore shoes or boots with points longer than two inches. The present fashion of shoes was introduced in 1633, but the buckle was not used till 1670.

Shoe of an Anchor, a small block of wood, convex on the back, and having a small hole, sufficient to contain the point of the anchor-fluke, on the fore-side. It is used to prevent the anchor from tearing or wounding the planks on the ship's bow, when ascending or descending; and for this purpose the shoe slides up and down along the bow, between the fluke of the anchor and the planks, as being pressed close to the latter by the weight of the former.

SHOKET, a village of Syria, in the pachalic of Damascus, on the Orontes, 140 miles north of Damascus.

SHOLAPOOR, a town and district of Hindustan, province of Bejapoor, situated in about the 18th degree of latitude. The town is 125 miles south-east from Poorat. Long. 75. 40. E. Lat. 17. 43. N.

SHOLAVANDEN, a town of Southern India, district of Madura, ten miles north-west from the town of Madura. Long. 78. 10. E. Lat. 9. 50. N.

SHOOTING.

The pursuit and destruction of wild animals for security, food, clothing, or pastime, have been amongst the occupations of men in all ages, since the primeval *bruerè* overspread the earth,

> And wild in woods the noble savage ran.

Before the more refined arts are introduced into any country, the chase is a necessity, and the chief business of life. The stronger and more noxious animals are destroyed for individual safety; the weaker for food. It is not until civilization and her handmaid luxury have seated themselves, that the chase becomes a pastime. It does not appear when the sportsman first sprang into existence. There is no corresponding word in any ancient language, since that could not be called a sport which was a necessity. It is probable that in the earliest ages of society the dog was the sole agent employed by the hunter. Afterwards various weapons, manual, missile, and projectile, as the club, the dart, the arrow, were used by the hunter and fowler. Then would follow springes, traps, nets, and all that class of devices for the capture of beasts and birds *feræ naturæ*, comprehended in the term toils. As dogs were employed to hunt quadrupeds, so, in process of time, hawks were trained to bring down birds for the service of their master. The arbalest, or cross-bow, preceded the matchlock, which, however, could scarcely be called an implement of the chase, but which, in the order of succession, brings us down to the rifle, and original fowling-piece with its long heavy barrel and flint and steel lock; and, lastly, we arrive at the double barrels and detant locks of the modern shooter.

In the days of the Saxon and Norman kings, and long previously, the Britons were famous for their skill in archery, both in war and in the chase. The feats of the bow were often introduced into the songs of the bards of the ancient Britons, and into the ballads of the Troubadours.

Archery.

Archery is now confined to shooting at the target. Ladies not unfrequently contend for the prize in this elegant amusement. Their bows, however, are not such as were used by the amazons of yore, nor are those of the gentlemen of the archery clubs such as decided the battle of Cressy.

Falconry.

Falconry, coeval with, and subsequent to the decline of archery, occupied that rank in British field sports which is now enjoyed by shooting. Falconry is of high antiquity; but at what time hawks were first trained to the sport does not appear. Aristotle informs us that "there was a district in Thrace, in which the boys used to assemble at a certain time of the year, for the sake of bird-catching; that the spot was much frequented by hawks, which were wont to appear on hearing themselves called, and would drive the little birds into the bushes, where they were caught by children; and that the hawks would even sometimes take the birds and fling them to these young fowlers, who, after finishing their diversion, bestowed on their assistants part of their prey." Martial has the following epigram on the fate of a hawk:

> Prædo fuit volucrum, famulus nunc aucupis, idem
> Decipit, et captas non sibi, mœrit, aves.

There is no record of trained hawks previous to the time of Ethelred. Under the Welsh laws of Hoel Dha, (A.D. 940), "the falconer has a privilege, the day that the hawk shall bill a bittern, or a heron, or a curlew. Three services shall the king perform for the falconer on such a day; hold his stirrup whilst he dismounts; hold the horse whilst he goes after the birds; and hold his stirrup whilst he mounts again. Three times shall the king that night compliment him at table." Shakspeare often uses the language of falconry. It is chiefly employed in a scene in the second part of Henry VI., wherein the king, queen, lord protector, and cardinal, are the chief speakers; which goes to prove, that the falconer's terms were, at one time, household words at the English court.

Hunting and archery.

Hunting and archery, which were then almost synonimous terms, (for the sport was somewhat similar to what deer-stalking now is, the rifle being substituted for the bow,) were in high repute with the Danish, Saxon, and Norman kings, whence arose the forest laws. Wolves and boars, which formerly infested the forests, were nearly exterminated in king Edgar's time, when that monarch prohibited the killing of deer and game in his woods. The punishment depended upon the will of the king, until the celebrated forest laws of Canute, which defined the rights and privileges of the monarch and others; but those laws were little regarded by succeeding kings, whose arbitrary will afterwards regulated the laws of the forest. "Besides other prerogatives of the Saxon kings," says Selden, "they had a franchise for wild beasts for the chase, which we commonly call forest, being a precinct of ground, neither parcel of the county, nor the diocese, nor the kingdom, but rather appendant thereto." And these prerogatives, he quaintly observes, were maintained, "that the world might see the happiness of England, where beasts enjoy their liberty as well as men." Another old writer says, that "the Saxon kings and the Danish king Canute made no new forests, but were contented with the woods that were their own demesnes, and were never granted to, or possessed by the subject; but the kings of the Norman race, not being satisfied with sixty-eight old demesne woods or forests, depopulated well-built towns and villages, to make to themselves places appropriated to their own diversion only. William the Conqueror laid waste thirty-six towns in Hampshire to make a forest, which still retains the name of the New Forest; and his forest officers exercised such arbitrary rule, as to abridge even the great barons of the privileges they enjoyed under the Saxon and Danish kings, not at all regarding the liberties given to the subject by Canute's forest laws. His son William Rufus is recorded in history for the severity of his proceedings against all that hunted in his forests, inflicting the punishment of death upon such as killed a stag or buck in his forests, without any other law than that of his own will." The killing of deer was punished with loss of sight by William the Conqueror.[1] William Rufus "did so severely forbid hunting a deer, that it was felony and a hanging matter to have taken a stag or buck."[2] In Cœur de Lion's time, the law was very severe against offenders taking the king's venison; it was even unlawful to carry a bow, or take dogs through a royal forest. "Qui arcus vel sagittas portaverint vel canes duxerint sine copulâ per forestam Regis, et inde attaintus fuerit, erit in miserecordiâ Regis."[3]

The forest laws professed to be for the protection of "vert and venison." *Vert* was whatsoever bore green leaves, and afforded food or cover to the deer; and *venison* signified such beasts of the forest or the chase as were the food of man. When reading old books, it is necessary to keep in mind this acceptation of the word venison.

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[1] John Selden.

[2] William of Malmsbury.

[3] England's Epinomis, p. 34.

This state of things continued until by the Charta de Foresta the forest laws were better defined and the penalties mitigated. The vast importance attached to the Forest Charter may be inferred from the fact, that although granted by king John at Runnymede, at the same time as the Great Charter, it was not incorporated in it, but was made the subject of a separate and distinct document. The Forest Charter was likewise confirmed by Henry III., contemporaneously with the Great Charter. On the latter occasion the Forest Charter was counter-signed by sixty-four bishops, abbots, and barons; and sentence of excommunication against all persons who should violate it was, with great ceremony, denounced in Westminster Hall, by the archbishop, in the presence of the king, bishops, and nobles, the bishops being robed and bearing torches.

The oath administered, at twelve years of age, to every young man dwelling within the precincts of a royal forest, was in the following rhymes:

> You shall true liege-man be
> Unto the King's Majesty:
> Unto the beasts of the FOREST you shall no hurt do,
> Nor to anything that doth belong thereunto:
> The offences of others you shall not conceal,
> But to the utmost of your power, you shall them reveal
> Unto the OFFICERS of the FOREST,
> Or to them who may see them redrest:
> All these things you shall see done,
> So help you GOD, at his HOLY DOOM

After the Forest Charter was granted any one was allowed to kill game, except in the royal and other forests, and certain other privileged places,[1] until the reign of Richard II., when a landed qualification of forty shillings per annum became necessary to entitle a person to keep "any greyhound, hound, dog, ferret, net, or engine, to destroy deer, hares, conies, or any other gentleman's game." The qualification required was increased with the improved value of land, from time to time, until, in Charles the Second's reign, it was enacted, that persons not having L.100 per annum arising from freehold, or L.150 from leasehold property, or not being of the degree of esquire, or otherwise privileged, should not keep or use "any guns, bows, greyhounds, setting dogs, ferrets, coney-dogs, lurchers, hays, nets, lowbels, hare-pipes, guns, snares, or other engines for taking or killing game."

It was not until the early part of the reign of George III. that killing game was taxed as a luxury, and made a source of revenue to government. A tax of two guineas was first imposed on all persons who should go out in pursuit of game; but the price of the certificate was afterwards raised to three guineas, and subsequently to three and a half guineas. The property qualification is abolished, and now any person who has taken out a certificate and obtained permission from the owner or tenant of the land, in which soever the right at the time may happen to be, is privileged to kill game at all seasonable times. During a long period the sale of game was prohibited, which gave a peculiar value to it, as it was not attainable by any but qualified and certificated persons and their friends, except by indirect means. It is now publicly sold by persons taking out licences for the purpose, and such licenced persons are liable to penalties, and are incapacitated from renewing their licences, should they purchase game from any but duly certificated sportsmen. The licenced dealers are, however, largely supplied by poachers, notwithstanding the penalties to which they subject themselves by trading with uncertificated persons.

Falconry fell into dissuetude in the days of the Georges. It is now scarcely known but by name, although the honorary distinction of hereditary Grand Falconer of England is still extant. As falconry fell into disuse, another kind of sport, which is now considered as disreputable, and practised only by poachers, was pursued by the country gentlemen; the capturing of birds of the game species by means of nets and setting dogs. The dogs were trained to lie down when near to game, and to suffer the net to be drawn over them, so that both dog and birds were entangled in the toil. In this manner partridges are still frequently taken by poachers in the night. A poacher's dog is sometimes known by his habit of crouching when close upon game, and this circumstance not unfrequently leads to a detection of the practices of his master. Netting was considered as a fair mode of taking game until the fowling-piece came into general use.

On the accession of the house of Hanover to the throne of Great Britain, falconry, netting, and shooting, were contemporary amusements. The number of shooters was very limited, the inferiority of the guns and ammunition being such as not to induce their general adoption; hawking was going out of favour; and, of the three sports, netting was the most commonly practised, until the beginning of the reign of George III., after which time it was no longer deemed the sport of gentlemen. At what time the fowling-piece first came into use is uncertain. We learn from Pope that pheasant shooting was in vogue in Windsor forest during the reign of Anne.

Shooting, as practised with guns to which flint and steel locks were attached, may be said to have risen and fallen with the Georgian era. During the latter part of that period, great improvements were made in all the implements and materials of shooting. Double barrels came into use, horse-nail stubs were employed in the manufacture of barrels, the patent breech and percussion-cap were invented, and the wire-cartridge has since been introduced. Not the least improvement has been that in the manufacture of gunpowder. The excellence of our guns and dogs has tended much to spread the love of shooting, which has become the most popular and universal of British field sports.

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[1] The places privileged were of four descriptions, viz. a forest, a chase, a park, and a warren. To these may be added a decoy for water-fowl, which had also peculiar privileges.

"A *forest* is a certain territory of woody grounds and fruitful pastures, privileged for wild beasts and fowls of forest, chase, and warren, to rest and abide there in the safe protection of the king for his delight and pleasure; which territory of ground so privileged is meered and bounded with unremoveable marks, meers, and boundaries, and replenished with wild beasts of venery or chase, and with great coverts of vert for the succour of the said beasts there to abide; for the preservation and continuance of which, there are particular officers, laws, and privileges belonging to the same, requisite for that purpose, and proper only to a forest and no other place." *Manwood's Forest Laws*, p. 143. "Beasts of forest are properly hart, hind, buck, hare, boar, and wolf, but legally all wild beasts of venery." *Coke's Institutes*, vol. i. p. 233. "A purlieu is a portion of a forest which was disafforested by the Charta de Foresta." *Manwood*, 242.

"A *chase* is a privileged place for receipt of deer and beasts of the forest, and is of a middle nature, betwixt a forest and park. It is commonly less than a forest, and not endowed with so many liberties, as officers, laws, courts, and yet is of a larger compass than a park, having more officers and game than a park. Every forest is a chase, but every chase is not a forest. It differeth from a park in that it is not inclosed." *Manwood*, 49, 147. "Beasts of the chase are, the buck, doe, fox, martern, and roe." *Manwood*, 144.

"A *park* is a large parcel of ground privileged for wild beasts of chase by the king's grant, or by prescription. A park must be inclosed." *Read. Game.* "The beasts of park properly extend to the buck, doe, fox; but in common and legal sense to all the beasts of the forest." *Read. Game.*

"A *free warren* is a place privileged by prescription or grant of the king, for the preservation of the beasts and fowl of the warren, viz. hares, conies, partridges, and pheasants." *Manwood*, p. 44. "If a pheasant, or other bird of warren, flew into a free warren, the falconer could not follow it, but it became the property of the owner of the warren." *Manwood.*

A *decoy* for wild fowl is to this day privileged, in so far as the owner has the exclusive right to the birds frequenting it; and no person is allowed to fire a gun or otherwise make a disturbance within a reasonable distance of it, without permission from the owner.

It has been remarked, that England (Great Britain) is peculiarly the land of sportsmen, the very name being unknown in all other countries. The observation is in a great measure true, for, if we look around the globe, we find that wherever wild animals are killed for the sake of sport, it is mostly by the Englishman. In Sweden the Englishman alone kills the bear for sport. The natives kill it for the sake of reward, or to rid themselves of a noxious neighbour. Their method is generally thus: The strength of the country is summoned *en masse*, and several hundreds of people armed, form a circle many miles in circumference, and march forward until they meet in the centre, by which means great numbers of bears, wolves, and lynxes are destroyed. But this is not done for sport; it is a compulsory matter, and the people engaged in it are paid by the government; it is a species of feudal duty, which the able-bodied are called upon to perform whenever public safety requires it. In Asia, the only sportsman that encounters the royal tiger is the Englishman; the native shekerrie shoots the tiger for profit. There also the buffalo and the boar are hunted by the Englishman alone. In Africa, it is the Englishman who hunts the lion, the hippopotamus, and the giraffe. And in America, it is the Englishman, or English settler, who hunts the panther, the bison, and the bear, for sport; the natives do so from necessity. Since, then, the Englishman is the universal sportsman, it behoves the officer, the emigrant, and the tourist, to make themselves acquainted not only with what may be called the first principles of sporting, but more especially with the sports peculiar to the countries to which they are proceeding, a theoretical knowledge of which may be gleaned from the volumes which annually proceed from the pens of our adventurous countrymen.

The Rifle.

THE RIFLE. The only fire-arms used by the sportsman are the rifle, the musket, and the fowling-piece; the latter may be classified into the swivel-gun, which is fired from a rest, and the shoulder-gun. A short, wide-bored musket, charged with a round or oval iron ball, was formerly used for the destruction of such animals as the lion, tiger, or bear. In modern times, the musket has been superseded by the rifle, and the iron ball by a leaden one, hardened with tin and weighted with quicksilver. A short piece is said to be preferred to a long one for shooting tigers, bears, and the like, as it may be more readily loaded, and is more easily managed in cases of emergency; indeed we apprehend the shooter should seldom fire, except when the animal is so near to him that if he aim coolly, he can scarcely fail to lodge a ball. We subjoin the method of taking aim at wild beasts from practical sporting writers. Captain Williamson gives the following instructions for shooting tigers:[1] "If the motion of an animal through the grass be perceived, the nearest elephant should be halted; and its left shoulder being pointed towards the moving object, is the most favourable position for taking a good aim. The hunter should fire without hesitation, observing to proportion his level as far within the space between himself and the tops of the yielding grass as the height of the cover may dictate; by this precaution, equally necessary when shooting fish that are in any degree beneath the surface of the water, the iron ball will, in general, take effect." Mr. Lloyd says,[2] "If a man purposes attacking a bear at close quarters, a double gun is decidedly the best; if it be in the winter season, a detonator is very preferable. Owing to having flint locks, both my barrels, on one occasion, missed fire, which might have been attended with most serious consequences; a large ball is very desirable. The best points to hit a bear, or any other animal, are in the forehead, in the breast, under the ear, or at the back of the shoulder; bullets placed in other parts of the body of an old bear usually have little immediate effect. If the snow be deep, and the bear is crossing a man, he should always aim very low; he must often, indeed, fire into the snow, if he expects to hit the heart of the beast."

In 1826 it was found necessary to destroy an elephant in Exeter 'Change. A detachment of foot guards were called in, and directed by surgeons where to fire; and 152 bullets were fired before it was disabled. This proves how utterly ineffectual the leaden musket ball would be in the forest. Captain Harris, in his South African tour, in 1837, took with him a double-barrelled rifle, carrying balls two ounces weight, and thus armed, no beast could stand before him. Speaking of the forehead of the elephant, he says,[3] "A ball hardened with tin or quicksilver readily penetrates to the brain, and proves instantaneously fatal." He gives instances of his killing large elephants at a single shot, and seems to have had no difficulty with the "king of beasts," which he has slain "in every stage from whelphood to imbecility." According to Captain Harris, travelling through countries infested by wild beasts is not so dangerous as it is commonly thought to be. He says, indeed, that during part of his journey, "scarcely a day passed without our seeing two or three lions, but, like the rest of the animal creation, they uniformly retreated when disturbed by the approach of man. However troublesome we found the intrusions of the feline race during the night, they seldom, at any other time, shewed the least disposition to molest us, unless we commenced hostilities." He, however, does justice to the terrors of the maned monarch when he says, "those who have seen the monarch of the forest in crippling captivity only, immured in a cage barely double his own length, with his sinews relaxed by confinement, have seen but the shadow of that animal which 'clears the desert with his rolling eye.'"

Fallow deer s ing.

FALLOW-DEER SHOOTING. There are only three kinds of deer in Great Britain; the red, the fallow, and the roe. The fallow deer, which was the dun deer of the days of Robin Hood, is the common deer of the parks. The positions of a stag at rest when fired at may be reduced to three, for each of which a different aim should be adopted. First, when presenting his side to the shooter, the aim should be low behind the shoulder. Secondly, when standing obliquely from the shooter, the aim should be just under the ear, which is a vital part; there is too the chance, when this aim is selected, of reaching the brain through the upper or back part of the cheek, or of striking the animal in some other part of the neck, which will generally bring him down or so disable him that he will be readily recovered. It may be observed here, that the quickest mode of dispatching a dog, horse, or any other domestic animal is to shoot them through the neck, just under the ear. Thirdly, when standing or moving directly from the shooter, the aim should be at the back of the head; thus a chance is secured, should the part aimed at not be struck, of lodging a ball in the neck or spine. When a deer is approaching the shooter, or standing with its head towards him, he should wait until he can have a cross, an oblique, or a driving shot. When a deer is wounded, however slightly, one or more dogs should be instantly slipped. The dogs for this purpose should, as far as practicable, combine the nose of the bloodhound with the speed of the greyhound. A kind of wiry-haired greyhound is used for this purpose in the Highlands.

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[1] Oriental Field Sports, by Captain Thomas Williamson. London, 1805.
[2] Field Sports of the North of Europe, by L. Lloyd, Esq. London, 1828.
[3] Wild Sports of Southern Africa, by Captain William Cornwallis Harris. London, 1839.

Deer Stalking. The red deer, which is larger, and the roe-buck, which is smaller than the fallow deer, are found chiefly in the uncultivated mountainous districts of the North. To destroy the deer of an adversary was once a mode of annoyance. Chevy Chase, it would seem, from the three first stanzas of the famous ballad of that name, was an expedition of this description:

> " To drive the deer with hound and horn,
>   Earl Piercy took his way;
> The child may rue that was unborn,
>   The hunting of that day.
>
> " The stout Earl of Northumberland,
>   A vow to God did make,
> *His pleasure in the Scottish woods,*
>   *Three summer's days to take,*
>
> " With fifteen hundred bowmen bold,
>   All chosen men of might,
> Who knew full well in time of need,
>   To aim their shafts aright."

The pursuit of deer with the rifle is termed deer-stalking. To kill the semi-domesticated fallow deer requires little skill beyond that possessed by a good marksman. The skill of the deer-stalker, in pursuit of the red deer, is not only dependant on a good use of the rifle, but is shewn in his ability to find and approach deer; to do which successfully requires the most unwearied perseverance. Many of the Scottish forests wherein the stalking of deer in their wild state is practised, are of immense extent. It is on such tracts of land as the forests of Mar and Athole that the red deer is sought. The forest of Athole alone is said to be more than forty miles long, and in one part eighteen broad, of which about 30,000 imperial acres are devoted to grouse, 50,000 partly to grouse and partly to deer, and there are reserved solely for deer-stalking 52,000 imperial acres. In these vast solitudes, the Highlander stalks the antlered monarchs of the herd, harts which, a century ago, bore the scars of the weapons of his ancestors. An old Celtic rhyme which has been thus Englished, shews the great age to which the deer and the eagle are supposed to arrive.

> Thrice the age of a dog is that of a horse;
> Thrice the age of a horse is that of a man;
> Thrice the age of a man is that of a deer;
> Thrice the age of a deer is that of an eagle.

So far as regards the age of the eagle, these lines contain an assertion which can neither be proved nor negatived. It is different as regards deer. There has long existed a custom of marking fauns that have been caught, and as each forester has a distinct mark known as his own, the age of a marked deer can generally be nearly ascertained.

The deer-stalker has recourse to a thousand manœuvres to approach a herd or solitary stag. The animals are usually descried at a long distance, either by the naked eye, or by the aid of an achromatic telescope, and the mode of approaching them entirely depends upon the situation in which they are discovered. Should it seem impracticable to steal upon them while at rest, the stalkers, armed with rifles, wait in the defiles through which the deer are expected to pass, whilst the attendants make a circuitous movement to get beyond the deer and drive them in the direction required. The deer-stalker, besides being an excellent shot, should have good judgment of ground and a hardy frame, combined with the patience and power to undergo extreme fatigue and privation.

When the red deer is fired at, he is usually at a considerable distance, and perhaps bounding away at full speed. Behind the shoulder, therefore, is the favourite mark. " In killing deer,"[1] says Mr. Maxwell, " it is necessary to select the head, or aim directly behind the shoulder. A body-wound may eventually destroy the animal, but the chances are that he will carry off the ball." Mr. Scrope,[2] whose experience and success in deer-stalking render his remarks valuable, says, " the most perfect shots and celebrated sportsmen never succeed in killing deer without practice; indeed, at first, they are quite sure to miss the fairest running shots. This arises, I think, from their firing at distances to which they have been wholly unaccustomed, and is no reflection upon their skill. It is seldom that you fire at a less distance than a hundred yards, and this is as near as you would wish to get. The usual range will be between this and two hundred yards, beyond which, as a general rule, I never think it prudent to fire, lest I should hit the wrong animal, though deer may be killed at a much greater distance. Now the sportsman who has been accustomed to shot guns, is apt to fire with the same sort of aim that he takes at a grouse or any other common game; thus he invariably fires behind the quarry; for he does not consider that the ball, having three, four, or perhaps five times the distance to travel that his shot has, will not arrive at its destination nearly so soon; consequently, in a cross shot, he must keep his rifle more in advance. The exact degree, as he well knows, will depend upon the pace and remoteness of the object. Deer go much faster than they appear to do, and their pace is not uniform, like the flying of a bird; but they pitch in running, and this pitch must be calculated upon."

The interest and anxiety attending this sport must be as intense as the pursuit is laborious. After climbing for hours the mountain side, with the torrent thundering down the granite crags above him, and tremendous chasms yawning beneath him, the stalker, with his glass, at length descries in some remote valley, a herd too distant for the naked eye. He now descends into the tremendous glen beneath, fords the stream, wades the morass, and by a circuitous route threads the most intricate ravines to avoid giving the deer the wind. Having arrived near the brow of the hill, on the other side of which he believes them to be, he approaches on hands and knees, or rather vermicularly, and his attendant, with a spare rifle, does the same. A moment of breathless suspense ensues. He may be within shot of the herd, or they may be many miles distant, for he has not had a glimpse of them since he first discovered them an hour ago. A moment, and the antlers appear; another, and the herd is in sight. Resting his rifle on the heather, he takes a cool shot at the finest hart, which falls; the rest bound away; a shot from the spare rifle follows, the " smack" of the ball is heard, and the glass tells that another noble hart must die. The dogs, which had been kept far back, are slipped, and are out of sight in a moment. The sportsman follows; he again climbs a considerable way up the heights; he applies the telescope, but nothing of life can he behold, except his few followers on the knolls around him. With his ear to the ground he listens, and amidst the roar of innumerable torrents, faintly hears the dogs baying the quarry, but sees them not; he moves on from hill to hill towards the sound, and eventually another shot makes the hart his own. The deer is then gralloched, and partially covered with peat; the horns are left upright, and a handkerchief is tied to them to mark the spot, that the attendants may find it at the close of the day. Let the reader imagine how much the interest of all this is enhanced by the majestic scenery of an immense, trackless, treeless forest, to which domesticated life is a stranger, where mountain, corrie, cairn, and glen, thrown promiscuously together, present the grandest of savage landscapes, which, as the field of wild adventure, cast into shade what Mr. Scrope calls "the tame and hedge-bound country of the south."

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[1] Wild Sports in the West, by W. H. Maxwell, Esq. London, 1833.

[2] The Art of Deer-Stalking, by William Scrope, Esq., F.L.S. London, 1839.

The Fowling-piece.

THE FOWLING-PIECE. Before making choice of a gun, the shooter should determine what weight he can conveniently carry. The heaviest gun, as regards shooting, will be most effective, but he should recollect that unless he be a very robust person, a light gun will, on the whole, bring him more game, as a few additional pounds in the weight of a gun makes a deal of difference in the distance a person can travel in a day, and, moreover, he cannot shoot as well when fatigued.

The most approved guns under the system which prescribes a heavy charge of powder, and a light one of very small shot, are double barrels, weighing, according to the fancy of the shooter, from six to nine pounds, and bearing the following relative proportions of length to guage: fourteen guage, thirty-four inches long; seventeen guage, thirty-two inches long; twenty guage, thirty inches long. Taking the season throughout, we are convinced, that the most effective gun is a short, wide-bored one, each barrel being charged with rather less than $1\frac{1}{2}$ drams avoirdupois weight of powder, and full 2 oz. of No. 2 shot, containing 220 pellets. This is the general charge, but it may be varied according to circumstances. When game is wild, we would charge the reserve barrel, and, on some occasions, both barrels, with $2\frac{1}{2}$ drams of powder, and a No. 5 blue cartridge for partridges, and with a No. 4 or 5 red cartridge for grouse shooting. No. 7 shot is best for snipe shooting. Small shot may be used for partridge shooting in September, though we do not see any reason for not adhering to No. 2, except that birds very near the gun are liable to be more disfigured by it.

Barrels twenty-six or twenty-eight inches long, and fourteen or sixteen guage, are of convenient size. We think it will not be questioned that these barrels are as efficient as long narrow-bored ones for short distances, viz. under thirty-five yards, and nine-tenths of game brought to the bag is killed within that distance. And for making long shots, the wire-cartridge has obviated the necessity of using long guns. A most material advantage attending the use of a short gun is, the comparative ease with which it may be carried. A pound additional weight at the breech is not so fatiguing to the arm as half that weight added to the end of the barrel; it is the top-heavy gun that distresses the shooter.

Different proportions of powder and shot are required for different sizes of shot. The following may be the proper proportions for a gun not exceeding eight pounds:

Size of shot. No.	Weight of shot. oz.	Weight of powder. drams.
2	2	$1\frac{4}{10}$
3	$1\frac{3}{4}$	$1\frac{1}{2}$
4	$1\frac{1}{2}$	$1\frac{3}{4}$
5	$1\frac{3}{8}$	2
6	$1\frac{1}{4}$	$2\frac{1}{4}$
7	$1\frac{1}{8}$	$2\frac{1}{2}$

These proportions cannot be materially deviated from without destroying the effect. If the powder is decreased, the discharge is weakened; if the powder is increased, the shot spreads; if the weight of shot is decreased, there will not be a sufficient number of pellets for effective shooting; if the weight of shot is increased, the discharge is weakened.

The usual objection to large shot is, that after it has travelled thirty yards it becomes dispersed; but let the powder be reduced to less than $1\frac{1}{2}$ dram, and that objection fails. If it is not overcharged with powder, a gun will shoot No. 2 shot close enough to kill at from thirty-five to fifty yards, with more certainty than if charged with small shot, and two or three drams of powder.

It is not so much the velocity as the momentum of a shot that renders it effective. The momentum of a shot increases in a direct ratio with its weight. The momentum of a No. 2 shot much more than compensates for the diminished weight of powder and additional weight of lead that we have recommended. Large shot droops more than small, and sooner comes to the ground, as it is not carried with the same velocity. It is the momentum, and not the velocity, that the shooter must look to.

We do not suppose that feathers or fur of game present any serious obstacle to either large or small shot; but if they did, the fact that large shot is most effective for shooting wild fowl armed with down, at once tells that it must be so for shooting game which is not so protected. Another advantage of large shot is, that when the aim taken is not quite correct, a single outside pellet will often bring down a bird, when it would require many small shots to do so.

The shooting of barrels depends mainly on three things, viz., the metal of which they are made, the boring, and the breeching. The quality of the metal is of much importance. All barrels expand when fired; and those made of inferior metal expand more than those made of stub-twist. Mr. Greener, in his excellent treatise on the "Gun,"[1] says, "that a barrel is a spring on an extended scale, and the more we can make it partake of the nature of a spring, the better. If we must have expansion, let us have it in its most beneficial form; an expansion that will aid the powder in expelling the lead. This cannot be entirely obtained, nor can the quantity of expansion be entirely destroyed, though you were to make your barrels of the weight of a twenty-four pounder. We must, therefore, decrease it, by making our iron as elastic and tenacious as possible. The qualities of elasticity and tenacity can only be obtained by hammer-hardening the iron. Barrels hammer-hardened will shoot as well without any artificial friction, as those whose friction is extreme, yet have not yet been benefited by the process."

The term friction implies a gradual contraction of the barrel towards the muzzle, which retards the progress of the shot, that more time may be allowed to the powder to burn. "The shooting of all barrels," says Mr. Greener, "depends on a certain degree of friction. The degree of friction necessary varies according to the nature and substance of the metal. Those metals that require least shoot best. The object of the friction is to create a greater force, by detaining the charge longer in the barrel. If, then, there should not be an extra quantity of powder to consume, the friction would be a decided evil." A greater degree of friction is generally allowed to a short barrel than to a long one. A gradual expansion of the barrel towards the muzzle is termed relief. Relief accelerates the progress of shot through the barrels. What is the proper degree of relief or friction for different descriptions of barrels, is a subject fruitful of much controversy; as is also the form of the breech. The best breech is that which will cause the greatest quantity of powder to consume in the barrel.

Mr. Greener would not prevent the barrel expanding when fired, by increasing its thickness, but by improving the quality of the metal. When the barrel expands much, or is held loosely when fired, a loss of strength is induced, as that power which, if possible, should be exerted on the shot, is uselessly expended in a contrary direction, whereas, when the barrel is firmly fixed, and made of metal that only expands in a trifling degree, or, as Mr. Greener observes, operates as a spring, that portion of the explosive force which strikes in any direction, except against the shot, is forced back, or rebounds upon the shot, and consequently becomes a portion of the available strength of the charge. Much of the force that is thrown on a solid fixed surface is returned, but not that which is expended on an yielding one.

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[1] The Gun, by William Greener. London, 1835

Mr. Greener shews that much loss of strength is induced by barrels not being firmly held when fired; and argues that the mode of proving barrels by allowing them to fly back into sand is defective, as, by reason of the projectiles giving way in one direction and the barrels in the other at the same time, there is not a sufficient strain on the barrels to prove them effectively. On this subject he says, "Let any one take his gun and load it as usual; suspend it by two ropes so as it can fly back; place a quire of brown paper as directly in front of it as possible; fire it, by squeezing the trigger and the back side of the guard together, so as not to displace the gun; examine the impression the shot has made in the paper. If they have stuck in at the distance of forty yards, they have done well. Load again, and fire from the shoulder, and you will find the shots driven through a great number of the sheets. Load again, but first take the barrels from the stock, lest you should happen to break your stock, as I have seen done by a gentleman placing his gun on a stone wall; while he rested, the gun by accident went off and shivered the stock into many pieces, and severely cut his hand by the splintering. (So severe is the recoil from a gun on being fired, when resisted by a solid, unyielding substance. When fired from the shoulder it is different, as the body yields to the recoil, and thus prevents that which would inevitably be inflicted, if the shoulder were placed against a solid substance.) Secure the barrels on a piece of wood, and behind place anything firm; for instance, a piece of lead sufficiently heavy, and that will not injure the end of the breeches, technically called the buts, when they strike it. Having secured them perfectly, fire the barrel in any way you can, and then examine the force of the shots in the paper, and if you do not find that they have penetrated further than they did when fired from the shoulder, say my doctrine is false. It follows, as a matter of course, from these experiments, that in shooting, the more firmly a gun is held to the shoulder, the better it will shoot.

"It is upon these experiments that I found my objections to the practice of allowing best barrels, when proved, to fly back into sand. Such a mode of proof is of no use. Were they fixed like common barrels, the force of the proof would be increased one-half. I doubt whether the present method be any test at all. I am satisfied that the force exerted in this mode of proof on the barrel, is not equal to the pressure of a large sporting charge, when fired from the shoulder.

"The fact that the shooting powers of a gun are increased by its being fixed in an immoveable frame, is proved with the practice of mortars. Mortars on iron beds, and these firmly embedded in the earth, will throw a shell farther when on the ground, than when placed on a platform, or on board a ship. It is for the purpose of destroying the recoil, that mortars for sea-service, though of the same calibre as those intended for land-service, are made three times the weight. Dr. Hutton states, that he found no advantage by retarding the recoil in practice with artillery. He means, that no advantage is gained by stopping at three feet a gun accustomed to recoil to the distance of six. The statement is perfectly true. If he were to allow a gun to recoil only an inch, and then strike against a solid substance, he would gain nothing. For if it recoil ever so little, the shooting force is as much weakened as if it recoiled twice as far.

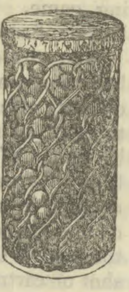
"To increase that force, a steady fixed resistance is required. The velocity of the projectile depends on the force of the immediate impulse. Before a gun, suffered to recoil, could rebound from striking some solid substance in its recoil, the charge would be gone, and could, therefore, receive no additional impetus from that rebound. The truth of this fact may be illustrated by throwing a hand-ball against any loose body with sufficient force to displace it. However hard or elastic that body might be, the ball would not rebound from it, but would fall perpendicularly down. Fix and secure that same body, and then the ball will rebound with little less force than that with which it was thrown against it. So it is with gunpowder. If it meet with a firm resistance, it will rebound and project the ball or shot with additional force."

On Charging the Fowling-piece. It may be premised that all powder, before being put into the barrel, is more or less damp; and most barrels, especially if they have been only imperfectly cleaned, or have been fired and laid by since being cleaned, are also more or less liable to damp. A portion, therefore, of powder should be flashed off in each barrel immediately before charging, for the triple purpose of expelling damp, proving whether the passage through the pivots on which the caps are to be placed, is open, and warming the barrels, so that any little moisture in the charge of powder may be absorbed. The barrels are then held perpendicularly and the powder poured in, in such manner that the whole charge may reach the bottom; and a wadding is then pressed down upon it. The shot is next poured in and another wadding pressed upon it. The shooter next removes the remains of the caps, and looks whether the powder has found its way to the orifice of the pivots, and if it has, he places fresh caps on. If the powder is not visible at the orifice of the pivots, he removes any obstacle with a pen-knife or pricker, and contrives to push down a few grains of powder.

Wire-cartridges.

Wire-Cartridges. The wire-cartridge (fig. 1.) was invented in 1828 by Mr. Jenour. It consists of a cylindrical case or net-work of wire, the meshes of which are somewhat more than an eighth of an inch square; at the lower end the wire partially closes; the wire case is then enveloped in fine paper, and at the upper end a cork wadding, cut so as to fit the guage of the gun, is affixed; the case is then filled with shot and bone dust. The first cartridges made, though ingenious in construction, were defective in operation. It was a matter of no ordinary difficulty to fabricate them in such a manner that the shot should leave the case at the precise distance required. This at first, could not be done so that they might be trusted in every instance. Every alternate cartridge might fire well; but the rest would fire irregularly, being liable to ball; that is, the shot would not leave the case until fifty or sixty yards from the gun, and such cartridges were, of course, not only useless but dangerous. They have been from time to time improved, and almost every difficulty has been overcome. The sporting cartridges now made never ball; they act with a considerable degree of precision and certainty; and that they may be safely trusted may be inferred from the fact that they are often preferred by persons engaged in pigeon matches. Various materials were used experimentally to fill up the interstices between the pellets, but nothing seems to answer so well as the material now used. Another difficulty in their construction presented itself. It was requisite to accommodate them to the various methods of boring pursued by different gunmakers, and the unequal length of barrels, the object in view being to produce a cartridge that would suit all barrels of the same guage; and this has been, in a great measure, if not wholly, accomplished. The liability to ball which, notwith-

Fig. 1.



standing various improvements made in them, was not effectually obviated for many years, during which they were tried, and in many instances prematurely condemned, either from real defects, or from the parties not knowing how to use them. They were not brought to perfection until the year 1837.

The wire-cartridges possess two principal advantages over loose shot; they are propelled with greater velocity, and thrown more evenly. A loose charge is always thrown in patches; the shots of a cartridge, as seen on a target, are comparatively equi-distant from each other. There are four classes of wire-cartridges, which the patentees have named the *battue*, the *blue*, the *red*, and the *green;* each intended for a different range. There is some little difference in the construction of each of the three kinds; the meshes of the frame-work are larger in the battue and the blue than in the red, and in the red than in the green, and there are doubtless other differences not perceptible to the uninitiated. The battue and the blue cartridges are intended for general use; the battue for the shortest distance; the blues will kill several yards further than loose shot of the same size, and of the four kinds, are, in our opinion, decidedly to be preferred; each blue cartridge being thrown more nearly alike, they are more certain in their operation than the red and the green, which are intended for longer distances. The red may be serviceable in open places, when game is wild, and the shooter is provided with a gun of not less than fourteen guage, or with a very short barrel, which does not throw its shot very strongly. The green cartridges are intended chiefly for wild-fowl shooting; these should be used in barrels of not less than twelve guage. The red and green cartridges retain the shot in the case longer than the others, and are carried with an astonishing force to an incredible distance, and at the same time very closely. The red may generally be trusted for long distances, especially from barrels of large calibre; but at short distances the smallness of the circle they describe renders them objectionable. The green cartridges should never be used for shooting game. The blue and battue only should be used in barrels of small guage.

The wire-cartridges do not require either a greater or less charge of powder than loose shot, but there is this peculiarity attending them. A heavy charge of powder throws the shot from the cartridge more closely than a small charge, by reason of its allowing more time for the escape of shot from the net-work. This is exactly the reverse of the manner in which the loose charge acts. The greater the charge of powder when loose shot and wadding are used, the more is the shot dispersed, and *vice versâ*. Either loose shot or cartridge shot is projected with greater force and velocity when a heavy charge of powder is used. When birds lie well, we would recommend the shooter who adopts the cartridge to charge lightly with powder, to give the shots time to spread well; when moderately wild, we would charge lightly with powder in the first barrel, and heavily in the reserve barrel; but when birds are very wild, both barrels should be charged with as much powder as the shoulder can conveniently bear, so as to give the charge the greatest possible force, and at the same time the greatest practicable degree of closeness. It is at long distances that the superiority of the cartridge is conspicuous; when the loose charge is used, the increase of force that is obtained by loading heavily only tends to dispersing the shot, thereby rendering the increased momentum of little avail.

Amongst the advantages attending the adoption of wire-cartridges, it may be mentioned, that the recoil is not so severe, and consequently a lighter gun may be used, than with the loose charge, and this is a great relief to the shooter in a heavy country, and especially on the hills in August, when the heat of the sun is frequently overpowering. The cartridges act well when fired from short barrels, perhaps more satisfactorily than when fired from long ones. The increased facility and expedition of loading is another advantage which should not be overlooked.

The main objection to wire-cartridges, and it is a material one to a person who is an indifferent marksman, is, that they do not describe a sufficient circle at short distances. When game is wild they are invaluable for the reserve barrel of a double gun.

The wire-cartridges usually kept on sale contain, for the different guages, the following weight of shot.

Calibre.	Weight of shot.
20	$\frac{7}{8}$ os.
19	1
18	1
17	1
16	$1\frac{1}{8}$
15	$1\frac{1}{4}$
14	$1\frac{1}{4}$ oz.
13	$1\frac{3}{8}$
12	$1\frac{3}{8}$
11	$1\frac{1}{2}$
10	$1\frac{3}{4}$

When ordering cartridges, it is necessary to give the *guage* of the barrel, the *weight* of the cartridge, the *size* of shot, and the *description*; that is, whether battue, blue, red, or green.

The green cartridges, fired from a common-sized fowling-piece, are not to be depended upon for any distance nearer than fifty yards; and, for that reason, they should only be used for wild-fowl shooting, for which sport they may answer very well when fired from a reserve barrel. We would not recommend their adoption, even for wild-fowl shooting, to a person using a common-sized single gun, since by so doing he would hazard missing when the most favourable opportunities of killing presented themselves. A No. 3 red cartridge would suit better.

The wire-cartridge has been proved to be much superior to the loose charge for the stanchion, and heavy shoulder guns used on the sea-coast and rivers. For the largest shoulder guns, B or BB loose shot, or a No. 1 cartridge is usually adopted. AA loose shot, or a B or No. 1 cartridge will better suit the stanchion gun.

Takin aim.

TAKING AIM. As the manner of taking aim is a matter of primary importance to success in shooting, a few observations on that head may not be misplaced here. When the dog points, or when birds rise near to him, the shooter should immediately draw back both hammers with the right thumb;[1] but should the birds rise at a considerable distance, to save time he need only cock one barrel, as in this case, he has only to fire once. He should never be in haste. It is more prudent to let the bird escape than to fire hastily. If on open ground, he should not fire until the bird is at least twenty-five paces distant, by which means he avoids, on the one hand, the hazard of mangling it, and, on the other, a probability of missing; for at the distance of from twenty-five to thirty yards, whether the piece be charged with loose shot or the wire-cartridges, the range of the whole charge will be wide, yet the pellets will be so close together that nothing can escape, if the aim be true, and, what is of no less moment, the finger also obedient to the eye. He should be deliberate in bringing up the piece to his shoulder, and in making it to bear on the object, but the moment he has brought it to bear, the finger should act in co-operation with the eye, the eye being kept open the while, so that the shooter may see whether the bird falls, or feathers fly from it; for if he does not, he may rely that there is something defective in his system of managing the fowling-piece. A shooter only requires coolness, a very little mechanical knowledge, and a gun properly mounted. Possessing these requisites, he will not be deficient in any other which he will not be easily able to supply. The novice should learn to shoot high enough at winged, and low enough at footed game, and well forward at both. He should seldom shoot directly at the object; but at the wing, if the bird is moving obliquely from him, the head, if the bird is rising, the legs, if descending; but if crossing, or flying obliquely at a considerable angle, he should make an allowance of a few inches according to the distance of the object from him. It is not usual to shoot at any object approaching the shooter. It should be allowed to pass, when he turns round and fires at it as it moves from him.

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[1] Many experienced sportsmen disapprove of the practice of cocking both barrels at the same time. They think that it ought to be a rule never to cock either barrel, until the game be upon the wing, then that the left barrel should be cocked and fired, and thereafter taken from the shoulder. The right barrel should then be cocked and fired if necessary; if not discharged, it should be put back to the half cock, and the left re-loaded.

Th Rook.

The Rook. We commence our notice of the different kinds of shooting with the fowling-piece now chiefly practised, with a few observations on those birds, not coming under the denomination of game, which occasionally afford the first lessons to the younger brethren of the trigger, and which therefore may properly take precedence, in description, of the more difficult branches of the art.

Young rooks, in the month of May, are generally shot whilst sitting on the branches, near their nests, on the tops of the loftiest trees, so that it requires a steady aim, and hard-stricken shot to bring them down with certainty; for if only wounded, they will frequently cling to the bough with their claws, and die suspended in that manner. The rook should be fired at with a small charge of rather large shot, and a heavy charge of powder. Rooks are gregarious, and feed on grain, worms, and insects. It is only during the season of incubation, and until the young ones can fly, that they frequent the rookery, which is mostly a small plantation, or clump of old trees, and near to some habitation. When rooks choose any particular cluster of trees, or plantation to build in, the same trees will, if standing, be tenanted again the next year by the same rooks and their offspring, notwithstanding they may have been much fired at, or in some other way disturbed. This opinion is not universal. In some counties there exists a prejudice against the practice of firing at rooks with gunpowder, especially when the rooks are few, and the number of trees limited, lest the rooks should desert the rookery; and, therefore, that as little alarm as possible may be created, they are fired at with balls from the air-gun, and sometimes the young shooter will try his skill with the cross-bow. The old rook is distinguished from the young one by the thick end of either mandible being white; and the beak of the young rook is black to the insertion. They are distinguished from other birds of a somewhat similar appearance, by a slight variation of colour; the rook has a blue, the carrion-crow a brown tinge, the jackdaw is partially grey, the raven is jet black.

After young rooks have been fired at several times, some of the strongest and best-fledged will quit the rookery, and alight on hedges or trees at some distance, where the shooter flushes them, and they afford good sport to the tyro learning to shoot birds on the wing. A warm sunny day is best for rook-shooting. In cold weather, particularly on windy days, young rooks will not quit their nests.

The ood-pigeo

The Wood-pigeon. The wood-pigeon is little regarded by the sportsman. A shot may be obtained by lying in ambush early in the morning, near to some wheat stubble, or field of newly-sown grain, where the birds feed; but the best sport the wood-pigeon affords is at the roosting places, where the shooter ought to take his station an hour before sunset. It is difficult to obtain a shot in any other manner, except when the birds are young, when they are sometimes killed in trees, in the same manner as young rooks. The shooter in pursuit of game often sees them, but rarely obtains a shot at them. Sometimes, but it is usually when he is not aware of them, they will suffer him to approach close to the tree in which they are perched. The tree is generally a large one, and perhaps in full foliage, and the shooter hears the rustling of the wings of the decamping birds, but seldom secures a shot. Whenever a wood-pigeon leaves a tree, the shooter should prepare for others, since, when there are several in the same tree, they will not leave it simultaneously, but move off in succession. They are large strong birds, and require heavy shot to bring them down.

Shooting tame pigeons is becoming a very common amusement; but it is oftener practised to decide a wager, than prove the skill of the parties. The Red House at Battersea, near London, is the scene of the principal matches. The birds are sprung from a trap, which is usually placed twenty-one yards from the gun; the birds of each person are provided by his opponent; blue rocks are the favourites; very heavy guns are used, but the weight of shot is usually limited. The birds must fall within a limited distance from the trap, or they are not counted amongst the successful shots.

The Lark, &c.

The lark, field-fare, lapwing, golden plover, and dottrel. Larks and field-fares are often the object of the young shooter's pursuit. Field-fares, the blue-backs and red-wings, arrive in October, and remain during winter. They are easily approached during a frost, or when the ground is covered with snow. They will then be found in search of the berries of the mountain-ash, the holly, and the hawthorn, and are killed in great numbers. Like wood-pigeons, field-fares do not leave a tree, or rise from the ground simultaneously, so that when one bird flies off, if the shooter will hasten to the spot, he will, in all probability, meet with a lagger.

The lapwing or pewit is a bird much sought for by the juvenile shooter. Lapwings are commonly found on marshes, or wet land abounding in rushes. Except during the season of incubation, they collect in flocks, and are so very wary as to be difficult of approach. They are often killed for the sake of their toppings, which are useful to the angler. As they wing round the shooter, it is extremely difficult to decide whether they are within range or not; they should be within a moderate distance when fired at, or they will escape in the interstices of the charge, as the size of the body bears a small proportion to the apparent size of the bird when on the wing. It is not uncommon to see several feathers cut out of the wings, and the bird fly away as if unhurt.

All these birds afford amusement chiefly to schoolboys. The sportsman in pursuit of game does not think them worthy attention; but the golden or whistling plover, and the dottrel, which are birds often met with in hilly districts, are generally considered as worth firing at, if they accidentally come in the way, but are not worth the trouble of following.

The Land-rail.

The Land-rail. The land-rail or corn-crake is a bird of passage. It may be found with pointers or spaniels early in spring, in hedges or long grass. The dogs for this sport should not be staunch; such as will foot the birds are best as it is with great difficulty they can be made to rise. It is only during the first fortnight after their arrival that they may be fairly killed in spring; after that time they begin to pair. In August and September, the sportsman sometimes casually meets with a land-rail, whilst beating for other birds.

Wild fowl.

Wild-fowl. Wild-fowl shooting is practised in various ways. The method of proceeding depends entirely on the situation in which the shooter expects to find the birds. In some of the inland counties, except during hard frosts, they are not met with anywhere but on large pools and rivers, and are only to be approached by having recourse to some stratagem, as waiting in a shed, or on an island, or on the banks of a pool, or stalking behind a horse trained to the purpose. The largest shoulder gun that is at hand may be used charged with the red or green wire-cartridges, the size of shot being regulated by the bore of the piece.

During a severe frost, wild-fowl are compelled to leave the pools, and are then found in small rivers, brooks, or in drains where there are springs of fresh water. The flights being broken, ducks are found singly or only few in number, and are consequently easy of access, and may be shot with a common fowling-piece. The size of shot should be No. 2, or 3. Wild-fowl are so fortified with down on some parts as to resist any but hard-stricken shot. Their back is the most vulnerable part, and all kinds of wild-fowl present it to the shooter as they rise. They are also easily brought down when they present a cross shot; but when approaching it is not advisable to fire at them. If a dog accompany the shooter, it should follow at heel. As the shooter pursues the course of a river or brook, he should keep out of sight as much as possible, and come suddenly on every turn or winding. When there is a mist during a frost, wild ducks will remain in the brooks and gutters all day. The earlier in the morning the better for this sport. Ducks may also be killed on the wing, on the verge of night, by the shooter lying hid near to fresh water springs. If it be a dark evening, he need only wait about a quarter of an hour, but if moonlight he may wait about an hour. They may also be walked up on a moonlight night, when, if they rise above the horizon, they may be killed almost as easily as in the day time. The objection to night shooting is, that birds knocked down are often lost. These are the principal methods by which ducks are killed by any but professed wild-fowl shooters.

The larger kinds of wild-fowl, such as hoopers *(wild swans)* and geese, can rarely be brought down by the common fowling-piece, unless struck on the head or back. Wild-fowl shooting, in creeks and harbours on the sea-coast, is conducted in a very different manner, and on a larger scale of operations. There are two kinds of guns used for the purpose, the shoulder-gun and the punt-gun; the latter being fired from a rest, or frame, or carriage, either in a boat or some other floating craft. Mr. Greener, to whose work we have already referred, says, "Never make duck guns (shoulder-guns) above seven-eighths in the bore, if you wish them to kill at a great distance, and not less than fifteen or sixteen pounds weight, and full four feet long." Colonel Hawker,[1] who has devoted nearly one hundred and fifty pages to the subject of wild-fowl shooting, says, "The barrel of a punt-gun, to be in good proportion, should, I conceive, (including the patent plug, of about six pounds weight, and from two to three inches in length), be about seventy or eighty pounds weight, from seven to nine feet long, and from an inch and a quarter to an inch and a half bore, according to the one length and weight, or the other. The smaller the bore is, in reason, the further you can kill at a small number of birds; but the larger size of these two shoots the best, and is the most regular pattern. Any thing beyond that size seldom answers." Both these writers seem to agree that the common punt-gun, though it weigh eighty or one hundred pounds, cannot be charged to the extent of its shooting powers, by reason of the tremendous recoil that would result; but each advises that the additional weight should be gained by using the barrels double. Thus more than a double advantage would be secured, for not only would there be two barrels at command, but the discharge from each barrel would be more effective. The charge of shot for a punt-gun averages from ten to twenty ounces; the shot is much larger than any used for shooting game.

The Colonel, and we apprehend he is the only practical writer on this department of the subject, describes the various kinds of punts (which are flat-bottomed boats or canoes, so constructed as to be manageable either on sands, or in mud, or water,) used in several different counties, and gives the following directions for shooting wild-fowl, from a punt, with a large shoulder-gun. "Sit down on some straw or rushes, with your gun by your side, and take with you a small Newfoundland dog. Row about, till you can see or hear a flock of wild-fowl on the mud. To find them sitting, if by night, look at first very low, so as to bring the surface of the mud in contrast with the horizon, by which means you will overlook the black edges of the creeks and holes, instead of seeing, and perhaps mistaking them for birds.

"When you have rowed within two or three gun-shots of the fowl, take in your oars, and reconnoitre the creeks. Having ascertained which is likely to be the best, lie down, and push along with the *setting pole* or *gunning spread*, and while the mud banks stand above the little channels, you are so completely hid, that you will seldom fail to get a shot, provided there is a creek within reach of the birds, and you do not go directly to windward of them.

"On arriving sufficiently near, should the water be so low that you cannot present your gun at the birds without kneeling or standing up, you must get aground at the side of the creek, or steady your canoe by means of forcing each oar from between the *thowls* into the mud, otherwise the recoil of the gun will set her rocking, and thus you might probably be tipped out. Having made all fast, rise up and fire. Take care, however, to rise high enough to be well clear of the mud, or not a feather will you touch; and present as follows: By day, or moonlight, if the birds are close, directly at them; or if beyond forty yards, shoot at their heads; unless they are feeding in a concave place, where the tide has left a kind of plash, in which case you must level rather under them, or you will only graze their back feathers. In star-light, take your aim just at the top of the narrow black line, in which birds always appear to one who is low down; and when so dark that you cannot see your gun, present, as you think, about a foot over, or you will most likely shoot above a foot under them.

"Should you have been successful, you will, if at night, generally hear your cripples (wounded fowl) beating on the mud, before you can sufficiently recover your eyes, from being dazzled by the fire, to see them. Your man then puts on his mud-boards, (which are flat square pieces of wood fastened to the feet, to enable the party to walk or wade through mud), taking the setting pole to support him, and assist the dog in collecting the killed and wounded; taking care to secure first the outside birds, lest they should escape to a creek. During this time you are left in charge of the punt; and should, if possible, keep a look out, in order to see if any more birds fall dead or wounded from the company, before they have flown out of sight.

"The gunner generally calculates on bringing home the half only of what he shoots, from the difficulty of catching the whole of his winged birds, which he calls *cripples*, and those that (to use the pigeon phrase) fall out of bounds, which he calls *droppers*. If the birds fly up, he generally declines firing, knowing that the moment they are on the wing, they become so much more spread, that he could seldom get more than three or four, for which it would be hardly worth while to disturb the mud; particularly as widgeon, by night, if not fired at, will, in cold weather, probably settle again at no great distance.

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[1] Instructions to Young Sportsmen. Eighth edition. London, 1838.

"In following wild-fowl, it is easier to get within twenty yards of them by going to leeward, than a hundred and fifty if directly to windward, so very acute is their sense of smelling.

"The best time, therefore, to have sport with a canoe and a shoulder-gun, (provided it be low water, or half ebb, while you are hid in the creeks), is in clear, frosty, moonlight nights, when the wind happens to blow towards you as you face the moon. It is then impossible for the wild-fowl to smell you; and you may, by getting them directly under the light, have the most accurate outline of every bird, and even distinctly see them walking about, at a much greater distance than a gun would do execution. From thus being on the shining mud-banks, they appear quite black, except some of the old cock widgeons, on the wings of which the white is often plainly to be seen.

"It does not follow, however, that nothing can be done without a bright moon. So far from it, that some of the best shoulder-gunners in the kingdom prefer but very little moon, even for the mud. Here, by constant habit, they can easily distinguish the black phalanxes of widgeons from the shades on the places they frequent, and particularly if they are feeding among the puddles which have been left by the tide. In this pursuit, and when not favoured by the best of light, there are a few cautions to be given to an inexperienced shooter. First, to ascertain that the black patch to be seen *is* a flock of birds, which he will do, by observing the occasional change of feature in the outside of it. Secondly, on approaching them, to be careful that their enormous masses and tremendous noise do not deceive him in the distance, and tempt him to fire out of shot. And, thirdly, not to be too eager in getting his dead birds, as it sometimes happens, in hard weather, that the remainder of the flock will again pitch down among them, particularly if he has winged some of the younger birds, which have not the cunning to make off for a creek, like the old ones. In this case, a reserved gun would, probably, more than double the produce of his first shot. It should be understood, that this night shooting is chiefly at the widgeon, as the geese, of late years, (since there have been so many shooters), have seldom ventured much in harbour by night, except sometimes at high spring tides, with a full moon; and the greater part of the ducks, teal, dunbirds, and such like, repair inland to the ponds and fresh springs, unless driven to the salt feeding ground by severe frost.

"A company of widgeons, when first collecting, may be heard at an immense distance, by the whistling of the cocks and purring noise of the hens; but when they are quietly settled, and busy at feed, you sometimes can only hear the motion of their bills, which is similar to that of tame ducks."

Geese, ducks, widgeons, hoopers, curlews, and other wild-fowl, are killed in this manner; but the most destructive method of killing them is with the heavy stanchion or swivel punt-gun, used by the persons on the coast who make a trade of wild-fowl shooting. When a fair shot can be obtained by this method, from twenty to fifty birds may be killed at one discharge; but it is laborious, wearisome work, and, except for a single occasion, can scarcely be called sport. This kind of shooting is carried on in the night, usually in frosty weather, at which time sailing about on water, or working the canoe through mud, cannot be accompanied with very agreeable sensations.

The size of shot for punt-shooting should, in some measure, be regulated by the size of the birds expected to be met with, and their degree of tameness; yet it is well to be prepared with shot of sufficient size, as hoopers, geese, and other large birds, are sometimes found when least expected

The Water-hen, &c.—There are various kinds of wild-fowl, which will dive rather than fly away when disturbed. They are, for the most part, clumsy birds on the wing, and are killed without difficulty when they can be made to rise. When shot at swimming, the shooter takes aim, and fires instantaneously, or they will be under water whilst he is drawing the trigger.

Dogs.

SPORTING DOGS. Before noticing the different kinds of game which are the object of the shooter's pursuit, a few observations on sporting dogs may not be irrelevant. The shooter's dogs are of four kinds; the pointer, setter, spaniel, and retriever.

Pointers and setters.

Pointers and Setters. If dogs were unknown in Europe, and some traveller from a distant part of the southern hemisphere were to relate that he had seen a new species of quadruped with wonderfully fine olfactory nerves, by the aid of which it was enabled to hunt to death the hare, stag, fox, or jackal, the tale would readily be credited; for the instinct of the hound, as compared with that of other animals, is not such as to excite surprise. But were the traveller to relate that he had seen a quadruped which, untaught, would stand motionless, as if converted into a statue, on coming in contact with the slightest scent of game, he would not be believed; it would appear incredible, such is the extraordinary instinct of the pointer and setter. We use the term *extraordinary* advisedly. There are other animals, and indeed other dogs, which possess a degree of instinct more nearly approaching to reason, but none possessing so extraordinary an instinct, an instinct not analogous to that of any other living creature that we are aware of. The pointer seems to be endued with it for the exclusive service of man; whereas the instincts of all other animals are conducive to the supply of their individual wants, and their usefulness to man is secondary thereto. It would be difficult to controvert the argument that this instinct was given to the pointer for the purpose of aiding men to capture or kill game, by means of such engines as nets or guns. This, we are aware, may be a doubtful position to maintain; but who can say for what other apparent purpose this peculiar faculty was given? It may, indeed, be urged, that the propensity to point, in the pointer, is a means ordained by providence for his subsistence in a wild state, by enabling him to approach within reach of his prey, and thus to accomplish, by another species of stealth, what the tiger and other animals of the cat tribe effect by ambuscade. Such an argument, however, is presumptively rebutted by the fact, that all existing races of wild dogs are gregarious, and resort to the chase for food; nor is there any record of the existence of dogs in a state of nature, except those calculated for the chase. It is therefore gratuitous to assert, that the instinct or faculty of pointing was bestowed upon the pointer as a means of subsistence, since he has ever been dependant on man for food.

It is strongly argued, that all dogs have descended from one common stock, and that by difference in food, climate, and training, they have become what they are at present; nor is it more improbable that such is the fact, than that the human race are descended from one common parent; for dogs are not more dissimilar than the various tribes of men, who differ not only in outward form, but morally and intellectually, as much as dogs vary in size, shape, temper, and sagacity. Those animals which can be domesticated improve by acquaintance with man, as the wild fruits by cultivation. All wild dogs have some qualities in common; but their instincts are somewhat limited, or not called forth. It is only in its domesticated state that we find the various qualities which render the dog so useful a servant to man. Wild dogs are, in comparison with domesticated dogs, what savages (for wherever they have been found, savages bear some resemblance to each other, and are engaged in similar pursuits) are to civilized society. It is inconceivable that the mastiff, terrier, cur, and numberless other dogs besides the pointer, could ever have been in a wild state, as they do not seem to be possessed of any instincts or faculties that could enable them to subsist unattached to the human race.

The long received opinion that the lion, as the king of brutes, is possessed of the highest degree of physical courage, is exploded. The palm of courage is now awarded to the dog. Courage, however, in the common acceptation of the term, is not a characteristic trait of the pointer or setter, which are, perhaps, except the cur, the least courageous of the canine race. The dog is the only brute animal that prefers the society of man to that of its own species; and no dog is more affectionate or faithful to man than the pointer or the setter.

England is not less famous for its horses than for its sporting dogs. Our grey-hounds, fox-hounds, and harriers are unequalled, and that they are so results from the care that has been taken to keep each species distinct. All our pointers are, in some degree, of Spanish extraction; and such of them as have most Spanish blood in their veins are unquestionably the best. The Spanish pointer is about twenty-one inches in height. He has a large head, is heavily made, broad-chested, stout-limbed, with a large dew-lap; his eyes are full, and widely apart, and his nose is broad; his tail is straight, short, and thick, and his ears large, pendulous, and fine; he should have a round, and not a flat foot. When pointing, he stands on three legs, one of the fore legs being raised, and his face and tail are in a line with his back. This is his invariable position when he comes gradually upon the scent; but whenever, by running with the wind, or from any other circumstance, he comes suddenly upon game, he will stand in the most picturesque and sometimes indeed grotesque attitude, frequently with his body almost doubled. A pointer may be sometimes seen standing with all four feet collected together on the surface of a small stone on a wall when the birds are almost under him. A very old dog of this description, when fatigued with ranging and too enfeebled to maintain his point long in the natural position, will sit down on his haunches with his face towards the game, yet ever and anon turning his head wistfully to see whether the gun be approaching. Notwithstanding however the vaunted excellence of British pointers, the generality of them are not such as they ought to be. It is much to be lamented that the same care is not taken in the breeding of pointers and setters as of hounds. Scarcely two pointers are to be seen so much alike that a naturalist would pronounce them to belong to the same class of dogs, inasmuch as they are dissimilar in size, weight, and appearance. There are, properly speaking, but two classes, the Spaniard and the mongrel. Nearly all the pointers we see are, in fact, mongrels, although each may have more or less of the original Spanish blood. Such, however, is the force of nature that a dog having in him very little of the blood of the pointer may prove a very serviceable dog to the shooter. We frequently meet with very good dogs, dogs deemed by their owners first-rate, which bear little resemblance, in point of shape and appearance, to the true pointer. Some have the sharp nose of the fox, others the snubbed nose of the bull-dog; some are slenderly formed; some long-legged, others short-legged; some heavy-bodied, others light; in short, there is every possible diversity.

The attempt to lay down a written rule whereby to distinguish between a good and an indifferent pointer would be futile. How much of the blood of the pointer a dog has in him will be read in his countenance, rather than inferred from his general shape and appearance. There is an indescribable something in the countenance of a thorough-bred or nearly thorough-bred pointer, which a little habit of observation will enable the sportsman to detect with tolerable accuracy, so that he may judge of the capabilities of a dog, as a physiognomist will read at a glance a person's disposition and ability in his countenance. It is to the disciplined eye only that these all but infallible tokens are discernible.

The instinct of pointing, we apprehend, is an inextinguishable and indestructible principle in the blood of the pointer, which, however it may be mingled with inferior blood, will always, in some degree, manifest itself; and on this ground we build our theory that the further any dog is removed from the original Spanish pointer the worse the dog is; and, consequently, that all attempts to cross the pointer with any other blood must necessarily deteriorate the breed. The grey-hound is seldom or never crossed to give him additional fleetness, nor the hound to improve his nose; why then should the pointer be crossed with dogs which, in so far as the sports of the field are concerned, scarcely inherit one quality in common with him? Attempts, however, are constantly made to improve the pointer by a cross with the blood-hound, fox-hound, Newfoundland dog, or mastiff, sometimes with a view of improving his appearance, and bringing him to some fancied standard of perfection; but in reality inducing a deformity. One of these imaginary standards of perfection is, that to one part thorough Spanish blood, the pointer should have in him an eighth of the fox-hound, and a sixteenth of the blood-hound. A cross will sometimes produce dogs which are, to some eyes, the *beau idéal* of beauty; but however handsome such dogs may be, they will necessarily possess some quality not belonging to the pointer; for instance, a cross with the hound gives the propensity to trace hares, if not to give tongue. A thorough-bred pointer carries his head well up when ranging; he will not give tongue, nor has he much desire to chase footed game. The hound pointer may be sometimes detected by his coarse ears, by his tail being curled upwards, and being carried high, or by his rough coat. An occasional cross with the mastiff or Newfoundland dog is said to increase the fineness of nose, but it is converting the pointer into a mere retriever. The pointer, as we before observed, is naturally cowardly, as compared with other dogs; therefore, whenever a pointer is ferocious or courageous, it may be inferred that the blood of some of the larger or stronger dogs runs in his veins. Another and the main source of the unsightliness of sporting dogs is the allowing an indiscriminate intercourse between pointers and setters. Good dogs may be thus obtained sometimes, but they are invariably misshapen; they have generally the head and brush tail of the setter, with the body of the pointer, and their coats are not sleek, and instead of standing at their point, they will crouch. When the sire is nearly thorough-bred, dogs of a superior description, but certainly not the best dogs, are sometimes produced by the Newfoundland or some other bitch not strictly a pointer. We are not willing to allow that the pointer is improved in any quality that renders him valuable to the sportsman, by a cross with the hound or any other sort of dog; though we cannot deny that the setter is materially improved in appearance by a cross with the Newfoundland dog, but what it gains in appearance, it loses in other respects.

Breeding mongrels, especially crossing with hounds, has given the gamekeepers and dog-breakers an infinity of trouble which might have been avoided by keeping the blood pure. The best pointer is the offspring of a pointer-bitch by a pointer-dog; such a dog is nearly broken by nature. The Spanish pointer seldom requires the whip; the hound pointer has never enough of it. One of the main sources of the sportsman's pleasure is to see the dogs point well. A deal is said about this and that dog being remarkably fine-looking; the only time to appreciate the beauty of a dog is when he is ranging and pointing; then let the sportsman compare the real pointer with the spurious one.

Courage[1] is another attribute of the pointer; a high-couraged pointer will continue ranging till he has not, as the saying is, a leg to stand upon, even though he should not meet with game.

The usual price paid for breaking a dog is from two to five guineas. The breaker runs the dogs in spring, and again in August, but without the gun; this, followed by a week's shooting in September, renders their education complete, but unless they have sufficient practice afterwards, the initiatory lessons will soon be forgotten. Young dogs will learn more in six successive days, than in six weeks, if taken out only at the rate of one day per week. The dog-breaker should be a person of discriminating judgment, and possessed of a good temper; and the art of winning, not by brute force, but by judicious management, an ascendancy over the dogs entrusted to his care. Breaking dogs, when many young ones are taken out together, is a very difficult and tiresome task. One or more old staunch dogs are usually allowed to accompany the young ones, to induce them to back. A dog pointing is conscious of the presence of game. A dog which backs another is not aware of the proximity of game at the time, otherwise than by inference. Whenever the dog in advance points, it is the breaker's duty to make all the rest that acknowledge the scent to point, and all that do not acknowledge the scent should be shewn the dog pointing, and be made to back, which is done by the breaker holding up his hand, and crying, in an under tone, "to-ho." The dogs are taught to fall the moment the game rises, or on the report of a gun. They should come in on hearing their names or the whistle, and should never be allowed to pass a fence before their master. The efficiency of the training which a dog has received may be conjectured from his manner of quartering his ground. He should range at a short distance in advance of the shooter, alternately to the right and left; and this should be taught rather by the motion of the hand than by the voice. An offence should never be overlooked if the dog seems conscious of it; but the breaker's knowledge of the disposition of the dog should be his guide in regulating the punishment. Some dogs will not bear the whip, or even rating, but require encouragment and good words on all occasions. When it is necessary to flog a headstrong dog, it should be done severely, the blows falling on the side, from the shoulder to the flank. The lash or switch with which the dog is punished, should not be made to lap round the body, nor should the dog be kicked. When the dog is in fault, and is very eager in pursuing the sport, no punishment that will be longer remembered, can be administered, than making him crouch five or ten minutes. In common with other sports, shooting has a vocabulary of its own. We have elsewhere given a list of some of the words made use of by the breakers and sportsmen to the dogs, which we transcribe, many of them being anything but euphonious to the unaccustomed ear. "*To-ho* spoken in an under tone, when the dog is ranging, is a warning to him that he is close upon game, and is a direction to him to stand. There is no necessity for using it to a dog that knows his business. Spoken in a peremptory manner, it is used to make the dog crouch when he has flushed game, or been otherwise in fault. *Down-charge*, or *down-to-charge*, is used to make the dog, whether it be near or at a distance, to crouch when the shooter charges, that the dog may not flush game when the shooter is unprepared. When the dog will not crouch, but continues beating, the leg-strap may be put on. *Take-heed*, and *be-careful*, are used when the dog ranges over ground where it is customary to find birds. *Take-heed*, is a word of correction; *be-careful*, of encouragement. The former is used by way of caution or notice to prevent the dog flushing birds by running over the ground too fast; the latter is likewise a caution, but used when the dog beats slowly or carelessly. *'Ware fence* is used to prevent dogs passing a fence before the gun. The dog should never, on any account, leave an enclosure until its master has left it. *'Ware*, or *beware*, is used to rate a dog for giving chase to a hare, birds, or cattle, pointing larks, or approaching too near the heels of a horse. *Seek*, is a direction to the dog to look for a dead or wounded bird, hare, or rabbit. *Dead* is used to make a dog relinquish his hold of dead or wounded game. The dog should retain possession of wounded game until it is taken from him; for should he suffer a bird that is only slightly wounded to disengage itself from his grasp, another *seek* becomes necessary, and the bird is either lost, or despoiled of its plumage by the catching and re-catching. Some dogs are taught to bring the game to their master. The breaker should teach the dog, in all cases, to retain game until it is taken from him, or until he hear the word *dead*, when he should instantly drop it. The dog should be punished if he break the skin with his teeth."[2]

The most useful dogs are those which are best broken. As much depends on the breaking as the breed of a dog. Dogs should be constantly shot over during the season by a successful shot, and exercised during the shooting recess, by some person who understands well the management of them, otherwise they will fall off in value. The half-bred ones will become unmanageable, and even the thorough-bred ones will acquire disorderly habits.

We look upon the setter to be an inferior kind of pointer, perhaps originally a cross between the pointer and the spaniel, or some such dog as the Newfoundland, for it has some qualities in common with each. The pointer has the finer nose, and is more staunch than the setter. Pointers are averse to water; setters delight in it; hence the advantage of the latter on marshes to the snipe shooter. The setter will face briars and gorse bushes better than the pointer, which is in this respect a tender dog; and for this reason the setter is preferred to the pointer for cover shooting. Besides, his being not so staunch as the pointer is an additional advantage in heavy covers. The sportsman who shoots over well-broken pointers, frequently passes game in the woods, while the pointers, which are not seen by him, are at their point; the setter, being more impatient to run in, affords the shooter many shots in cover, which the overstaunch pointer would not. The pointer is always to be preferred on open grounds. In hot weather the pointer will endure more fatigue than the setter.

The Spaniel.

The Spaniel or Cock Dog. The spaniel is the best dog for beating covers, provided he can be kept near the gun. He is generally expected to give tongue when game is flushed; some spaniels will give notice of game before it springs, which may be very well where wood-cocks only are expected to be found. Wood-cock and pheasant shooting are usually combined; where covers are limited, pheasant shooting cannot be conducted too quietly. Wherever the underwood is so thick that the shooter cannot keep his eye on the dogs, spaniels are to be preferred to pointers or setters, whatever species of game the shooter may be in pursuit of. If spaniels cannot be kept near the shooter, they are the worst dogs he can employ.

Retrievers.

Retrievers. The business of the retriever is to find lost birds. Newfoundland dogs are the best for the purpose. They should have a remarkably fine sense of smelling, or they will be of little use in tracing a wounded pheasant, or other game, through a thick cover, where many birds have been running about. A good retriever will follow the bird on whose track he is first put, as a blood-hound will that of a human being or deer. They should be taught to bring their game, or in many instances their finding a wounded bird would be of no advantage to the shooter.

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[1] Courage, as applied to the pointer, signifies a willingness and determination to range; it is an union of the qualities known by the terms mettle and bottom, as applied to horses.

[2] The Oakleigh Shooting Code. London, Ridgways. Third Edition.

We proceed next to give some description of the art of shooting game, in the course of which we shall endeavour to confine our obseravtions to such of the habits and peculiarities of the birds and quadrupeds under notice, as it is essential the shooter should be made acquainted with, and at the same time to detail the means of proceeding most likely to ensure success in the pursuit of them.

The Partridge.
Plate CCCCLXI.

The Partridge. We commence with the partridge, as shooting that bird is generally the young shooter's first lesson at game, although in the order of the season grouse shooting takes precedence. Partridge shooting commences on the first of September, and ends on the first of February.

The habits of the partridge at different seasons should be closely understood and studied by the shooter, that he may be able, with a tolerable degree of certainty, to find them at any given time. In the early part of the season, they will be found, just before sunrise, running to a brook, a spring, or marsh, to drink; from which place they almost immediately fly to some field where they can find abundance of insects, or else to the nearest corn-field or stubble-field, where they will remain, according to the state of the weather, or other circumstances, until nine or ten o'clock, when they go to bask. The basking place is commonly on a sandy bank-side facing the sun, where the whole covey sits huddled together for several hours. About four or five o'clock, they return to the stubbles to feed, and about six or seven they go to their jucking-place, a place of rest for the night, which is mostly in aftermath, or in a rough pasture field, where they remain huddled together until morning. Such are their habits during the early part of the season; but their times of feeding and basking varies much with the length of the days. While the corn is standing, unless the weather be very fine or very wet, partridges will often remain in it all day; when fine, they bask on the outskirts; when wet, they run to some bare place in a sheltered situation, where they will be found crowded together as if basking, for they seldom remain long in corn or grass when it is wet. Birds lie best on a hot day. They are wildest on a damp or boisterous day.

The usual way of proceeding in search of partridges in September is, to try the stubbles first, and next the potato and turnip field. Birds frequently bask amongst potatoes or turnips, especially when those fields are contiguous to a stubble-field. The best partridge shooting is obtained in potato and turnip fields. It not unfrequently happens that potatoes or turnips are grown on a headland in a corn field; in that case the headland will be a favourite resort of birds.

After the middle of October it is ever uncertain where birds will be found; the stubbles having been pretty well gleaned, birds do not remain in them so long as in the early part of the season. When disturbed at this time they will sometimes take shelter in woods, when they are flushed one by one. The best shots that can be obtained at partridges in winter, are when the birds are driven into woods.

When a covey separates, the shooter will generally be able to kill many birds, but late in the season it is seldom that the covey can be broken. In November and December the shooter must not expect to have his birds pointed, but must remain content with firing at long distances. We transcribe the following observations on dispersing coveys: "In the early part of the season, when the shooter *breaks* a covey, he should proceed without loss of time in search of the dispersed birds, for the parent birds begin to call almost immediately on their alighting, the young ones answer, and in less than half an hour, if not prevented by the presence of the shooter and his dogs, the whole covey will be re-assembled, probably in security in some snug corner, where the shooter least thinks of looking for them. As the season advances birds are longer in re-assembling after being dispersed. It is necessary to beat very closely for dispersed birds, as they do not stir for some time after alighting, on which account dogs cannot wind them until nearly upon them, especially as they resort to the roughest places when dispersed. Birds dispersed afford the primest sport. The pointing is often beautiful, the bird being generally in a patch of rushes, or tuft of grass or fern, and close to the dog. When a bird has been running about some time, dogs easily come upon the scent of it; but when it has not stirred since alighting, and has perhaps crept into a drain, or run into a hedge-bottom, or the sedgy side of a ditch, no dog can wind it until close upon it, and the very best dogs will sometimes flush a single bird. In the month of October, and afterwards, the shooter will find it difficult to approach within gun-shot of a covey, nor can he disperse them, except by firing at them when he chances to come close upon them. Should he then be so fortunate as to disperse a covey, he may follow them leisurly, for they will then lie several hours in their lurking place, which is chosen with much tact, as a patch of rushes, a gorse bush, a holly bush, the bottom of a double bank fence, or a coppice or wood. The length of time that will transpire before a dispersed covey will re-assemble, depends, too, on the time of the day, and state of the weather. In hot weather, they will lie still for several hours. A covey dispersed early in the morning, or late at night, will soon re-assemble. A covey dispersed between the hours of ten and two, will be some time in re-assembling. A covey found in the morning in a stubble field, and dispersed, will next assemble near the basking place. A covey dispersed after two o'clock, will next assemble in the stubble field at feeding time. A covey disturbed and dispersed late in the afternoon, or evening, will next re-assemble near the jucking-place. A covey being disturbed on or near to their jucking-place, will seek a fresh one, perhaps about two fields distant; and if often disturbed at night on their jucking-place, they will seek another stubble field to feed in, and change their quarters altogether. The most certain method of driving partridges from a farm, is to disturb them night after night at their jucking-place, which is usually in a meadow, adjoining to a corn field, where the aftermath is suffered to grow, or in a field rough with rushes, fern, thistles, or heather. When a covey is dispersed on a dry hot day, it is necessary to search much longer, and beat closer, for the dispersed birds, than when the day is cool, and the ground moist. A dog should be only slightly rated for flushing a bird on a hot day."[1]

The number of birds in a covey varies much, perhaps the average may be from ten to fifteen. In some years, when the coveys are large after a fine hatching season, it is not uncommon to see upwards of twenty birds in a covey; and sometimes after a wet season, ten birds may be deemed a fair covey. Birds are always most numerous after a dry summer. When there are thunder-storms about midsummer, great numbers of young birds are drowned. The young birds have many enemies besides the elements, such as cats, young dogs, hawks, foxes, and vermin of different descriptions. When the eggs are taken, or the young birds destroyed soon after leaving the shell, there will be a second hatch. Sportsmen often meet with second hatches in September, when the old birds rise screaming, and generally alight within fifty yards, as if to induce the young birds to follow. In that case the fair sportsman will not fire at the old birds, but will call in his dogs and leave the ground. At such times he should look well after the young dogs, as, when they see the birds running, they are apt to snap up such of them as cannot get out of the way. The very young birds are called cheepers, from their uttering a scream as they rise. Full grown birds never scream as they rise, except when the young ones are helpless, nor do young birds after they are large enough for the table.

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[1] The Oakleigh Shooting Code.

The cock partridge is distinguished from the hen by the brown feathers which form a crescent, or horse-shoe, as it is sometimes called, on the breast.

The pointer is decidedly the best dog for partridge shooting. Markers and retrievers will be of much service to the shooter whose object is to kill a great quantity of birds, rather than to enjoy the sport.

T asant. e CLXI.

The Pheasant. The pheasant is the most splendidly arrayed of undomesticated British birds. It is deservedly in high request amongst sportsmen, and it claims the first attention of the game-preserver. The numberless plantations and coppices which are everywhere springing up, afford yearly additional shelter. The pheasant prefers woods of oak and beech, that it may feed on the acorns and mast. The fine old woods consisting of these trees may perhaps be diminishing, but they are more than replaced by plantations of larch or other quick-growing trees. Pheasants generally choose the larch or spruce-fir to roost in, and plantations of this description, if near corn, turnip, or potato fields, afford sufficient cover for them. They are, in many counties, allowed to become so numerous, as to do serious mischief to the labours of husbandry.

During August and the early part of September, pheasants will remain nearly all day in potato and corn fields. Pheasant shooting commences on the first of October, and ends on the first of February. In October, the shooter usually meets with them in potato and turnip fields, deep stubbles and rushy fields near covers, but especially under hedges, holly trees, or in coppices near to covers. In such situations they will suffer the shooter to approach very near to them; they are generally pointed by the dogs, and, a large majority of them being young birds, are easily killed; but in that month the trees are so full of foliage, and the briars and brushwood are so annoying, that it is seldom possible to beat the woods with any degree of pleasure, for not only are they almost impervious, but the pheasants are seldom seen when they rise, or if seen and shot, are very frequently lost, or not found without considerable loss of time. It is in November, when the birds have moulted, and when the leaves have fallen, and the brambles are decaying, and the paths in the woods are beginning to be worn, that pheasant shooting is in perfection. The birds are then full grown, and also better fed than later in the season.

It is not usual to kill the hens wherever pheasants are strictly preserved; but it is necessary to kill the cocks where they are too numerous. Pheasants do not pair, and as it is better that there should be but few cocks, the shooter's being able to single them out and kill them, tends ultimately to the increase, and not to the diminution of the number of birds in cover. At the commencement of the season the shooter will frequently flush a nide of pheasants, but in the after part of the season he will oftener find solitary birds. Pheasants will occasionally wander a considerable distance from the wood to which they belong, especially during winter, in search of food, and in wet and foggy weather. The pheasant basks at the root of a tree, or under a hedge, in the same manner as the partridge, but each bird nestles itself separately. Pheasants approach nearer to domesticated poultry than any other kind of game. Pheasant shooting is most destructive where the plantations are not more than forty yards wide; when the shooters remain on the outside, while the beaters and dogs rouse the game within. The pheasant shooter does not expect set shots; his object is to cause the birds to rise as near to him as he can. Having no notice of them, he should ever be on the alert for snap shots.

A short double-barrelled fowling-piece, of wide bore, is preferable to a long one. The shot should be large, and it is well to use plenty of it. A close-shooting gun is not to be recommended to the pheasant shooter. The birds should rarely be fired at in cover when more than thirty yards from the gun, or they will escape wounded in the underwood. They are generally brought down within twenty yards from the gun. Pheasants are most plentiful in Norfolk, Suffolk, and some of the adjoining counties. There are some in every county in England, and in most of the counties in Scotland. A perfect bird has a white annular space on the neck, but this mark is often wanting.

The pheasant makes a considerable noise when rising, sufficiently so to unnerve the young and over-anxious shooter. The bird should be allowed to rise clear of the bushes, and to its full height, before the shooter fires at it, or it is probable he will fire too low; and again, the short fan-like feathers on either side of the tail appear, as the bird is rising, to be part of the bird, making the body seem longer and larger than it really is; and this circumstance, together with the rapidity of the movement of the bird when rising, is the cause of the shooter firing too low. The aim should always be at the head, unless the bird is crossing, and then well forward. Firing too soon, lest the bird should be out of reach, is a very common error, particularly with young sportsmen.

For reasons which we have before adverted to, the setter, or cock-dog, is to be preferred to the pointer for pheasant shooting. Pheasants will sometimes lie very close, so that it is with great difficulty they can be made to rise; therefore dogs that will dash into the thicket are most useful. Beaters and retrievers are indispensable to the pheasant shooter.

The Hare

The Hare. The shooter seldom beats purposely for hares. Birds are mainly the object of his pursuit. He chooses his ground, and regulates the charge of his fowling-piece with reference to the birds he expects to meet with. Hares are started casually, as it were, while he is in quest of birds. Leveret shooting often commences with grouse shooting, on the 12th of August, though it is not uncommon, nor is it considered unfair, to kill leverets during the summer months. Hares are not in season until September. The shooter should desist from killing them in February, but he is not prevented from killing them at any season, by any legislative enactment, if he have taken out a game certificate. It is the prescriptive law of the chase, held sacred by sportsmen, that prevents him.

In September, hares lie close, in hedges, in woods, or in growing corn, and are somewhat difficult to be found. They are scared from the woods by the leaves falling in autumn, and they are then found, particularly after stormy weather, in pasture and stubble fields. Dogs will frequently point them. In November and December, they are often seen on their seats, or forms, as they are sometimes called, by the shooter keeping his eyes on the ground about eight or ten yards from him. It is usual, however, to allow the hare a chance of escape, by starting her before firing at her; it is accounted unsportsmanlike to kill puss on her seat. In January, hares are found on fallows, marshes, or in pastures, or in or near to gardens.

The shooter should fire well forward at a hare, and not too high. He should not fire at a long distance, as the probability of his wounding her would be greater than that of killing her. If running direct from him, a hare should not be fired at, unless within twenty-five paces from the gun, or she will often run off, though severely wounded in the hind-quarters. A beater will render essential service to the shooter in quest of hares, in the early part of the season; the beater walks on the contrary side of the hedge to the shooter, and a few yards in advance, so that the hare, to avoid the former, jumps out on the side of the latter. When beating hedges in the vicinity of covers, the shooter should take care to place himself on that side nearest the covers. When shooting at the edge of a cover, if the hare fired at is not quite deprived of the use of her legs, it would be advisable to fire again immediately, for should she crawl through the hedge, the chances would be against her being retrieved.

The Rabbit.

The Rabbit. Rabbits are alternately deemed game and vermin. They are sometimes shot for sport, sometimes for profit, and sometimes on account of the mischief they do to trees and other vegetation. They sometimes seat themselves all day long, after the manner of hares, but more frequently they remain the greater portion of the day in their burrows. As they are shy of approach, and run under ground on the least alarm, the shooter frequently finds it expedient to hide himself at a little distance from the warren, and wait until they come out. Where rabbits are numerous, as in most warrens they are, some will be continually playing within a few yards of the entrance of the burrows, and when found in such situations (for they are very tenacious of life), they should be struck very hard, or they will contrive to crawl, or rather roll into their earths, before the shooter can pick them up. It is astonishing what efforts they will make to escape, though three legs be broken, when near to the entrance of a burrow. It is of little use firing at them when they are more than twenty paces distant from the gun. Rabbits afford more what are termed snap-shots than any other game, as they are mostly found in or near to plantations, or amongst brambles, hollies, gorse or deep fern, in places of extreme difficulty. It requires a quick eye and steady hand to stop a rabbit running across furrows, or over uneven ground. Rabbits for sale, or when destroyed as vermin, are oftener taken by means of ferrets and nets, than killed by the gun. A short gun, having a large bore, and charged heavily with powder, and a small quantity of No. 4 shot, is best for rabbit shooting. It would be well that a companion or servant should lead a dog in a slip—a terrier is as good as any—to be loosed the moment the gun is fired; thus many a rabbit will be secured, that would else have run into its hole. When earthed, it frequently happens that a rabbit is not able to crawl more than three or four feet deep from the surface, where it dies, when it may be recovered by thrusting a bramble down the hole, and twisting it so as to entangle the rabbit; but a more certain method, if the rabbit is not too far down, is to screw the worm of the ramrod into its body, and so drag it out, as a cartridge is drawn from the barrel of a gun. The best time for rabbit shooting is in the evening, or during sunshine just after a shower, when great numbers of the rabbits venture from their burrows.

The Busta

The Bustard. The bustard is a rare but valuable acquisition to the game-bag. As it cannot be approached unless the shooter takes advantage of some adventitious circumstances, it is seldom an object of pursuit to the sportsman. Bustard shooting commences on the first of September, and ends on the first of March.

The Sn

The Snipe. There are three kinds of snipes, viz. the solitary or double snipe, the full or whole snipe, and the jack or half snipe. The last is considered to be scarcely worth powder and shot; it is the full snipe which principally engages the shooter's attention. We have before given directions for shooting this bird. "The common or full snipe is a shy bird when in company, but when alone will allow the shooter to approach within a dozen paces of it before it springs. When it does spring, however, it moves with a velocity that defies the epithet *slow!* It is best to shoot as soon as possible. The shooter will bring down a snipe with much less difficulty at from fifteen to twenty paces than at any other distance. The aim is thus taken before the bird begins to make its cross flights, and before it has attained its full speed. The irregularity of its flight is of little consequence during the first and second twirling, before the bird is safely on the wing, since its flight is then comparatively tardy. But let the snipe fly ten yards from whence it sprang,—let it be, for instance, twenty-five paces distant from the gun, it is then at the top of its speed, and in the very midst of its sidelong, elliptical gyrations, and more than a match for the majority of shooters, especially if the day be windy. A snipe killed at fifteen or twenty paces distance, with No. 7 shot, the aim being true, will be struck by twenty or thirty pellets, but the chances are more than twenty to one against the aim being true. The snipe, when struck, is generally three or four inches from the centre of the cone which the shot forms as it flies, which is very different from being in the exact centre. A section of the body of a snipe does not present a surface as large as that of a penny-piece. If any person will fire at a target at fifteen yards distance, he will find that a snipe would not be cut to pieces even at that distance, unless it chanced to be precisely in the centre of the charge as thrown. When speaking of a snipe presenting no larger a surface as a mark than a penny-piece, we of course mean a snipe flying directly from the shooter. It would be imprudent to shoot at a snipe flying across at less than twenty-five paces distance, as it then presents more than double the surface of one going straight from the shooter. Thirty paces is the distance we should prefer for a cross or oblique shot. At thirty, or even at twenty-five yards, unless the barrel throws shot remarkably close, there are interstices in the charge as thrown, in which a snipe would escape untouched. Provided the flight of a snipe were equally steady at all distances, and that in every instance the shooter could choose his own distance, a snipe would have the least chance for its life at twenty yards. But there are two points to be attended to in determining the proper distance—the flight of the bird, and the manner in which the shot is thrown. In snipe-shooting the latter is subservient to the former. The few full snipes occasionally found on heathery and rush-clad hills, as well as in the enclosed grounds, lie much more dispersed than the gregarious birds of the marsh. Hence those found on the uplands are easy, and those on the fens difficult of approach. It is, however, the same description of bird that is found in both situations." When the shooter uses wire cartridges, which, by the bye, are not precisely calculated for snipe-shooting, it would be prudent to allow the bird to move to a considerable distance before firing. It is scarcely necessary to add, that the shot used for snipe-shooting should be very small. When several snipes rise together, they are styled a wisp.

T
W dcock.

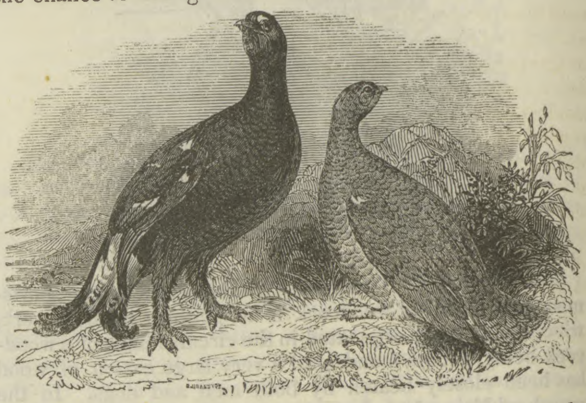
The Woodcock. There is a proverb current among sportsmen, that to kill a woodcock is to perform a day's work, which doubtlessly originated in the circumstance of a woodcock being seldom found until a very large extent of wood has been closely beaten by both men and dogs. In the month of November, however, when woodcocks are most abundant, it would not be a difficult task, according to that standard of labour, to do the work of a week in a day, in any noted cover, for every cover frequented by woodcocks, (or cocks as they are called in the sportsman's nomenclature), acquires a notoriety which it seldom loses, since any wood well frequented with cocks one year, has generally a fair supply the next. But whether the same cocks that frequent a wood this year, return the next, with their offspring, or whether an entirely new set of occupants take possession, we leave the ornithologist to decide. A certain description of woods are seldom known to fail of woodcocks during the winter months; these woods or plantations are such as are swampy, or have a stream of water running through them, or woods abounding in springs, or where, from the nature of the ground, or want of draining, the top water encourages the growth of moss. The woodcock is rarely found where moss is not abundant. During a frost, cocks are found near fresh water springs; at other times, they are most commonly flushed in the open glades of the densest woods, or rather in those parts of the woods not choked up at the bottom with fern, rushes, or brambles, but where they can freely run about, and in those parts where willows, osiers, hazel-trees, or crate-wood is plentiful. In such places it will readily be ascertained whether there are cocks or not, by the borings in the moss or dead leaves, and by the droppings. Should the cock not be brought down, it will not fly far after being fired at; it should, when practicable, be marked down, as by this means several successive shots may be obtained at it when the gun is unsuccessful. It is seldom that the skilful shooter springs a cock which he does not eventually kill. The difficulty of woodcock shooting arises, for the most part, from the birds springing in the thickest part of woods, and contriving to wing their flight through the trees, in such a manner as to baffle the sportsman's aim. After being fired at in a wood, cocks will frequently alight amongst hedge-rows on the outskirts, especially under a hedge running close to and parallel with a water-course, when they are easily killed, as they will not rise until the shooter is close upon them; and their flight is not difficult to master when there are no trees to obstruct the aim. Woodcocks are found in October on moors, and in covers near the sea. About the last week in October they find their way to the inland covers, where they remain during the early part of the winter, and they are sometimes found there again in March. A sharp frost, or a dense fog, at the end of October or beginning of November, is usually the shooter's first intimation of the arrival of cocks; and if he is ambitious of the fame of killing them, he must fag hard during the month of November, or it is probable that his return for the season of the numbers bagged will not be satisfactory. November is unquestionably the best month for cock shooting.

The Red Grouse.
Plate CCCCLXI.

The Red Grouse. Grouse shooting commences on the 12th of August. We have already alluded to the vast extent of the northern moors. The number of birds killed on the opening day, on some parts, is very great. It is not uncommon for an experienced and skilful shooter, on the best moors, to bag fifty brace on the 12th of August. What may be termed a good day's sport, differs much on different moors. On well-preserved moors, the average may be from ten to twenty brace. On subscription moors, the shooter should not be dissatisfied if he has the opportunity of killing from three to five brace per day, during the first week of the season, though this would be deemed a low average for the Scottish moors. After the first week, few sportsmen, except those residing in the immediate neighbourhood of the hills, ever trouble the moor game.

Many causes contribute to the popularity of grouse shooting, amongst which may be enumerated the following. It commences during the parliamentary recess, and long vacation—the legislator's, lawyer's, and collegian's holiday; and it is no wonder that after being cooped up all summer, these, or any other classes of society, should seek relaxation in the sports of the field. August is the season when every one, from the peer to the shopkeeper, who can afford the indulgence, either rusticates or travels. In that month the casual tourist, the laker, and the angler, are often in the North, when the temptation to draw a trigger is irresistible. Grouse shooting fascinates the young shooter more than any other kind of sport, inasmuch as the season commences with it. The opening day is looked forward to with pleasing anticipation all summer. To the more practised sportsman, grouse shooting recommends itself by reason of the superiority of the sport over every other kind of shooting. Partridge shooting is a comparatively tame and uninteresting amusement. Partridge shooting, as compared with grouse shooting, may be termed domestic sporting. To the majority of sportsmen, a grouse shooting excursion only occurs once a year, and then lasts only a few days. The sport therefore seldom palls; but during the long interval of time that elapses between each, the coming season is ever looked forward to with additional interest. Grouse shooting is, in many respects, a source of greater expenditure to the sportsman: it requires more preparation, and is attended with more difficulties than any other kind of shooting; but these circumstances, whatever some people may imagine to the contrary, so far from detracting from, serve to enhance the enjoyment of the sport; for we are apt to estimate whatever is obtained with difficulty and expense at a higher rate than what is gratuitously afforded us. To the lover of the romantic and the picturesque, grouse shooting has attractions of the highest order. It is the sport of all others peculiarly British: the partridge, the pheasant, the black-cock, are widely dispersed over other countries; but the red grouse is only found in the British Islands.

There are seldom more than a dozen grouse in a brood; rarely indeed so many. Towards the end of autumn, the broods congregate together, and are seldom seen afterwards until pairing time in January or February, except in great numbers. Broods thus associated are termed packs. When it happens that the birds are well grown at the opening of the season, and much fired at in August, they will pack before September. When there is fine weather in August, grouse, until the broods are packed, will suffer the shooter to approach very near to them before they rise. In wet or windy weather they are wild. Very few grouse are killed by the sportsman after August; they are then scarcely approachable. Grouse delight in tall young heather, when there are plenty of bare places or pads or tracks. Hares also, and cocks, and we may perhaps add, pheasants, in their respective covers, delight in those parts where they can run about freely. The brow of a hill is more likely ground than either extreme heights or valleys, or flats. Solitary birds lie better than broods. When birds are wild, the shooter should follow an individual rather than a brood. It is well understood by sportsmen, that the fewer birds there are in a brood, nide, or covey, the better will they lie. Grouse bask on the sunny hill-side, oftentimes under a rock, or in a stone pit, during the middle of the day, at which time the task of ranging for them is toilsome in the extreme. Grouse shooters should be accompanied by a guide and markkers. The former is indispensable to a person not intimately acquainted with every turn and knoll, during the mist that nine mornings out of ten envelopes the hills in August. It is inconceivable how completely bewildered a person who fancies he is acquainted with every inch of ground may be when surrounded by the haze. Neither sun, moon, nor stars are visible; nor is there a fence, road, or building to direct him. A stone pit, or mountain rill, are often the only objects that present themselves, except the interminable heather. The distant hills that would else be his guides, are shut out from his view, which does not extend beyond the range of his fowling-piece. At such times it requires no ordinary precaution to prevent losing young dogs, which can scarcely be prevented running off when a gun is fired in the distance. During the continuance of the mist, which generally disappears about eight o'clock, markers can be of but little use, except that they may be employed in carrying a basket, extra guns and shot, or leading dogs, of which it is well to have a change. No dog can range two days successively for grouse. Pointers, for reasons we have before given, are preferable to setters, or any other kind of dogs, for grouse shooting. Grouse shooters should separate and range singly; they should have no noisy attendants; nor any dogs that require rating. The sport cannot be carried on too quietly. If the shooter throws off before eight o'clock, which it is not prudent to do unless there are many guns on the moors or foul weather is expected in the afternoon, he should run only one dog as long as the heather is wet, afterwards two, and in the afternoon three dogs. In wet weather one dog is quite sufficient. If hot weather, we advise rest from eleven to two. If the shooter have not exhausted himself during the middle of the day he will best fill his bag in the afternoon; he may not, indeed, then find so many, but those he does find will be dispersed birds that will almost lie to be trodden on. An old shooter thus on a dry afternoon following a wet morning will sometimes load himself or his attendant, after the less experienced have left the moor disgusted, with scarcely a bird in their possession. Shooters are generally recommended to carry as heavy a gun as they can conveniently manage on the moors. It should be borne in mind that the heaviest gun will do most execution; but none except those accustomed to such exercise, can carry a heavy gun with comfort all day long, exposed to an autumnal sun. We would therefore not recommend barrels more than thirty inches long, nor of a larger guage than sixteen, on account of the excessive heat of the weather at this season. As the sportsman, in grouse shooting, has ever an opportunity of choosing his own distance when birds rise near to him, he will be more certain of killing if he let the birds fly twenty-five yards from him before he fires the first barrel, when, if he have both barrels cocked, he will have ample time to throw in the reserve barrel while the birds are within reasonable distance. In nothing is the superiority of the detonating over the flint lock more apparent than in its allowing the shooter to fire the second so soon after the first barrel. We suspect that the habit of taking the gun from the shoulder after the first barrel was fired, originated in the necessity of waiting until the smoke from the pan was blown away, which nuisance no longer exists. A person who is a decidedly bad shot should not use the cartridge in the first barrel, as the loose charge gives a larger circle at a short distance, and consequently increases the chance of killing.



The Blackcock. Black game shooting commences on the 20th of August, and ends, with red grouse shooting, on the 10th of December. Black game frequent moors covered with heather, but they are as often found in rushy fields, or even in stubbles adjoining to moors. They are not met with at any great altitude, but confine themselves chiefly to the lower hills, or the base of the loftier mountains. They are seldom found, except where there are plantations or forests of fir trees. Black game do not frequent the central parts of large wastes so much as those parts bordering on inclosed lands. Red grouse recede where civilization progresses; and they are consequently in a fair way, at no very distant period, of being banished from England. As a vast extent of heath-land is not requisite for black game, there is no room to fear their extinction for some centuries to come. Although not so numerous as red grouse, they are more widely scattered over England. Even in the south of England there is cover congenial to them. Should both black and red game become extinct in England, the hills of Scotland will long afford shelter to each. With the exception of the pheasant, black game is the only species of game not yearly diminishing in number in Britain. A full-grown blackcock weighs the same as a fine pheasant cock, about three pounds and a half. The female, which is called the grey-hen, and ought never to be fired at, is much smaller. Black game shooting on moors resembles red grouse shooting, and in the woods, pheasant shooting. The black cock is a magnificent bird, and an old one is ever deemed a valuable addition to the contents of the game bag. Black game have increased very considerably in England during the last few years, still they are much more abundant in Scotland. Sweden is perhaps the country best suited to them.

The Capercailzie. Similar to the blackcock, in many respects, is the capercailzie, or cock of the wood, once the native, and now the denizen of the Highland forests. The capercailzie cock weighs sixteen pounds. Speaking of this bird, as it exists in Sweden, Mr. Lloyd says,[1] "The favourite haunts of the capercali are extensive fir woods; in coppices or small cover he is seldom or never found. The principal food of the capercali, when in a state of nature, consists of the leaves of the Scotch fir; he very rarely, however, feeds upon those of the spruces; he also eats juniper berries, cranberries, blaeberries, and other berries common to the northern forests; and occasionally also, in the winter time, the buds of the birch, &c. The young capercali feed principally at first on ants, worms, insects, &c." It was the felling of the timber, aided, perhaps, by the cross-bow, which is not ill-adapted to the purpose, that exterminated this primeval habitant of the old Caledonian forests. Some years since an attempt was made to re-introduce this bird to its ancient haunts in Scotland, but without success. "It is a pity," continues Mr. Lloyd, "that attempts are not made once more to introduce the capercali into the United Kingdom, for, if the experiment was undertaken with judgment, it would most probably be attended with success; the climate, soil, &c. in Scotland, at least, not being very disimilar, in many respects, to the south of Sweden. In Scotland, besides, independently of the natural forests, there are now considerable tracks of land planted with pines, from which trees, when the ground is covered with snow, those birds obtain nearly the whole of their sustenance." Since this was written, several brace of these birds have been sent over from Sweden; and on the estates of the Marquis of Breadalbane the experiment of localising them is in course of trial. We believe they were procured by Mr. Lloyd himself, and under his auspices, from his knowledge of the habits of the bird, we doubt not that the cock of the wood will become permanently established in the Highlands. It may be inferred that the same description of country (the heaths and forests being on a more extended scale,) which suits the blackcock, would likewise suit the capercailzie, since, as Mr. Lloyd observers, "the capercali occasionally breed with the black game; the produce of which partake of the leading characteristics of both species. Their size and colour, however, greatly depend upon whether the connexion was between the capercali cock and the grey hen, or *vice versâ*." In winter, the male birds congregate in packs after the manner of black game. In Sweden the capercailzie is usually shot with the rifle.

Th
Pta igan.
Pla
CCC XI.

The Ptarmigan. We have now for some time traversed, with the reader, the highest hills that are covered with heather, but there are heights beyond. The poet says,

For Liberty! go seek
Earth's highest rocks and ocean's deepest caves!
Go where the eagle and the sea-snake dwell![2]

It may be admissible in poetry to give the highest cliffs to the king of birds, but zoology assigns a lower elevation to "the eagle's birth-place;" yes, you may ascend above the äerie of the eagle, where the croak of the raven is never heard, where the fox and the weazel but seldom disturb the lonely habitants. You may ascend until, in the glowing language of Mr. Mudie,[3] "you begin at last to feel alone, severed entirely from the world of society, of life, and of growth, and committed to the solitude of the ancient hills and immeasurable sky. The snow lies thick on the side of the summit, and even peers over the top, defying the utmost efforts of solstitial heat. There is no plant under your feet, save lichen on the rock, apparently as hard and as strong as that to which it adheres—it can hardly be said to grow—and moss in some crevice, undistinguishable from the dull and cold mud into which the storms of many winters have abraded the granite. You are above the reach of all sound from the inhabited parts of the country." And what do we find in this region of snow? "A few mottled pebbles, or at least what appear to be such, each about twice the size of your hand, lie at some distance, where the decomposed rock, and the rudiments of what may be called the most elevated mountain vegetation, just begin to ruffle the surface. By and by a cloud shadows the sun, the air blows chill as November, and a few drops fall, freezing or melting in their descent, you cannot well tell which. The mottled pebbles begin to move; you throw a stone at them to shew that you can move pebbles as well as the mountain. The stone hits beyond them; they run toward your feet, as if claiming your protection; they are birds, ptarmigan, the uppermost tenants of the island, whom not even winds, which could uproot forests, and frosts, which could all but congeal mercury, can drive from these their mountain haunts. It has often been observed, that of all the human inhabitants of the earth, the mountaineer, be his mountain ever so barren, is the last to quit; and the same holds true of the mountain bird." The same writer traces the different elevations at which various species of game is found, beginning with the pheasant, as the tenant of the lowermost woods; the partridge, of the plain; the blackcock, of the confines of cultivation; the grouse, of the lesser hills and mountain-side; and the ptarmigan, of the snow-crowned summits. He also adds, "in these birds we trace a sort of resemblance to the general colour of the places which they inhabit, though we know not well the cause of the colour in either case. The ptarmigan is mossy rock in summer, hoar frost in autumn, and snow in winter. Grouse are brown heather, black game are peat-bank and shingle, and partridges are clods and withered stalks all the year round." And we will add, the capercailzie is the black branch of the pine. A similar scale is applicable to the seasons at which these birds are hatched. Although, taking each species individually, we find the earliest birds in the warmest country and on the richest land: collectively, the order is reversed; the higher their location, the earlier do they arrive at their full growth. The ptarmigan is ready for the table before the period at which it may be legally shot, the twelfth of August. Descending the hill, we find the red grouse not three parts grown at that period. A little lower, and the scarcely-fledged black-cock rises almost helpless, on the twentieth of August. Lower still, on the fertile plain, the young partridge does not assume his grey mantle and purple crescent until long after the first of September. And in the warm woods the pheasant does not don his panoply of gold until the fall of the leaf.

Few are the sportsmen who climb the granite cliffs, and wade the winter snows in which ptarmigan delight to bury themselves. A ramble there, is a journey of curiosity or observation, rather than a sporting excursion. It is a pilgrimage to the loftiest Highland altitudes. The fowling-piece becomes converted into the palmer's staff; and the sportsman merges in the adventurer, the enthusiast, the worshipper of Nature!

(B. X.)

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[1] Field Sports of the North of Europe.

[2] Rienzi, a Tragedy. (1st edition.) London.

[3] The Feathered Tribes of the British Islands. By Robert Mudie. 2d edition. 1835. London, Whittaker.

SHORE, a place which is washed by the sea, or by some large river.

Count Marsigli divides the sea-shore into three portions; the first of which is that tract of land which the sea just reaches in storms and high tides, but which it never covers; the second part of the shore is that which is covered in high tides and storms, but is dry at other times; and the third is the descent from this, which is always covered with water.

The first part is only a continuation of the continent, and suffers no alteration from the neighbourhood of the sea, except that it is rendered fit for the growth of some plants, and wholly unfit for that of others, by the saline steams and impregnations; and it is scarcely to be conceived by any but those who have observed it, how far on land the effects of the sea can reach, so as to make the earth proper for plants which will not grow without this influence; there being several plants frequently found upon high hills and dry places, at three, four, and more miles from the sea, which yet would not grow unless in the neighbourhood of it, nor will they ever be found elsewhere.

The second part or portion of the shore is much more affected by the sea than the former, being frequently washed and beaten by it. Its productions are rendered salt by the water, and it is covered with sand, or with the fragments of shells in the form of sand, and in some places with a tartarous matter deposited from the water. The colour of this whole extent of ground is usually dusky and dull, especially where there are rocks and stones covered with a slimy matter.

The third part of the shore is more affected by the sea than either of the others; and it is covered with an uniform crust of the true nature of the bottom of the sea, except that plants and animals have their residence in it, and the decayed parts of these alter it a little.

Shore, *Jane*, the celebrated mistress of Edward IV., was the wife of Matthew Shore, a goldsmith in Lombard-street, London. Historians represent her as extremely beautiful, remarkably cheerful, and of most uncommon generosity. The king, it is said, was no less captivated with her temper than with her person. She never made use of her influence to prejudice any person; and if ever she importuned him, it was in favour of the unfortunate. After the death of Edward, she attached herself to Lord Hastings; and when Richard III. cut off that nobleman as an obstacle to his ambitious schemes, Jane Shore was arrested as an accomplice, on the ridiculous accusation of witchcraft. This, however, terminated only in a public penance, excepting that Richard rifled her of all her little property; but whatever severity might have been exercised towards her, it appears that she was alive, though sufficiently wretched, under the reign of Henry VIII., when Sir Thomas More saw her, poor, old, and shrivelled, without the least trace of her former beauty. Mr. Rowe, in his tragedy of Jane Shore, has adopted the popular story related in the old historical ballad, of her perishing by hunger in a place where Shoreditch now stands. But Stow assures us, that that street was so named before her time.

SHOREHAM, a town of the county of Sussex, in the rape of Bramber and hundred of Fishergate, fifty-six miles from London. It stands on the river Adar, about a mile from the sea, and has a bridge over that river. It has a custom-house, which presides over that at Brighton. The harbour is not deep, but useful as shelter, when the wind is high, for vessels unloading on the beach at Brighton, although there is scarcely any water when the tide is out. It is an ancient place, ill built, with few good houses. The church is old, and was originally monastic. It is a borough, which, on account of bribery in 1771, was extended, to comprehend all the forty shilling freeholders of the rape on which it stands, and still continues to elect two members to the House of Commons. There is some trade in building ships, and a considerable oyster fishery. A market, well supplied, is also held on Saturday. The population was, in 1801, 987; in 1811, 980; in 1821, 1282; and in 1831, 1734.

SHORT, James, an eminent optician, was born in Edinburgh, on the 22d of June in the year 1710. At ten years of age, having lost his father and mother, and being left in a state of indigence, he was received into Heriot's Hospital, where he soon displayed his mechanical genius, in constructing for himself little chests, book-cases, and other conveniences, with such tools as fell in his way. At the age of twelve he was removed from the Hospital to the High School, where he shewed a considerable taste for classical literature, and generally kept at the head of his forms. In the year 1726 he entered the university, where he passed through the usual course of education, and took his master's degree with great applause.

By his friends he was intended for the church; but after attending a course of theological lectures, his mind revolted from a profession which he thought little suited to his talents, and he devoted his whole time to mathematical and mechanical pursuits. He had been fortunate enough to have the celebrated Maclaurin for his preceptor, who having soon discovered the bent of his genius, and made a proper estimate of the extent of his capacity, encouraged him to prosecute those studies in which nature had qualified him to make the greatest figure. Under the eye of that eminent master, he began in 1732 to construct Gregorian telescopes; and, as the professor observed in a letter to Dr. Jurin, "by taking care of the figure of his specula, he was enabled to give them larger apertures, and to carry them to greater perfection than had ever been done before him."

In the year 1736 Mr. Short was called to London, at the desire of Queen Caroline, to give instructions in mathematics to the Duke of Cumberland; and immediately on his appointment to that honourable office, he was elected a fellow of the Royal Society, and patronized by the Earls of Morton and Macclesfield. In the year 1739 he accompanied the former of these noblemen to the Orkney Isles, where he was employed in adjusting the geography of that part of Scotland; and happy it was for him that he was so employed, as he might otherwise have been involved in a scuffle which took place between the retainers of Sir James Stewart of Barra and the attendants of the earl, in which some of the latter were dangerously wounded.

Mr. Short having returned to London, and finally established himself there in the line of his profession, was, in 1742, employed by Lord Thomas Spencer to make for him a reflector of twelve feet focus, for which he received six hundred guineas. He made several other telescopes of the same focal distance with greater improvements and higher magnifiers; and in 1752 finished one for the king of Spain, for which, with its whole apparatus, he received twelve hundred pounds. This was the noblest instrument of the kind that had then been constructed, and perhaps it has never yet been surpassed, except by the astonishing reflectors of Herschel.

Mr. Short used to visit the place of his nativity once every two or three years during his residence in London, and in 1766 he visited it for the last time. On the 15th of June 1768 he died, after a very short illness, at Newington Butts, near London, of a mortification in his bowels, and was buried on the 22d of the same month, having completed his fifty-eighth year.

Short-Hand Writing. (See Stenography.)

Short-Sightedness, a certain defect in vision, by which objects cannot be distinctly seen unless they are very near to the eye. (See Optics).

SHOT, a denomination given to all sorts of balls for fire-arms; those for cannon being of iron, and those for guns and pistols of lead.

Case Shot formerly consisted of all kinds of old iron, nails, musket-balls, and stones, which were used as above.

Shot of a Cable, on ship-board, is the splicing of two cables together, that a ship may ride safe in deep waters and in great roads; for a ship will ride easier by one shot of a cable, than by three short cables out ahead.

SHOUMSHU or Choumchoo, one of the Kurile islands, the nearest to Asia, thirty-six miles in length and twenty in breadth. It contains mines, which yield a small quantity of silver. There are large lakes abounding with fish, and the natives have an herb from which they extract brandy. There are only forty-four male inhabitants, who pay tribute to Russia. It is ten miles south from Kamtschatka.

SHOVEL, Sir Cloudesly, a distinguished British admiral, was born about the year 1650, of parents in the lower rank of life. He was first put apprentice to a shoemaker; but disliking this profession, he a few years afterwards abandoned it, and went to sea. He was at first a cabin-boy with Sir Christopher Mynns, but having applied to the study of navigation with indefatigable industry, his skill as a seaman soon raised him above that station.

The corsairs of Tripoli having committed great outrages on the English in the Mediterranean, Sir John Narborough was sent in 1764 to reduce them to reason. As he had received orders to try the effects of negotiation before he proceeded to hostilities, he sent Mr. Shovel, who was at that time a lieutenant in his fleet, to demand satisfaction. The dey treated him with a great deal of disrespect, and sent him back without an answer. Sir John dispatched him a second time, with orders to remark particularly the situation of things on shore. The behaviour of the dey was worse than ever, and upon Mr. Shovel's return, he informed Sir John that it would perhaps be possible, notwithstanding their fortifications, to burn all the ships in the harbour. The boats were accordingly manned, and the command of them given to Lieutenant Shovel, who seized the guard-ship, and burned four others, without losing a man. This action so terrified the Tripolins, that they sued for peace. Sir John Narborough gave so favourable an account of this exploit, that Mr. Shovel was soon afterwards made captain of the Sapphire, a fifth-rate ship.

In the battle of Bantry-Bay, after the Revolution, he commanded the Edgar, and, for his gallant behaviour in that action, was soon afterwards knighted by King William. Next year he was employed in transporting an army into Ireland; a service which he performed with so much diligence and dexterity, that the king raised him to the rank of rear-admiral of the blue, and delivered his commission with his own hands. Soon afterwards he was made rear-admiral of the red, and shared the glory of the victory at La Hogue. In 1694 he bombarded Dunkirk. In 1703 he commanded the grand fleet in the Mediterranean, and did every thing in his power to assist the Protestants who were in arms in the Cevennes.

Soon after the battle of Malaga, he was presented by Prince George to Queen Anne, who received him graciously, and next year employed him as commander-in-chief. In 1705 he commanded the fleet, together with the Earl of Peterborough and Monmouth, which was sent into the Mediterranean; and it was owing to him chiefly that Barcelona was taken. After an unsuccessful attempt upon Toulon, he sailed for Gibraltar, and from thence homewards with a part of the fleet. On the 22d of October, at night, his ship, with three others, was cast away on the rocks of Scilly; and all on board perished. His body was found on the island of Scilly, by some fishermen, who stripped it of a valuable ring, and afterwards buried it. Mr. Paxton, the purser of the Arundel, hearing of this, found out the fellows, and obliged them to discover where they had buried the body. He carried it on board his own ship to Portsmouth, whence it was conveyed to London, and interred with great solemnity in Westminster Abbey. A monument was afterwards erected to his memory by the direction of the queen. He married the widow of his patron, Sir John Narborough, by whom he left two daughters.

SHOUT, Clamour, in antiquity, was frequently used on ecclesiastical, civil, and military occasions, as a sign of approbation, and sometimes of indignation. Thus as Cicero, in an assembly of the people, was exposing the arrogance of Antony, who had had the impudence to cause himself to be inscribed the patron of the Romans, the people on hearing this raised a shout to show their indignation. In the ancient military discipline, shouts were used, first, upon occasion of the general's making a speech or harangue to the army from his tribunal. This they did in token of their approving what had been proposed. Secondly, they were used before an engagement, in order to encourage and spirit their own men, and fill the enemy with dread. This was a practice of great antiquity; but, besides, it wants not the authority of reason to support it; for as mankind are endowed with two senses, hearing and seeing, by which fear is raised in the mind, it may be proper to make use of the ear as well as the eye for that purpose. Shouts were also raised in the ancient theatre, when what was acted pleased the spectators. It was usual for those present at the burning of the dead to raise a great shout, and call the dead person by his name, before they set fire to the pile.

SHREWSBURY, a town in the liberty of the same name, and the capital of the county of Shropshire, 156 miles from London. It is situated on a peninsula formed by the river Severn, which nearly surrounds it, and over which are two stone bridges. It comprehends three parishes, with a church to each, which were formerly collegiate, namely, St. Alkmands, St. Marys, and St. Chads. The town was in ancient times well fortified, and had a strong castle towards the north, a part of which still remains, and the keep has been converted into a garden. There is a free grammar school, at present in high repute, for communicating classical instruction, which possesses some valuable exhibitions at Cambridge. It is well endowed, and has a good library and neat chapel connected with it. There is a county hall, a jail, two bridewells, and a house of industry. The streets are narrow, and some of them rather steep, and the greater part of the houses are of ancient construction and fashion. It is a borough, and the corporation has extensive judicial power within the liberty, though it is now commonly transferred to the assizes for the county, which are held here. Shrewsbury has some trade by the river Severn, and some by a canal, which connects it with Ellesmere, and other parts of the kingdom. The principal manufactory is that of flannels, many of which, indeed, are woven in Montgomeryshire, and brought to Shrewsbury to be finished, but many are made within the town, and of late years machinery has been extended for that purpose. There are likewise some linens, and some coarse woollen cloths made. The country around is highly fertile, and the two markets, on Wednesday and Saturday, are most abundantly supplied. The town returns two members to parliament, and gives the title of earl to the ancient family of Talbot. The population was, in 1801, 14,739; in 1811, 16,606; in 1821, 19,854; and in 1831, 21,227.

SHUGAWULPOOR, a large town of Hindustan, in the province of Malwah, situated on the north-east bank of the river Jummary. It consists of a fortified town or citadel, and extensive suburbs, in which are some good houses, and an extensive bazaar. It is a considerable market for shipped muslins, 65 miles E.N.E. from Oojain. Long. 76. 45. E. Lat. 23. 24. N.

SHUKASKU, a large village of Irak in Arabia, on the western bank of the Euphrates. It is a flourishing place, and carries on a brisk trade with Bussora, the Euphrates being navigable to this place by means of large boats. It is surrounded by rich pastures; on which are reared numerous horses.

SHUMSABAD, a small town of the Sikh territorial province of Lahore, situated on the east side of the Jhylum river, 100 miles N.W. by W. from Lahore. Long. 72. 15. E. Lat. 32. 16. N.

SHUNDRABANDY, a town of Southern India, in the district of Tinnevelly, 40 miles S.W. from Madura. Long. 77. 45. E. Lat. 3. 35. N.

SHUS, a large mass of ruins in the province of Khuzistan, in Persia, extending twelve miles from the Kerah to the Abzal. They occupy an immense extent of ground, and are supposed, by Major Rennel and Colonel Kinneir, to be the ancient capital of Susa.

SHUSTER, the principal district of the province of Khuzistan, in Persia, and composing a separate government. It constitutes the finest portion of Susiana, being watered by four noble rivers, and a multitude of smaller streams, by which means the land is fertilised, and rendered productive. But the bounties of nature are here blasted by the oppression and malignity of man, and the ignorant and rapacious rulers of Persia, causing devastation and ruin over all the territories subject to their sway. This wealthy province, accordingly, which was formerly rich in its productions of cotton, sugar, rice, and grain, is now a forsaken waste; from the Abzal to the Tigris, and the river which Colonel Kinneir considers the Gyndes, on the western side, and from the banks of the Karoon to those of the Shat-ul-Arab, all is dreary and desolate; and upon the east side of Shuster, a lonely wild, upwards of sixty miles in length, extends from that city to the entrance of the valley of Ram Hormuz. Even in the most flourishing parts of the country, namely, between Bundekeel and Dezphoul, the corn is reared by the officers of the government, and the richer citizens of Shuster and Dezphoul, the original cultivators of the soil being all ruined by the heavy contributions imposed upon them, and which had been exacted with such severity, as to drive them from their habitations. Ram Hormuz, which forms part of this district, is one of the most romantic valleys in Persia. It is ruled by five hostile chiefs, four of whom are brothers, and have each a castle, from which they make frequent sallies, and carry off the corn and cattle of their rivals.

Shuster, a city of Persia, the capital of the province of Khuzistan, and the residence of a Beglerbeg, is situated at the foot of the mountains of Bucktiari, on an eminence overlooking the rapid course of the Karoon, across which is a bridge of one arch, upwards of eighty feet in height; from the summit of which the Persians frequently throw themselves into the water without sustaining the slightest injury. The streets, as in most eastern towns, are narrow and dirty, though the houses are good, being principally built of stone; it is defended on the western side by the river, and on the other sides by the old stone wall, which is now fallen into decay. The ruins which still remain attest the former magnificence and extent of this city. Those most worthy of attention, are the castle, the dike, and a bridge. Part of the walls of the former, said to have been the abode of Valerian, are still standing on a small hill at the western extremity of the town. It is on two sides defended by a ditch, and on the other two by a branch of the Karoon. It has but one gateway, built in the Roman fashion, and formerly entered by a chain-bridge. Not far from the castle is the dike, built by Sapor, across the Karoon, twenty feet in breadth, and four hundred yards in length, with two small arches in the middle. It is built of culstone, bound together by clumps of iron; and having, from want of care, given way to the torrent, Prince Mahomed Ali Meerza, governor of Kermanshaw, has rebuilt it. Over the artificial canal, formed by the building of this dike, is a bridge built of hewn stone, consisting of thirty-two arches, twenty-eight of which are yet entire. This city is generallly believed to have been the ancient Susa, though Colonel Kinneir, and Major Rennel, both good authorities, rather assign the ruins of Shus as the site of this renowned capital. Long. 48. 59. E. Lat. 32. N.

SHROPSHIRE, or Salop, a county of England. (See Salop.)

SHROVE-Tuesday, is the Tuesday after Quinquagesima Sunday, or the day immediately preceding the first of Lent, being so called from the Saxon word to *shrive*, which signifies to confess. Hence Shrove-Tuesday signifies Confession-Tuesday, on which day all the people in every parish throughout England, during the Catholic times, were obliged to confess their sins, one by one, to their own parish priest, in their own parish-churches; and, that this might be done the more regularly, the great bell in every parish was rung at ten o'clock, or perhaps sooner, that it might be heard by all, and that they might attend, according to the custom then in use.

SHROUDS, a range of large ropes extending from the mast-heads to the right and left side of the ship, to support the masts, and enable them to carry sail.

The shrouds as well as the sails are denominated from the masts to which they belong. Thus there are the main, fore, and mizen shrouds; the main-top-mast, fore-top-mast, and mizen-top-mast shrouds; and the main-top-gallant, fore-top-gallant, and mizen-top-gallant shrouds. The number of shrouds by which a mast is sustained, as well as the size of the rope of which they are formed, is always in proportion to the size of the mast and the weight of the sail it is intended to carry.

Bowsprit shrouds are those which support the bowsprit. Bumpkin shrouds are those which support the bumpkins. Futtuck shrouds are shrouds which connect the efforts of the topmast shrouds to the lower shrouds. Bentick shrouds are additional shrouds to support the masts in heavy gales. Preventer shrouds are similar to bentick shrouds, and are used in bad weather to ease the lower rigging.

SHRUB, *frutex*, a little, low, dwarfish tree, or a woody vegetable, of a size less than a tree, and which, instead of one single stem, frequently puts forth from the same root several sets or stems.

SHUTTLE, in the manufactures, an instrument used by weavers, which guides the thread it contains, either of woollen, silk, flax, or other matter, so as to make it form the woofs of stuffs, cloths, linens, ribands, and other fabrics, by throwing the shuttle alternately from left to right, and from right to left, across between the threads of the warp, which are stretched out lengthwise on the loom.

In the middle of the shuttle is a kind of cavity, called the eye or chamber of the shuttle, in which is inclosed the spoul, which is a part of the thread destined for the woof; and this is wound on a little tube of paper, rush, or other matter.

SIAK, is a river and a large district of Sumatra. The district extends about 450 miles along the north-east coast. This district has a considerable trade, which is carried on by vessels from the coast of Coromandel, which supply cargoes of piece goods, and also raw silk, opium, and other articles, which they provide at Prince of Wales' island or Malacca, receiving in return gold, wax, sago, salted fish and fish roes, elephants' teeth, camphire, rattans, and other canes. Spars and masts, and large supplies of frame timber used to be imported by the Dutch East India Company for the use of Batavia. The maritime power of the kingdom of Siak has always been considerable.

The river Siak is one of the largest in the island, and discharges itself into the sea opposite Malacca in N. lat. 1. 40. From a survey ordered by the British government of Prince of Wales' island, it appears that from its mouth to the town of Siak, is sixty-five miles. The width of the river is in general from about a half to three quarters of a mile, and its depth from seven to fifteen fathoms; but on the bar at low water, there is only fifteen feet of depth, and there are several shoals near its mouth.

m.

SIAM, an extensive kingdom of India beyond the Ganges, situated principally between the 10th and 15th degrees of north latitude, in the heart of the great peninsula between India and China. It is bounded on the north by unknown tracts, that extend as far as Thibet and China; on the south it has the Gulf of Siam and the Malay peninsula; on the east it has ranges of mountains, by which it is separated from Cambodia and Cochin China; and on the west it is bounded by the Burmese dominions. The extent of this kingdom, like many others in the east, appears to have varied with the success of its arms. It formerly was estimated to extend in length three hundred and sixty miles, by three hundred in average breadth; but it has since been contracted by the encroachments of the Burmese within narrower limits. It may be considered as consisting of the extensive valley through which the great river Menan flows, on the banks of which all the principal towns are situated; and it possesses besides a great extent of sea-coast along the Gulf of Siam, which is but thinly inhabited, as the Siamese have an aversion to settle on the sea-coast, from their dread of the Malay pirates. The valley of the Menan is subject to be inundated during the rainy season by the periodical floods of that river, the artificial sites of the villages and the trees being the only objects that rise above the expanse of the waters. It is only this part of the country which is known to Europeans; and it is an extensive flat, consisting of alluvial land, with many extensive morasses, from which the exhalations under a tropical sun are noxious to Europeans, causing fluxes, dysenteries, and acute fevers. In those tracts which are beyond the reach of the inundations, the country is parched and dried up.

Soi nd pro cts.

The country is described by those who composed the British embassy which accompanied Mr. Crawfurd to Siam in 1822, as rich and fertile in a high degree, and possessing extensive commercial resources. This is almost entirely owing to the peculiar fertility of the soil, very little of the merit being due to native industry, except in the formation of canals. It is to the overflowing of the river Menan and its numerous tributaries, that this fertility is owing. The country yields the most abundant crops of rice and of other plants, which require a redundant supply of moisture. Wheat is also reared on the higher grounds, but not in any great quantity, so that it requires to be imported for the use of the Europeans who reside here. All the richer productions of the tropical climates would also thrive in the same place; but there is little industry amongst the people, who are depressed by the tyranny of their rulers, and have no encouragement to cultivate the country. There is no country in the world where all sorts of fruits, the most luscious and exquisite, arrive at greater perfection. The pine-apple, the tamarind, and the banana, abound in Siam. Of the mangoes, there are not less than thirty species, all excellent; and so is also the coffee plant. The sugar cane grows to perfection, though only for home consumption; for the rude natives do not possess the art of refining it. The areka and the betel-nut are produced; the latter is exported in considerable quantities by the Portuguese in their ships, and also in Chinese junks. Pepper, on the other hand, is not reared to nearly the same extent as in Java. The cocoa nut is a great resource to the indolent Siamese. It is applied to numerous uses; its milk seasons many of the dishes, and the oil affords an excellent seasoning; it is also used for torches, and as a kind of pitch, which, when clarified, is well adapted for painting. Here are, besides, many medicinal plants and gums, and also oil of jessamine, benzoin, lack, crystal, emery, antimony, oil, wax, lack varnish, wild cinnamon, cassia buds, and iron wood, the last of which is much used by the natives as anchors for their vessels. Cotton grows abundantly, and is as fine as silk; "but," says a European visitor to this country, "these wretches do not know how to value it beyond stuffing beds and pillows."

Siam Animals.

Siam abounds in all the wild animals known in the tropical countries, which find ample cover in the deep forests of the interior. The elephant ranges in the outskirts of the kingdom, amongst the mountains and jungles which form its eastern and its western boundary. The hunting of this animal is a royal monopoly; a great number are taken every year, the finest of which are selected for the studs of the king and nobles, and the rest are exported to other parts of India. The white elephant is found in some parts; it is a very rare animal, and is so prized, that it has occasioned wars between sovereign states. The rhinoceros also frequents the forests, whose skin is much sought after as an object of trade. He is a dangerous animal when enraged, and is not easily overcome, as his skin is so hard that it can hardly be penetrated by a musket ball. But one of the most numerous and most dangerous animals found in the woods is the tiger, which grows to a large size, and is remarkably fierce in the interior regions of Siam. The monkey race are in vast variety, and spread over the cultivated fields, which they speedily lay waste. There are numerous other wild animals, namely, lizards of various kinds, cameleons, tortoises, hedgehogs, and a species of porcupine, which yields valuable bezoar.

The domestic animals are horses, cows, buffaloes, sheep, goats, and elephants. There is abundance of common poultry; and besides, peacocks, pigeons, partridges, snipes, parrots, and other birds. The horses are very inferior, the best being imported from Batavia; and the same may be said of all domestic animals except the hog, the flesh of which is superior to the same animal in Europe. Insects and vermin abound here as in other parts of India; and the sea and rivers yield abundance of excellent fish, on which a great proportion of the lower classes subsist. There are besides lobsters and turtle of a good quality, and the manjo fish, which is so much esteemed in Calcutta.

Minerals.

The mineral riches of Siam are but little known. It is inferred that gold must exist in the mountains, as it is collected in small quantities in the streams, by which it is washed down. Iron, tin, lead, and copper, are likewise procured, but in small quantities. The copper is of a good quality. Iron is imported in considerable quantities from Europe, no diligence being employed to procure it in the country. The mountains in the interior yield diamonds equal to those in Hindustan, also sapphires, rubies, and agates.

Trade.

The Siamese, from the fertility of their soil, and the facilities of internal traffic afforded by the numerous streams and canals which everywhere intersect the country, are less dependent than most other nations on foreign trade. They are supplied chiefly by the Chinese, who, from their similarity of character and other causes, are the only people permitted to trade freely here. The Chinese commerce with Siam is said to be very extensive, and to employ no less than from 30,000 to 40,000 tons of shipping annually in the port of Bankok alone. It is to the supple character of the Chinese, the long connexion that has subsisted between the two countries, and the number of that nation resident in Siam, that this great trade is to be ascribed. The articles which chiefly attract the Chinese traders, are sugar, sapan wood, of which 18,000 tons are exported annually, pepper, cardamoms, sharks fins, birds' nests, beche de mer, hides, about 200,000 of which are exported annually; bones of the elephant, the rhinoceros, the tiger, the deer, and the buffalo; indigo, cotton, wines, and a variety of smaller articles. The Chinese traders, in their junks, arrive every year in February, March, and April, from Hainan, Canton, Soukah, Amoy, Ningpo, and other places. They take away, besides the above articles, a considerable quantity of culmin. There are annually about eighty vessels, mostly freighted by Chinese settlers at Bankok, or Siamese nobles, some of whom engage in traffic. Rice and salt of the very best quality are exported to all the European settlements to the eastward.

Among the articles produced in smaller quantities, but which are still valuable for Indian or European cargoes, are agil-wood, a perfumed or scented wood, benjamin, ivory, and stick lac. Iron, formed into cooking utensils, forms an extensive article of export from Siam. There are four American ships come annually for cargoes of sugar, for which they pay in dollars.

Siam carries on a considerable trade with the British settlement of Singapore. This trade is chiefly managed by the Chinese, either natives from China, or their descendants settled in Siam, the Siamese being an indolent race, devoid of the spirit of industry or of enterprise. The vessels and cargoes belong invariably to the Chinese. The principal articles which they import, are British piece goods, or goods of Indian manufacture, such as Bengal muslins, chintz, gurrahs, and sannahs; gold dust, bees' wax, gambier, rattans, tea, sago, sea-weed, cowries, and coarse paper, likewise constitute articles of import. In addition to those articles, cotton twist is much in demand. Amongst the imports into Siam, opium is one of the most important, about two hundred and fifty chests of this article being annually consumed. It is brought chiefly in junks, from Penang and Singapore; and though a contraband article, for a length of time met with a safe and speedy sale, the very persons appointed to enforce the prohibition being the principal dealers. But since the laws have been so rigidly enforced against the importation of opium into Canton, and the whole stock seized by the Chinese authorities, the dealers of it being besides threatened with death, and the British resident, Elliot, seized and imprisoned, the same severities have been enforced against the trade in Siam. The laws are equally strict against the importation of the drug, a severe fine being the penalty, which, if the offender cannot pay, as is commonly the case, his goods are confiscated; and if the sum raised be still insufficient, he is condemned, with his whole family, to perpetual slavery. In June 1839 several unfortunate Chinese sailors were accordingly seized with opium on board, from Singapore, and were cast into prison, where they were treated with great severity.

No impediment is offered to the admission of European ships into the Siamese ports; nor are the imposts heavy. The port charges for a ship of three hundred and fifty tons do not amount to more than 1200 dollars, and the duties on imports are generally eight per cent., though many articles are free. Sugar pays 3s. 2d. per cwt. The real impediments to commerce, consist in the privileges of the king, who is, properly speaking, the only merchant in the kingdom, as he claims the right of pre-emption in the market, from which he derives a large profit. His agents are hard to deal with. They regard foreign trade merely as a source of dishonest profit; and European vessels are only admitted to give an opportunity for extortion. It was to procure the abolition of those oppressive monopolies that Mr. Crawfurd's embassy was sent to Siam in 1822. But he failed entirely to attain this object.

The Menan, by which ships enter, discharges itself into the Gulf of Siam; but it has a bar at its mouth, to cross which, the aid of a pilot is required. The southerly monsoons is the best season for ships to visit Siam, and the northerly for returning to Hindustan, through the straits of Malacca. Bankok, situated on the river near the bay, is the chief place of trade. It is capable of making little defence against a European force; it is indeed, in a military point of view, quite defenceless; nor is there any fortification at the mouth of the river, or all the way up to the capital. A fleet of prows constitutes the whole naval defence of the kingdom of Siam, the bar of the river affording a defence against vessels of war.

Government.

The sovereign of this country exercises, as in other eastern kingdoms, absolute sway. He has no hereditary nobility of any kind, nor any popular assembly to controul his supreme will. The whole male population are liable to military conscription. Their names are enrolled in a register, and they are bound to perform military service for six months in the year; they receive no pay, carry their own provisions, and are only provided with arms and accoutrements. The country is divided into districts, and a chief is placed over each, under whose colours they march to battle. They have made no progress in the science of war, and possess neither discipline nor courage. Like the Burmese, they trust to fortifications of stockades of trees, and posts encircled by a ditch. But the real defence of the country consists in the natural obstacles of jungles, morasses, and the branches of rivers by which it is everywhere intersected. They march without order, nor do they take any precautions against a surprise. They seldom stand more than one discharge, which is sure to frighten one or other of the parties engaged, when they quit the field in disorder. Their chief dependance is on their elephants, which, when they are frightened or wounded, become equally formidable to friends and foes. There is nothing like a standing army. A body of guards, composed chiefly of foreigners, who are attached to the person of the sovereign, is the only force which is not disbanded. They are chiefly Tartars, with a corps of Mohars, who frequently display a desperate courage, however, said to be owing to the stimulus of opium. A small part of the taxes is levied in money, the greater part of the revenue being received in kind.

The rules followed in the administration of justice, are rude and barbarous. The tribunals are composed of three members; but the president alone decides. By the laws of Siam, children are clothed for the first time, at the age of four or five; and they are never afterwards uncovered for chastisement. Parents may sell their children. But they never resort to this proceeding except from absolute want. It is not true, as has been reported, that they sell their daughters, if offended with them, for courtezans. The duties between a pupil and his teacher are reckoned next in importance to those of parent and child. Their system of education resembles that of the Burmese. Priests are not allowed to become teachers of the female sex. The principal object of their education is to enable them to superintend their husbands' affairs. Marriage is considered merely as a civil contract, and the priests are not called upon to assist in it. Polygamy is admitted, but is only practised by the higher classes; and even they consider the first wife only as mistress of the house, whilst all the rest are little better than slaves. In general, the lot of the females is severe in this country, the heaviest part of the labour falling upon them; nor are they allowed to eat with their husbands, nor even to sail in the same boat; they attend no public amusements, but spend their time almost entirely at home. In every intricate case, the ordeal is resorted to as the easiest solution of all difficulties. The accused is required, as a satisfactory purgation of his innocence, to walk over red hot iron, or burning coals. Another ordeal is by water, when the person who remains longest beneath is declared innocent. Pills that cause vomiting are also employed; and he on whom they first take effect is adjudged guilty. But in some cases, the accused are subjected to the perilous test of being thrown to tigers, which in their fury, will, it is supposed, make the proper distinction between the innocent and the guilty. The punishments, as in all barbarous countries, are shocking by their severity. Sacrilege is punished by fixing the head of the offender to the hearth, where it is consumed by a slow fire. A stake is thrust through the body of assassins, in such a manner as to cause exquisite pain. Noblemen are sometimes subjected to degrading punishments, being condemned to cut grass for the elephants; some are subjected to the pillory; others are allowed to languish in prisons in the most miserable state, or they are seen wandering about the city, chained seven and seven together, begging their bread from door to door. They are confined at night within a circle formed with stakes, and are obliged by turns, and at short intervals, to call out their names.

R ion.

The religion of Siam is the same system which has diffused itself so extensively over the east and north of Asia, which is variously designated in different countries, as the doctrine of Boodh or Buddha, or of Gaudama, and in Tartary of Shamanism. The language of their sacred books, like the Sanscrit and the Zend in Persia, differs entirely from that in ordinary life, and is called Bali, apparently the same Indian language which is called Pali by the Burmans. The creed is singularly severe; but the common people escape from its austerities, as they believe that a rigid adherence to its maxims is only prescribed to the priests, to whose mortifications they trust as an atonement for their errors. They have an order of monks professing celibacy, and residing in convents. They harangue the people from morning to night, who not only express their feelings in murmurs of applause, but load the preacher with costly gifts. Their temples are distinguished above all those in Asia, by their magnificence, and by the gigantic statues which they contain. The principal pagoda in the city is of a long and narrow form, covered externally with tin, whilst the interior is one complete blaze of gold, and contains an idol, forty-five feet in height, which reaches to the roof, and is said to be composed entirely of that precious metal.

Sci e, lite ure, &c.

The Siamese have made scarcely any advances either in science or literature. Their progress in mathematics is not great, their attention being confined chiefly to arithmetic, on account of its utility in commerce. They know little of astronomy beyond some of its humblest practical applications. They first learned from Cassini to find out the place of the sun and moon by calculation. But they have not turned their knowledge to any account in navigation, their junks making use merely of the compass, and creeping where they can along the coasts for safety. Time is measured by vessels having a small hole perforated and placed in a tub of water, the construction of clocks being beyond their mechanical powers. Their system of medicine is equally imperfect, consisting chiefly in certain receipts, the virtues of which they say have been ascertained by experience. They are entire strangers to anatomy, having a religious scruple against opening dead bodies. They are fond, like many other barbarous nations, of music and poetry, and their bards are chiefly exercised in songs and in impromptu recitations. Their festivals and pleasure excursions upon the water are always enlivened with music. Their taste, however, appears to be equally rude in this as in all other arts or sciences. Instrumental music is chiefly valued on account of its loudness; the organ is preferred on this account to any other European instrument; and next to it hautboys, drums, trumpets, and fifes. Their theatrical amusements are, as might be expected, extremely rude, consisting of extravagant fables or gross caricatures, often levelled against the reigning monarch, or against persons in power, who choose to wink at these liberties, being the only vehicle of public opinion. Dancing and wrestling are amongst their most favourite amusements; and their puppet shows, the theatrical exhibitions in which they chiefly delight, are got up with great parade and expense by the king and the nobles for the amusement of the people.

Mor ha- racter

The moral character and habits of the Siamese are rated extremely low by those travellers who have visited the country. From the highest to the lowest, they are, according to their account, mean, cowardly, and mercenary. Like most of the Eastern nations, they have no regard to truth. These bad qualities are perceived in every action of their lives; and their rapacity in their intercourse with strangers is well known. To increase their wealth and promote their own interest, form the lasting object of all classes, which is pursued by every indirect and fraudulent practice. Timidity is a remarkable characteristic of the nation, insomuch that two Europeans would put to flight fifty of them; and the doctrine that cruelty and cowardice go together, is exemplified in their treatment of those who are made prisoners in their wars with the Burmese, or are kidnapped on the frontier; they are employed in public works of the most servile nature, with chains about their necks, legs, and feet, and are condemned to this degradation for life. Amongst their other evil propensities they carry on gambling to a great excess; and some have attributed the low state to which trade has occasionally fallen, to a species of lottery, in which all classes engage, and which is countenanced by the king. To such a length is the rage for these gambling speculations carried, that it is the cause of serious disorders. The victims of this vice, impoverished, and reduced to nakedness, betake themselves to open and lawless violence for subsistence. They follow robbing as a trade, and herd together in bands, so that it is not safe to venture out in decent attire, as they plunder openly, and commit daily murders.

Population

Europeans have no very accurate knowledge of the statistics of Siam, and the estimate of the population by different travellers is rather conjectural. According to such imperfect statements as have been received, the entire population of the country was stated at four millions. The inhabitants resemble the Chinese and Mongols in their features; they have a broad face, and very prominent cheek bones, whilst the remainder of their cheek has rather a hollow appearance. The eyes are small, with a deep yellow tinge in the white part; the mouth large, and the lips thick and full. Both males and females take as much pains to blacken their teeth, as the Europeans do to preserve them white. The men eradicate their beards, but allow their nails to lengthen like the Chinese. They are extremely gross feeders, eating rats, buzzards, grasshoppers, and other insects. They are, as has been already stated, indolent, and have made no progress in mechanical arts, nor in agriculture. It is chiefly by the Chinese that the country is cultivated, and that sugar and other productions are raised. They, along with the Portuguese settled here, manage the commerce that is carried on. They are strangers to the making of silk and woollen cloths; and even the fabrics of cotton are not nearly on the same scale as in Hindustan. Their artists in gold are however remarkably expert, and their fillagree work is extremely beautiful. They also excel in beating out gold leaf, which is greatly employed in adorning their temples and idols.

History.

The Siamese annals affect to detail with much minuteness the events that have occurred in Siam and the adjacent states and countries for the last fourteen hundred years; but these, like most Eastern histories, consist of fables or gross exaggerations. The kingdom of Siam was unknown in Europe until the discovery of the route to India by the Cape of Good Hope. The first traces of their history were received through the Portuguese, who frequently acted as auxiliaries to the contending factions. In 1684 ambassadors were sent from Siam to Louis XIV., and in consequence M. Cerberet and La Loubère were dispatched as ambassadors to Siam, where they arrived in 1687, and immediately attempted to make a proselyte of the king to the Catholic faith. The monarch declined the religion so freely proffered to him by the French, but entered into a strict alliance with them, and allowed them two garrisons, Bankok and Mergui. In 1688, the king was, however, by a sudden revolution, dethroned and murdered, which was followed by the expulsion of the French. From this period Siam was the scene of much internal discord, and of many sanguinary massacres; and in 1754 was involved in a serious war with the Burmese, who having conquered Pegu, and enlarged their territories, came in contact with the dominions of Siam. A long war ensued, which terminated altogether to the disadvantage of the Siamese, who were repeatedly defeated with great slaughter; their capital was sacked by the Burmese in 1766, who besides took all their maritime possessions on the bay of Bengal and along the west coast of the Malay peninsula, including the important places of Tavoy, Mergui, and Tenasserim. Though greatly reduced by this unsuccessful war, and frequently brought to the brink of ruin, Siam still exists as an independent kingdom, to which it is indebted partly to the dissensions of the Burmese, and partly to the actual strength of the country.

An embassy was sent to Siam by the British government in 1822, which was placed under the charge of Mr. Crawfurd, who had an audience of the king of Siam, by whom he was received so favourably, that he had every reason to expect a favourable termination to his mission. But these hopes were frustrated by the jealous and unaccommodating policy of the government. They made propositions one day which were revoked the next; and displayed their faithless character so clearly, that all negotiations were finally broken off; and the embassy were finally interdicted from going about the town or on the river, and were not allowed to trade. An American embassy was more agreeably received by this jealous government in 1833, and it is said succeeded in concluding a commercial treaty with the government. *Asiatic Journal*, new series. Hamilton's *Gazetteer*.

SIBERIA, a vast tract of territory comprehending the northern regions of Asia, which has been partly described under Russia; so that it will only be necessary in this place to supply some particulars which have not been so fully detailed in the former article. Siberia may be considered as a gradually descending plain from the Altai mountains to the Frozen Ocean, which is indeed indicated by the course of all the great rivers, the Obi, the Jenesei, and the Lena, which flow from these mountains in a northerly course until they terminate in that sea. Although under the dominion of Russia, and of regular government, improvements have been gradually diffused amongst its rude tribes; and although cities, some of them populous and thriving, have risen up, yet it is on the whole a barren and unproductive country, the predominance of cold throughout the greater part of it chilling the progress of vegetation, and preventing either fruits or grain from arriving at maturity. Nor, though it is by no means destitute of rivers, is the direction which they take calculated to favour the course of commerce, or to give facilities for the transmission of its productions from one part of the country to another. Flowing, as already stated, from south to north, they run out of the regions of civilization and commerce into those of perpetual winter; they lead into inhospitable deserts, to which there is no resort either of goods or of men; and therefore they are, and will ever remain, useless for the purposes of trade, and of little use to the country through which they flow. Nor is there by sea any easy access to this cold and inhospitable tract. The Frozen Ocean on the north presents an insuperable barrier to navigation; and the eastern shore, washed by the Pacific Ocean, is so far removed from the great seats of wealth and commerce in Europe, that no great intercourse can ever take place. Siberia has no surplus produce that can tempt a European vessel to perform the circuit of half the globe in order to obtain it.

History.

This region was unknown in the ancient world. The knowledge of the Greeks and Romans did not extend beyond Scythia, or independent Tartary; they were altogether ignorant of the vast regions which lay farther to the east and north, from which issued those vast hordes of barbarians who overthrew the Roman empire. During the devastations and wars which succeeded, and by which the great empires of Asia were shaken and thrown down, a greater knowledge was obtained of these northern regions, especially by the Mahommedan conquerors; but it does not appear that they ever penetrated into these districts, or that they were ever thoroughly explored until the progress of Russian conquest brought them under the sway of this rising power, which did not take place till the middle of the sixteenth century. In the reign of John Basilowitz I., indeed, an incursion had been made into Siberia, and some Tartar tribes subdued; but these conquests were not permanent, and we hear of no further communication between Russia and Siberia till the time of John Basilowitz II. It was opened again at that time by means of Anika Strogonoff, a Russian merchant, who had established some salt-works at a town in the government of Archangel. This man carried on a trade with the Samoiedes who inhabited the banks of the Obi and the Petchora, and who are accustomed to come along the river Vitenegda to its confluence with the Dwina, where they exchanged their furs with the Russians. He acquired in this manner a considerable fortune in a short time; and he determined on exploring the districts whence these valuable commodities were derived. He sent thither a party of his dependents, who, in exchange for Dutch toys and other trifles, obtained the most valuable furs. He judged it prudent, after he had carried on the trade for some time, to communicate the whole affair to the brother of the reigning emperor, Theodore Iwanovitch, and ultimately his successor. The Czar perceiving the advantage that might be derived by his subjects from a regular intercourse with Siberia, despatched a body of troops into that country, chiefly needy adventurers, who crossed the mountains that form the north-eastern boundary of Europe, though they never seem to have passed the Irtysch, or have penetrated beyond the western branch of the Obi. The people they met with were rude and barbarous; they were small in stature, destitute of towns and villages, ignorant of bread, and subsisting entirely by fishing and the chase. They were struck with the novelty of what they saw, and with a variety of unknown animals; with men riding on elks, or dervises mounted on sledges drawn by rein-deer or dogs. The natives received with high gratification the presents that were brought to them, and they eagerly in return desired to visit the Russian capital, of which their visitors had given them a splendid description. They were dazzled with the magnificence of Moscow and the emperor. Some Tartar tribes were laid under contribution, and a chief named Yediger consented to pay an annual tribute of a thousand sables. But this produced no lasting advantage to Russia; for, soon afterwards, Yediger was defeated and taken prisoner by Kutchum Khan, a descendant of the great Genghiz Khan; and thus the allegiance of this country to Russia was dissolved.

For some time we hear of no further attempts made by the Russians on Siberia; but in 1577 the foundation of a permanent conquest was laid by Yermac Temofeeff, a Cossack of the Don. This man was at first the head of a banditti who infested the Russians in the province of Casan; but being defeated by the troops of the Czar, he retired with six thousand of his followers into the interior parts of that province. Continuing his course still eastward, he came to Orel, the most easterly of all the Russian settlements; and here he took up his winter quarters. But his restless genius did not suffer him to continue for any length of time in a state of inactivity; and from the intelligence he procured concerning the situation of the neighbouring Tartars of Siberia, he turned his arms towards that quarter.

Siberia was at that time partly divided amongst a number of separate princes, and partly inhabited by the various tribes of independent Tartars. Of the former Kutchum Khan was the most powerful sovereign. His dominions consisted of that tract of country which now forms the south-western part of the province of Tobolsk, and stretched from the banks of the Irtysch and Obi to those of the Tobal and Tura. His principal residence was at Sibir, a small fortress upon the river Irtysch, not far from the present town of Tobolsk, and of which some ruins are still to be seen. After a course of unremitting fatigue, and a series of victories which almost exceed belief, but of which we have not room to give the detail, our intrepid adventurer dispossessed this prince of his dominions, and seated himself on the throne of Sibir. The number of his followers, however, being greatly reduced, and perceiving he could not depend on the affection of his new subjects, he had recourse to the Czar of Muscovy, and made a tender of his acquisitions to that monarch, upon condition of receiving immediate and effectual support. This proposal was received with the greatest satisfaction by the Czar, who granted him a pardon for all former offences, and sent him the required succours. Yermac, however, being soon after drowned in an unsuccessful excursion, the Russians began to lose their footing in the country. But fresh reinforcements being sent, they not only recovered their ground, but pushed their conquests far and wide; and wherever they appeared, the Tartars were either reduced or exterminated. New towns were built, and colonies were planted on all sides. Before a century had elapsed, all that vast tract of country now called Siberia, which stretches from the confines of Europe to the Eastern ocean, and from the Frozen sea to the present frontiers of China, was annexed to the Russian dominions.

Cli te.

The air of Siberia is extremely piercing; and it is remarked that in advancing eastward it becomes more intense. M. Gmelin, who was sent to explore this country in 1733, gives some remarkable examples of the extreme cold which prevails. He mentions, that at the foot of Kiringa, on the 10th of February 1738, the mercury, at eight in the morning, stood at 254 in the thermometer which he had along with him, and which answers to 72° in Fahrenheit below 0. In December, at the same place, it answered to 90° in Fahrenheit below zero, about three in the afternoon; and afterwards in the course of the same month, to 99, 107, and 113 below 0, the greatest cold answering to 120° in Fahrenheit below 0. At this time sparrows and magpies were seen to fall to the ground struck dead with the intense cold, but revived if they were speedily brought into a warm room. The air at this time is represented as if it were changed to ice, a thick fog, not dissipated by any exhalations as in spring and autumn; and the writer states that he could scarcely stand three minutes in the porch of his house for cold. At Yakutsk, on the Lena, in November, Captain Cochrane[1] mentions that Reaumur's thermometer stood at 32° and 35°, which answers to 40° and 46° in Fahrenheit below zero; in his journey to Irkutsk it stood at 30° of Fahrenheit, and 35° below zero; and on the 13th of January the rapid waters of Angora were bound up by the frost, and it became passable on the ice. The Siberian rivers are however frozen earlier, and it is late in the spring before they are thawed. The northern and eastern districts of Siberia are rendered unfit for agriculture by the excessive cold. The whole tract beyond the 60th degree of N. lat. is a barren waste, yielding neither corn nor fruits. Pallas mentions, that to the north of Demiansk, a village in the government of Demiansk in about $59\frac{1}{2}$° N. lat., hardly any thing is reared but barley and oats, at most but a little grain. Hemp and flax are sown, but in three years they have scarcely one tolerable crop. The cabbage that is sown produces no head, but spreads itself in loose green leaves. The repeated attempts that have been made about Okhotsk, between 59° and 60° N. lat., and 160° E. long., or at Udskog-Ostrog, 50° 20′ lat., 150° 40′ long, to cultivate corn, have been entirely unsuccessful, the long winter, and the night frosts in autumn preventing either fruits or grain from coming to perfection; and in Kamtschatka, where the southernmost course terminates in 51° N. lat., similar trials have been made without success. A great part of the Siberian territory that is situated in a more temperate climate, being composed of marshy and saline steppes, is extremely barren. But there are other tracts that are equally productive, that not only abound in extensive pastures, but produce abundance of grain, not of wheat, but of barley, rye, and other inferior descriptions; whilst farther south there are districts of remarkable fertility. Amongst the Ural and other ranges of mountains, rich and verdant vales and glens are to be met with, which afford pastures for numerous herds of cattle; a remarkably wealthy district extends along the heart of the Tobol, Iset, and the Issim, and is so abundant in grain, that it supplies the government of Tobolsk, as well as the provinces of Perm and Orenburg. Also in the territory of Krasnoyansk, a circle town of the government of Kolhyvan, between 55° and 56° of N. lat., such is the fertility of the soil, notwithstanding the severe and continued winter, that no instance was known of a general failure.[2] This fertile tract commences at Krasnoyansk, and extends to Baikal and the surrounding countries. The quality of the soil is here so rich, being of a black and light mould, that it rejects the use of manure. Most of the fields, if they are left fallow for one year, continue to bear ten or fifteen years more. In consequence of this fertility, provisions are abundant and cheap. Not only are oats, barley, and rye cultivated, but also wheat, though it is not so abundant. These countries, which, if they were industriously cultivated, might give subsistence to populous nations, are chiefly covered with pastures. Beyond the lake Baikal, especially towards the east, as far as the river Argun, they are remarkably fruitful and pleasant; but such is the indolence of the inhabitants, that several fine tracts of land, which would make ample returns to the peasant for cultivating them, lie neglected. The pastures are excellent, and abound in fine horned cattle, horses, goats, and other beasts, on which the Tartars chiefly depend for subsistence. However, there are several steppes or barren wastes, and unimproved tracts in these parts; and not a single fruit tree is to be seen. There is great variety of vegetables, and in several places, particularly near Krasnoia Sloboda, the ground is in a manner overrun with asparagus of an extraordinary height and delicious flavour. The bulbs of the Turkish and other sorts of lilies, are much used by the Tartars instead of bread. This want of fruit and corn is richly compensated by the great quantities of wild and tame beasts and fowls, and the infinite variety of fine fish which the country affords.

In that part of Siberia which lies near the icy sea, as well as in several other places, there are woods of pine, larch, and other trees; besides which, a considerable quantity of wood is thrown ashore by the waves of the icy sea, but whence it comes, is not yet ascertained. On the Ural mountains also, are found pines, birch, fir, cedar, larch, aspin, alder; and on the opposite side a few oaks, elms, lindens, and other trees.

The extreme rigour of the climate, which stunts the vegetation of Siberia, has no effect on the animal creation, which abounds in the most frozen and desolate tracts. Nature, in protecting from the rigour of the cold those animals with a thick fur, which in its rich gloss and softness no art can rival, has rendered them valuable, and they are accordingly hunted for their skin, which forms an important article of commerce. Of all these furs, the most valuable is the sable, which is found on a species of weazel. This animal is met with in Asiatic Russia, from the Aleutian islands, and from Kamtschatka to the districts of the Petschora and the Kama. The finest sables are those which come from Yakutsk and Wertschink; and amongst these are found the rare and precious yellow, and still more rarely, the white sable. In Kamtschatka, these precious furs are to be found in the greatest abundance, but not of so fine a quality; the skin being thick, and the hair long, but not very black. When this country was first invaded by Europeans, these animals were in such abundance, that for iron wire to the amount of ten rubles, sables might have been obtained to the amount of five or six hundred. But the animal has been so diligently hunted, that it has become scarce, so that one skin may be exchanged on the spot for ten pounds. The great art is, to catch the animal without injuring the skin, for which purpose various contrivances are resorted to. The hunter, following the track of the animal, discovers his covert, which is usually a burrow in the earth; the animal, to escape him, ascends a hollow tree, which the hunter immediately surrounds with a net; and kindling a fire under it, forces the little creature to descend, when it falls into the net and is caught. Various other animals are hunted for their skins, which form a considerable article of commerce. Wild-fowl abound every where in Siberia, namely, wild ducks and geese, swans, woodcocks, snipes, bustards, snow-birds, pheasants, partridges, &c.; these are so plentiful, that even in the governments which are the poorest in wild animals, they form an ordinary and not very costly dish. The eider fowl, which supplies the fine and soft down that is so much esteemed in all countries, harbours about the coasts of the White Sea and the Northern Ocean. In Siberia are found the prodigious remains of animals, none of which are now found to exist; the bones and entire carcase of the mammoth, that extraordinary animal, which surpasses in bulk every known species, is found preserved in the ice on the shores of rivers in the north, and on the coasts of the Frozen Ocean. The bones of the elephant and rhinoceros occur also in vast quantities. The seas that wash the coasts of Siberia, and the rivers, teem with a great variety of marine animals and with fish. The Frozen Ocean and the Eastern Seas abound in whales, seals, otters, also the narhwal, the pott-fish, from whose brain spermaceti is prepared, the sea dog, the dolphin, the sea lion, the sea cow, the sea bear, and various other species, which are sought after for their skin or their blubber. The Obi abounds beyond all the others in vast quantities of migrating fish which pass from the sea; not only those which are found in other rivers, but a variety of fish which are caught no where else, namely, sturgeons, starlet, white salmon, pikes, murœna, or white salmon of Pallas, quobbe, and a multitude of other fish, of which the Russian names would convey no information to the reader. The migrating fish proceed up the rivers in June, and the fishing in the Obi is carried on by the Ostiacks and Samoiedes. The Irtysch, the Jenisei, and the Lena, as well as their numerous tributaries, contain abundance of excellent fish, mostly resembling those already named. The fishing on the coasts and islands of the Eastern ocean is remarkable for the variety and quality of its objects; and as agriculture is here impracticable from the soil and the climate, the inhabitants depend for their subsistence on the fishing, and the chase. All the large cetacea of the Arctic seas are here pursued with avidity, and the oil which they afford forms an article of commerce. Of all the lesser animals which are objects of the chase on the Eastern ocean, the sea otter is the most important. Its beautiful fur is everywhere highly esteemed, and sells in China for a very high price. The rivers in Kamtschatka abound more especially with fish, which supply the inhabitants with subsistence, which no labour could extract from the barren soil. These fish, which are mostly of the salmon kind, proceed up the rivers in such vast multitudes, that the shores are often found covered with the dead.

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[1] Narrative of a Pedestrian Journey through Russia and Siberian Tartary, vol. ii. p. 108.

[2] Tooke's View of the Russian Empire, vol. iii. p. 238.

Mountains

The surface of Siberia is diversified by alternate ranges of mountains and by widely extended plains. The Ural mountains, so called from the Tartar word signifying a belt or girdle, which form the natural boundary between Asia and Europe, extend almost in a direct line above 1500 English miles. The mountains between the Caspian and the Aral may be considered as the commencement of the Ural mountains; which, after being divided by the straits of Weygat, terminate in the mountain chain of Nova Zembla, several subordinate ridges branching off in a western, as well as in an eastern direction, from the same chain. These mountains are rich in minerals, and they are in many parts also clothed with tall firs, larches, birch, and other woods. They are well watered by rivers, and at different degrees of elevation are found beautiful pellucid lakes, ponds, and numerous streams, all teeming with fish. The breadth of the Ural mountains at Sollkamskoi and Verchoturia, the high road out of European Russia, is about forty miles, and their height from four to five thousand feet. At their northern extremity, along the lower Obi, their elevation is not so great. The Ural mountains, at their northern extremity, lock in by several ridges with the great Altaic chain, which traverses northern Asia from west to east through its whole extent, and fix the respective limits of the Chinese empire from the Irtysch to the Amour. The great Altai stretches northward beyond Siberia, into the regions of Tartary; and proceeding with various windings toward the N.N.E., throws out considerable masses, between which the head waters of the Jenesei, the Obi, and the Irtysch, take their rise; and the lesser Altai separates the Chinese territories from the Russian government of Kolivane, through which the streams mentioned above pursue their course. Near its summit a Chinese patrol was found guarding the limits of the empire by the traveller Shcangin. The highest mountains consist of granite, and are covered with perpetual snow. The lower mountains consist of porphyry, jasper, and serpentine, and exhibit many beautiful varieties of these rocks. The highest summit of these mountains, in the government of Kolivane, does not rise more than 3000 feet above the level of the sea. One summit, however, to the north of the river Ouba, has an elevation of 5691 feet. Although the Altai mountains bear different names, they range eastward as far as the ocean. The higher parts are generally bare, and the shores of the rivers which run through them are generally clothed with forests. As they extend east from the Jenesei to the Baikal sea, they assume a grander character, and are called the Sayanskoi mountains. They are chiefly naked granite rocks, sharp and abrupt, and frequented chiefly by hunters; and they determine the boundaries between Siberia and Mongolia. The mountains of Baikal have nearly the same direction as that sea, and run down to the west on the right of the Angora, where it flattens in a morasse steppe of prodigious extent. To the east, it advances from the origin of the Lena on both sides of that river, and here it is lost in a wide extended floetz ridge. In the inferior regions of the Angora and the Lena, coal is frequently produced. Several of these mountain ranges in the neighbourhood of the Baikal are so high, that they are covered with perpetual snow. The Nertshinskoi mountains, otherwise called the mountains of Daouria, extend from the lake Baikal and the sources of the Selenga and the Amour, down the two sides of these rivers; on the one side, as far as where the Argoon falls into the Amour; and on the other, or northern side, up to the sources of the Niusa and the Oldekon, where it joins the spacious range of Okhotsk. The portion of this range enclosed by the Amoor and Argoon, which is properly called the Nertshinskoi chain of mountains, is found to be the richest in minerals of any of the mountains hitherto explored in these regions; producing, amongst other sorts, zinc, iron, copper, and lead ores containing silver and gold. These mountains present, according to the descriptions of a traveller who visited them in search of the rhubarb plant, a wild scene of desolation;

thick woods, torrents and precipices, without a human habitation, except a few sheds erected by hunters when they are in pursuit of game. In approaching the eastern ocean, these mountains decline in elevation, and turning to the north, run parallel to the sea, leaving a narrow space between them. The mountains of Okhotsk run northward down the Lena to Yakutsk; one runs eastward to the sea of Okhotsk, whilst another continues its course with the peninsula of Kamtschatka, which consists of a rocky chain of mountains, about which little information has ever been acquired.

St es, wa s, mo- ras

The surface of Siberia comprises every variety of soil. The tracts which are called steppes are dry, elevated, and extensive plains, which are not inhabited, and some of them, which are uninhabitable, are destitute both of food and water. Others have shrubs growing on them or a stunted herbage, and are watered by streams or wells, though without inhabitants, and thus afford pasture to the herds and flocks of the shepherds who range over these desolate plains. In regard to the soil on these steppes, great variety prevails, none being fruitful and proper for meadow or arable land, or indiscriminately for both; in others the soil is unfruitful, whether it be sand or salt, or in some cases of a rocky formation.

Ri s.

Siberia is well watered by numerous and large rivers, an account of which may be found in the article RUSSIA. It may merely be mentioned here, that those great rivers are the Irtysch, the Obi, the Jenesei, and the Lena, which have all their sources in the frontier range of mountains, and roll onwards to the Frozen Ocean. All the other numerous rivers which rise in Siberia, are tributaries of those main rivers.

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The cold and mountainous regions of Siberia are great depositories of those vast stores of mineral wealth by which the Russian empire is encircled. The elevated districts of this vast country abound in the most precious ores of all the different metals.

An official account of the produce of the mines of gold, silver, and platina, in Russia, has been published at St. Petersburg; it embraces a period of sixteen years, from 1823 to 1838 inclusive, and shews the following results:—

	Gold. Poods.	Silver. Poods.	Platina. Poods.
Produce of the Imperial mines—			
In Ural,	1,592½	...	29
In Altai,	538½	14,704¼	...
In Nertshinskoi,	9¾	3,301¾	...
Produce of mines belonging to individuals,	3,009¾	...	1,230
	5,150½	18,006	1,259

Value in Sterling about L.12,000,000 and L.6,000,000.

During the same period, the value of money coined at the Imperial Mint at St. Petersburg, from Russian and foreign bullion, was about L.14,000,000 in gold, L.8,000,000 in silver, and L.400,000 in platina.

Pop tion

The population of Siberia consists of numerous tribes, who differ in their origin and their manners, and have been gradually subjected to the Russian authority, paying a stated tribute, which is not oppressive, and following their own pursuits unmolested. The Mongols, who withdrew from the Chinese dominion during the last century, and voluntarily placed themselves under the dominion of Russia, inhabit the regions about the Selenga, in the government of Irkutsk, from the 122d to the 125th degree of longitude, and between the 50th and 53d degree of north latitude They consist of seven stems, or twenty families, which were estimated to compose 6918 males in 1766. The Burats inhabit Daouria, the banks of the Selenga, of the lake Baikal, and of the Upper Jenesei. They are remarkably industrious, and are chiefly employed in pastoral pursuits. The Tartars form a very numerous race, and are found scattered over Siberia, under the different appellations of Tobolskian Tartars, from the river Tobol, on which they dwell; the Tomskian Tartars, who inhabit both sides of the river Tom, above and below the city of Tomsk; the Krasnayarskian and the Kusneretskian Tartars, who greatly resemble the Mongolian tribes; the Tartars of the Obi, who are partly agricultural and partly pastoral in their habits; the Tartar tribe, which dwelt formerly between the Obi and the Jenesei, but which now inhabit the whole country along the river Tschulym; other tribes, of which it would serve little purpose to give the barbarous appellatious, inhabit the country between the Obi and the Irtysch, which is called the steppe of Baraba. There are others on the left shore of the Jenesei, upon which they follow their pastoral occupations amongst the Sayome mountains. Certain districts in the governments of Tobolsk and Kolhyvan, and partly in the eastern half of that of Perm, beyond the Ural mountains, are to be regarded as the peculiar home and seat of the Siberian Tartars. The northern districts of Siberia are possessed by twenty tribes, peculiar to itself. The principal are the Tungouses on the Jenesei, the Ostiaks, the Yakantes, the Samoiedes, and the Tchantchis. The extensive deserts on which roam the pastoral tribe of the Tungouses, extend eastward across the Lena, as far as the Amoor and the Eastern Ocean. They extend northward from the 53d to the 65th degree. The history of the Samoiedes is little known. Their present abodes are on the coasts of the Frozen Ocean, from about the 65th degree of north latitude, quite to the sea shore. They swarm up to the 75th degree of north latitude, dwelling on the coldest and most desolate regions of the earth, from the White Sea to the other side of the Jenesei, and almost up to the Lena, and, therefore, being both in Europe and in Siberia. There are the Ostiaks of the Obi, of the Narym, and of the Jenesei. The Ostiaks are not numerous; but they include many subordinate tribes, which it is unnecessary to specify by name, as they all resemble each other in manners. Giorgi gives the following statement of the population in 1801. In the government of Tobolsk, 622,422; in the government of Irkutsk, 451,937.

Religion.

The religion generally diffused amongst these wild tribes, if it deserve the name, is a rude superstition, or idolatry, congenial to the state of barbarism which generally prevails. The system of Boodh, or of the Lamas, is the creed of the Mongols and Tartars; and the residence of the Lama, the chief of that religion, is on the Upper Selenga, to the south of Baikal. The great temple was entered by a late traveller, who found there about a hundred priests, clothed in red, and seated in successive rows. The high-priest was seated upon a lofty and splendid throne, behind which was an altar, upon which were placed the images of their gods, the inferior ones being arranged in rows along the wall. Offerings were presented to them of rice, brandy, and sometimes a hen or sheep roasted whole. Their worship consists in a great measure of noise, the most formidable sounds being produced by a combination of the most noisy instruments, such as bells, kettle-drums, trumpets, shells, and other instruments. Those superstitious rites are, however, denounced by the pure followers of the genuine Lamas. They practise other vile and bloody rites, by way of expiating the anger of their gods; such as leaping, and howling in a frightful mannner, and pretending to wound their backs with knives. Amongst the rude wanderers in the northern regions of Siberia complete paganism prevails, consisting of the ignorant arts of sorcery, and the worship of deformed stone images. The light of Christianity has hardly yet penetrated into these benighted regions. By the recent enterprising and active efforts, however, of the missionary societies of Britain, aided by the countenance of the Russian government, a beginning has been made in the great work of civilizing and of converting these barbarous tribes.

Missionaries have been spread over the country; and the sacred volume has been translated into some of the native languages, and distributed amongst the natives. The greatest obstacle to their conversion arises from their brutish ignorance and their debased habits.

Commerce.

The commerce of Siberia consists in those products which are consumed at home, and of those which are exported to European Russia, in return for foreign products. The exports are chiefly metals and furs, besides those commodities from China and the East, of which Siberia is merely the dépôt in their transit to Europe The two staple commodities of export, namely, metals and furs, are chiefly monopolised by the government, to whose officers the tribute of the wandering tribes is paid in furs; and for these no return is made, unless in the salaries of the civil and military officers, or the pay of the troops.

Siberia is divided into two governments, namely, Tobolsk and Irkutsk, which are again subdivided, the former into the four circles of Tobolsk proper, Tomsk, Yeniceysk, and Kolyvan; the latter, into Irkutsk proper, Nertschink, Yakutsk, and Okhotsk, in which last is included Kamtschatka, with the islands.

SIBYLS, in pagan antiquity, certain women said to have been endowed with a prophetical spirit, and who delivered oracles, showing the fates and revolutions of kingdoms. Their number is unknown. Plato speaks of one, others of two, Pliny of three, Ælian of four, and Varro of ten; an opinion which is universally adopted by the learned. These ten Sibyls generally resided in the following places: Persia, Lybia, Delphi, Cumæ in Italy, Erythræa, Samos, Cumæ in Æolia, Marpessa on the Hellespont, Ancyra in Phrygia, and Tyburtis. The most celebrated of the Sibyls is that of Cumæ in Italy, whom some have called by the different names of Amalthæa, Demiphile, Herophile, Daphne, Manto, Phemonoe, and Deiphobe. It is said, that Apollo became enamoured of her, and that to make her sensible of his passion he offered to give her whatever she asked. The Sibyl demanded to live as many years as she had grains of sand in her hand, but unfortunately forgot to ask for the enjoyment of the health, vigour, and bloom, of which she was then in possession. She had already lived about seven hundred years when Æneas came to Italy, and, as some have imagined, she had three centuries more to live before her years were as numerous as the grains of sand which she had had in her hand. She gave Æneas instructions how to find his father in the infernal regions, and even conducted him to the entrance of hell. According to the most authentic historians of the Roman republic, one of the Sibyls came to the palace of Tarquin the Second, with nine volumes, which she offered to sell for a very high price. The monarch disregarded her, and she immediately disappeared, but soon afterwards returned, when she had burned three of the volumes. She asked the same price for the remaining six books; and when Tarquin refused to buy them, she burnt three more, and still persisted in demanding the same sum of money for the three that were left. This extraordinary behaviour astonished Tarquin; he bought the books; and the Sibyl instantly vanished, and never afterwards appeared to the world. These books were preserved with great care by the monarch, and called the Sibylline verses. A college of priests was appointed to take care of them; and such reverence did the Romans entertain for these prophetical books, that they were consulted with the greatest solemnity, when the state seemed to be in danger. When the capitol was burned in the troubles of Sylla, the Sibylline verses, which were deposited there, perished in the conflagration; and to repair the loss which the republic seemed to have sustained, commissioners were immediately sent to different parts of Greece to collect whatever verses could be found of the inspired writings of the Sibyls. The fate of these Sibylline verses, which were collected after the conflagration of the capitol, is unknown. There are now many Sibylline verses extant, but they are universally reckoned spurious; and it is evident that they were composed in the second century by some of the followers of Christianity, who wished to convince the heathens of their error, by assisting the cause of truth with the arms of pious artifice.

SICERA, a name given to any inebriating liquor by the Hellenistic Jews. St. Chrysostom, Theodoret, and Theophilus of Antioch, who were Syrians, and who therefore ought to know the signification and nature of sicera, assure us, that it properly signifies palm-wine.

SICILIANA, the name of an ancient dance in $\frac{6}{8}$ time, slow in movement, and simple and touching in its melody.

SICILY, a large island in the Mediterranean Sea, adjoining to the southern extremity of Italy, and extending from latitude 36° 25′ to latitude 38° 25′, and from longitude 12° 50′ to longitude 15° 40′ east from London. Its greatest length is 210 miles, its breadth 133, its circumference 600. For a description of the island, see NAPLES.

SIDDONS, MRS. (whose maiden name was Sarah Kemble,) the greatest actress that ever trode the stage, was born at Brecon, in South Wales, on the 5th of July 1755. Roger Kemble, her father, was manager of a provincial company of players, and amongst this class of persons he seems to have held a highly respectable rank. Sarah, who was his eldest daughter, appeared very early on the stage, and went the usual round of juvenile characters without exciting much expectation. At the age of eighteen she married Mr. Siddons, an actor in her father's company, soon after which event she removed to Cheltenham, where she attracted some attention, and was recommended to Garrick. Her first appearance on the London boards was not successful, simply because she never had a proper part assigned her. Mrs. Siddons accordingly returned to the provinces much mortified; but the praises showered upon her by such audiences as those of York, Manchester, and Bath, induced the managers of Drury Lane to re-invite her to the metropolis. Her reappearance took place on the 10th of October 1782. The character which she chose was that of Isabella in "The Fatal Marriage." The effect of that performance was extraordinary and unparalleled. It gave a shock of wonder and delight to the public mind, like the news of some great and unexpected victory. On that night, Mrs. Siddons at once took possession of the tragic throne, on which, for thirty years, she reigned without a rival. Some idea of the excitement which she created may be learned from the fact, that "the grave and reverend seignors" of the English bar presented her with a purse of one hundred guineas. During the season, Mrs. Siddons played *Euphrasia*, *Jane Shore*, *Calista*, and, for her two benefits, *Belvidera* and *Zara*. In all of these characters she greatly added to her fame; the public were astonished at the vastness of her powers, and tragedy became the fashion. In subsequent seasons she encreased her circle of characters, adding from Shakespeare those of *Lady Macbeth*, *Constance*, *Isabella*, *Queen Katherine*, (the most chaste, beautiful, and perfect performance that ever drew a tear,) *Rosalind*, (not in her line, for she was altogether too stately and heroic for comedy,) *Desdemona*, *Volumnia*, *Portia*, *Hermione*, *Imogene*, and a few others. This list shows, that her range was surprising, but she was not equally excellent in all her parts. Her comedy never gave great satisfaction, although there was occasionally much to admire in it. When the metropolitan season closed, it was the custom of this, as it is of every great actor, to visit the principal cities of Ireland, Scotland, and the provinces of England. Every where she enchanted the lovers of the drama. She became a favourite with their majesties, and was in the habit of reading plays to them, an occupation of more honour than emolument. However, Mrs. Siddons, by her professional exertions, realized a for-time equal to her wishes, and retired from the stage in 1812. Her death took place on the 8th of June 1831, when she was in her 76th year.

The symmetry of this great actress's person was most captivating. Her features were strongly marked, but finely harmonised; the flexibility of her countenance was extraordinary, yielding instantaneously to every change of passion; her voice was plaintive, yet capable of firmness and exertion; her articulation was clear, penetrating, and distinct;—above all, she was completely mistress of her powers, and possessed that high judgment which enabled her to display all her other qualifications to the greatest advantage. One of Mrs. Siddons's highest, if not her very highest endowment, was the power of identifying herself with the character which she personated. The scenes in which she acted, were to her far from being a mere mimic show; so powerfully did her imagination conjure up the reality, that the tears which she shed were those of bitterness felt at the moment. From her frown of proud disdain and scorn, the very actors themselves shrank with something like terror. Her greatest characters were Katherine in Henry VIII., and Lady Macbeth, in which she manifested a dignity and a sensibility, a power and a pathos never equalled by any female performer. Lastly, Mrs. Siddons was truly an original; she copied no one, living or dead, but acted from nature and herself. In all the relations of life her conduct was most exemplary. "She was more than a woman of genius," says the poet Campbell, who knew her well, "for the additional benevolence of her heart made her an honour to her sex, and to human nature." (R.R.R.)

SIDMOUTH, a town of the hundred of East Budleigh, in the county of Devon, 159 miles from London, The population was, in 1821, 2747; and in 1831, 3126.

SIDNEY, Sir Philip, was born, as is supposed, at Penshurst in Kent, in the year 1544. His father was Sir Henry Sidney, an Irish gentleman, and his mother, Mary, the eldest daughter of John Dudley, Duke of Northumberland. He was sent, when very young, to Christ-Church College at Oxford, but left the university at seventeen to set out on his travels. After visiting France, Germany, Hungary, and Italy, he returned to England in 1575, and was next year sent by Queen Elizabeth, as her ambassador to Rodolph, the Emperor of Germany. On his return he visited Don John of Austria, governor of the Netherlands, by whom he was received with great respect. In 1579, when Queen Elizabeth seemed on the point of concluding her long projected marriage with the Duke of Anjou, Sir Philip wrote her a letter, in which he dissuaded her from the match with unusual elegance of expression, and great force of reasoning. About this time a quarrel with the Earl of Oxford occasioned his withdrawing from court; during which retirement he is supposed to have written his celebrated romance called Arcadia.

In 1585, after the Queen's treaty with the United States, he was made governor of Flushing and master of the horse. Here he distinguished himself so much both by his courage and his conduct, that his reputation rose to the highest pitch. He was named, it is said, by the republic of Poland as one of the competitors for that crown, and might even have been elected, had it not been for the interference of the queen. But his illustrious career was soon terminated; for being wounded at the battle of Zutphen, he was carried to Arnheim, where he died on the 15th of October 1586. His body was brought to London, and buried in St. Paul's cathedral. He is described, by the writers of that age, as the most perfect model of an accomplished gentleman that could be formed even by the wanton imagination of poetry or of fiction. Virtuous conduct, polite conversation, heroic valour, and elegant erudition, all concurred to render him the ornament and delight of the English court; and as the credit which he enjoyed with the queen and the Earl of Leicester was wholly employed in the encouragement of genius and literature, his praises have been transmitted with advantage to posterity. No person was so low as not to become an object of his humanity. After the battle of Zutphen, whilst he was lying on the field mangled with wounds, water was brought him to relieve his thirst; but observing a soldier in a like miserable condition, looking wistfully towards him, he resigned it to him, saying, "This man's necessity is still greater than mine." Besides his Arcadia, he wrote a discourse on Poetry, and some other pieces both in prose and verse, which have been published. There is a complete edition of his works in three volumes octavo, Lond. 1725.

Sidney, *Algernon*, was the second son of Robert Earl of Leicester, and Dorothy, eldest daughter of the Earl of Northumberland. He was born in 1617. During the civil wars he took part against the king, and distinguished himself as a colonel in the army of the parliament. He was afterwards appointed one of King Charles's judges, but declined appearing in that court. During the usurpation of Cromwell, Sidney, who was a violent republican, retired to the country, and spent his time in writing those discourses on government which have been so deservedly celebrated. After the death of the Protector, he again took part in the public transactions of his country, and was abroad on an embassy to Denmark when Charles was restored. Upon this he retired to Hamburg, and afterwards to Frankfort, where he resided till 1677, when he returned to England and obtained from the king a pardon. It has been affirmed, but the story deserves no credit, that, during his residence abroad, Charles hired ruffians to assassinate him. After his return he made repeated attempts to procure a seat in parliament, but all of them proved unsuccessful. After the intention of the Commons to exclude the Duke of York from the throne had been defeated by the sudden dissolution of parliament, Sidney joined with eagerness the councils of Russel, Essex, and Monmouth, who had resolved to oppose the duke's succession by force of arms. Frequent meetings were held at London; whilst at the same time, a set of subordinate conspirators, who were not, however, admitted into their confidence, met and embraced the most desperate resolutions. Keiling, one of these men, discovered the whole conspiracy; and Algernon Sidney, together with his noble associates, was immediately thrown into prison, and no art was left unattempted to involve them in the guilt of the meanest conspirators.

Howard, an abandoned nobleman, without a single spark of virtue or honour, was the only witness against Sidney; but as the law required two, his discourses on government, found unpublished in his closet, were construed into treason, and declared equivalent to another witness. It was in vain for Sidney to plead that papers were no legal evidence; that it could not be proved they were written by him; and that if they were, they contained nothing treasonable. The defence was overruled; he was declared guilty, condemned, and executed on Towerhill, December 7, 1678. His attainder was reversed in the first year of William III.

He was a man of extraordinary courage, steady even to obstinacy, and of a sincere but rough and boisterous temper. Though he professed his belief in the Christian religion, he was an enemy to an established church, and even, according to Burnet, to every kind of public worship. In his principles he was a zealous republican. Government was always his favourite study; and his essays on that subject are a proof of the progress which he made. His Treatise on Government, and some other pieces, with memoirs of his life, were published by Thomas Holles, in 1763, in a quarto volume.

SIDON, in *Ancient Geography* a city of Phœnicia in Asia, famous in Scripture for its riches, arising from the extensive commerce carried on by its inhabitants. Heavy judgments were denounced against the Sidonians on account of their wickedness, which were accomplished in the time of Ochus king of Persia. That monarch having come against them with an army on account of their rebellion, the city was betrayed by its king; upon which the wretched inhabitants, seized with despair, set fire to their houses, and forty thousand, with their wives and children, perished in the flames. It is forty-five miles west from Damascus. E. long. 36. 5. N. lat. 37.

SIDUS, GEORGIUM, in *Astronomy*, a new primary planet, discovered by Dr. Herschel in the year 1781. By most foreign, and even by some British philosophers, it is known by the name of *Herschel*, in honour of the discoverer. As the other planets are distinguished by marks or characters, the planet Herschel is distinguished by an H, the initial letter of the discoverer's name, and a cross to shew that it is a Christian planet.

SIEBENBURGEN. See TRANSYLVANIA.

SIENNA, or SIENA, a district of Italy, still called a duchy, though now a part of the grand duchy of Tuscany. It is mostly situated on the Apennines, and was an independent state, till it was subdued and united with Tuscany in 1557. The capital is the city of that name, on the great road from Florence to Rome. It is surrounded with walls, and, when approached from Rome, has a magnificent appearance, but, on the side towards Florence, the view of it is hidden by woods and gardens. The city is old and rather ill built, but it contains many fine palaces belonging to noble families. It is the see of an archbishop, the cathedral, 330 feet in length, is celebrated for its fine cupola. There is a spacious market-place, with a council house and theatre, that are ornamental. It contains twenty-three churches, several of which are adorned with the finest paintings in fresco. The university, founded in 1321, once enjoyed the greatest fame of any in Italy, but at present has not more than two hundred and sixty students, though it still retains its museum, an anatomical theatre, a library, and other similar institutions. Its manufactures are a few woollen cloths, hats, strings for musical instruments, paper, and objects formed of marble or of ivory. Its population is 24,500 persons. Lat. 43. 22. Long. 11. 5. E.

SIERRA LEONE, a colony of Great Britain, situated on the western coast of Africa. Lat. 8. 10. Long. 12. 30. It is a peninsula, bounded on the north by the river called Sierra Leone, on the south and west by the sea at Calmont creek, and on the east by a line up the Calmont to the Watslod creek, and down this last to the Dunce, which is indeed a part of the Sierra Leone river. These boundaries enclose a tract of country extending eighteen miles from north to south, and twelve miles from east to west; but there is an additional tract of country adjoining Sierra Leone, which was ceded to Great Britain by an African chief in 1819. Sierra Leone, as its name indicates, is a mountainous tract of country, but with numerous intervening valleys. The heights are covered to their summit with lofty forests, giving to the distant scenery a rich and romantic appearance. The territory on the north side of the river is, however, low and level. Numerous streams descend from the hills, which collect into a basin called the Bay of Franca, celebrated as a watering-place. The Sierra Leone is more of an estuary than a river; it is twenty miles in length, by ten in breadth, at its mouth. The Rokelle affords a water communication for some distance into the interior. The range of the thermometer at Sierra Leone is very slight, and the average heat throughout the year is 82°. The rains continue for six months, and the torrents which descend from the mountains deluge the plains beneath. The mountains in the vicinity of Free Town, the capital, have now been cleared and cultivated, which has greatly added to the salubrity of the climate. Indeed, the settlement is now stated in the medical reports to be as healthy for Europeans as any other tropical country, so that it is no longer the pestiferous charnel-house which it was formerly considered. The edible fruits of Sierra Leone are numerous and luscious, including pine apples, superior in flavour to those cultivated in England; the baobab, or monkey bread, a valuable tree; oranges, plantains, bananas, limes, and many others. The country is prolific in various precious products of the soil, besides fruits. The animal kingdom is very abundant, comprising many species of antelopes, monkeys, and other denizens of a tropical country.

Free Town, the capital of the colony, is built upon the south side of the Sierra Leone river, and at the northern extremity of the peninsula. Immediately in front of the town, the river forms a bay, where there is good and commodious anchorage for vessels of all classes, and timber ships of considerable size proceed with facility nearly twenty miles higher up the stream, for the purpose of taking in their cargoes. The town is beautifully situated on an inclined plane, at the foot of some hills, on which stand the fort and other public buildings, that overlook it and the roads; whence there is a fine prospect of the town rising in the form of an amphitheatre from the water's edge, above which it is elevated seventy feet. It is regularly laid out into streets, stretching three quarters of a mile in length, intersected by others at right angles, and parallel with the river. The buildings are commodious, and substantially built of stone, which at once contribute to the beauty of the place, and to the health and comfort of the inhabitants. Numbers of cocoa-nut, orange, lime, and banana trees, are dispersed all over the town, imparting to it a peculiarly picturesque appearance. The Madeira and Teneriffe vines flourish well in the gardens. Nearly all our garden vegetables are raised there; and what with yams, cassada, and pompions, there is rarely any want of vegetable products for the table. There are good meat, poultry, and fish markets; and almost every article of housekeeping can be procured at the shops of the British merchants. The population of the capital may be estimated at 10,000.

Throughout the peninsula, several villages have been formed, viz., Leicester, founded in 1809; Regent, in 1812; Gloucester, in 1816; Kissey and Leopold, in 1817; Charlotte, Wilberforce, and Bothwell, in 1818; Kent, York, Wellington, and Waterloo, in 1819. These villages are generally situated in different parts of the mountain, but all are connected by good roads with each other, and with the capital. The two Banana islands, situated to the south-west of Free Town, were ceded to the British government in 1819, by a family who receive an annual payment for them. The total population of Sierra Leone is about 35,000, of whom not more than 200 are Europeans; the remainder are captured or liberated slaves, or their descendants, together with some native Africans. Many of the colonists, besides the Europeans, possess considerable wealth. The total number of slaves emancipated in Sierra Leone, between June 1819 and January 1833, was 27,697. Some of these, no doubt, retain their habits of indolence, but in general the freed African relishes liberty, and is grateful for the boon conferred on him, and several, by their industry and economy, are said to have acquired property amounting to L.1000 sterling. There are public schools in each parish, and from 3000 to 4000 children attend them. A large portion of the colony are enjoying, and all have access to, the means of moral and religious instruction. Upwards of one-fourth are regular attendants on the public ordinances of religion. They have built for themselves various and expensive places of worship; some of them are employed as spiritual instructors of their sable brethren; and all together, considering its circumstances, this negro colony is composed of an orderly and well-conducted people. Agriculture has not, indeed, been sufficiently prosecuted hitherto, but matters will improve in this respect when population increases, and presses upon the means of supply. The soil is in part very fertile, and more might be rendered so by clearing.

The trade of this settlement is as follows: For the year ending December 1834, there cleared inwards seventy-three vessels, whose united tonnage was 17,307. Fifty-four of these belonged to Great Britain. The number which cleared outwards during the same period was eighty-four, the tonnage of the whole being 19,068. This shows an increase on the previous year. The total value of the imports for 1831, were L.104,639; and of the exports L.81,280. Subsequent returns for 1833-4, show a decrease, which does not correspond with the number of vessels which arrived at, and departed from the settlement. The chief articles of export are timber, cam wood, palm oil, ivory, rice, bees' wax, gold, hides, &c. In 1835, these were exported to the extent of L.58,174. The chief articles imported into Sierra Leone, are cottons, gunpowder, linens, salt, guns, iron, hard-wares, and cutlery, and others of our own manufactures. This settlement is kept up at a considerable yearly expenditure. For the five years ending 1824, it was L.75,000 per annum; for the succeeding five years, it fell to about one-half that sum; but still the revenue bears no proportion to the outlay. Sierra Leone is governed by a civil-lieutenant governor, assisted by a council. There is a chief-justice, and a vice-court of admiralty. There is also established, the mixed commission for the adjudication of vessels taken in the slave-trade. A detachment of the Royal African corps (blacks) is stationed in the settlement, under a lieutenant-colonel.

This colony was founded by Great Britain with the most philanthropic views. At the suggestion of Dr. Smeathmane, the negroes discharged from the army and navy, after the American war, were conveyed to Sierra Leone, furnished with necessaries for forming a colony in their native land. But a series of calamities overtook this singularly interesting band of settlers, which obliged those who escaped pestilence and the sword to take shelter on Bance island, a small place. However, the Sierra Leone Company was formed in Britain in 1787, and it sent out five vessels with stores, and other succours, to these black freemen, together with a large reinforcement of free negroes from America. Still the difficulties with which the colony had to struggle, again placed it in critical circumstances, whilst in 1794, it was plundered by the French; and so much had calamities accumulated, that the company entered into an arrangement with the government, to place the colony under their jurisdiction. It was subsequently placed under the African Institution, established for the improvement of the western part of Africa. Great accessions were made to its population, by sending thither the negroes taken in slave ships, and to initiate them in the habits of civilized life; the Church Missionary Society undertook to furnish schools and religious instructors. But the success of this body has not been equal to its benevolent intentions, at least with regard to other parts of Africa, little or no impression having as yet been made on the general mass of the population from this quarter. Since the dissolution of the African Company, Sierra Leone has again reverted to the British crown.

SIERRA-MORENA, a range of remarkable mountains in the south of Spain. These mountains begin in the vicinity of Alcaraz, on the eastern borders of La Mancha, and extend between that province, Estremadura, and Alentejo, which it leaves to the north, and enters the kingdoms of Jaen, Cordova, Seville, and Algarve, and terminates at the sea shore at Cape St. Vincent. In its course through Cordova, it is called the Sierra de Cordova. On the south of Estremadura, and the north of Seville, it bears the name of the Guadalcanal mountains; it then trends to the south-west, where the northern side is called the Sierra of Calderion; on the south, in the Portuguese province of Algarve, it is called the Sierre de Monchique.

The highest point of these mountains does not exceed 2700 feet above the level of the sea; but from their summits being barren, and the lower parts mere morasses, they were long deemed impassable, and were so deemed at the period when the author of Don Quixote chose them for the scene of the exploits of his hero.

In the late war with France, a pass through them was deemed by the Spaniards to be impregnable, but the French troops were adroit enough to turn them, and thus were enabled to pour their armies into Andalusia, and besiege Cadiz.

After the peace of 1763, king Charles the III. entertained the project of cultivating this district; and Olavide, a benevolent and enterprising capitalist, transported thither a number of Germans, who were formed into colonies, and built several villages, and the town of Carolina. The face of the country was changed, and the soil found productive; the progress was advancing, when Olavide was involved in difficulties with the Inquisition, which gave a check to the operations, which the hostile operations carried on at subsequent periods have continued.

SIEUR, a title of respect amongst the French, like that of *master* amongst us. It is much used by lawyers, as also by superiors in their letters to inferiors.

SIFANTO, or SIPHANTO, an island of the Archipelago, west of Paros, north-east of Milo, and south-west of Serphanto. The air is so good here, that many of the inhabitants live to the age of a hundred and twenty; and their water, fruits, wild fowl, and poultry, are excellent, but more especially the grapes. It abounds with marble and granite, and is one of the most fertile and best cultivated of these islands. The inhabitants employ themselves in cultivating olive-trees and capers; and they have very good silk. They trade in figs, onions, wax, honey, and straw-hats, and may be about eight thousand in all. E. Long. 25. 15. N. Lat. 37. 9.

SIGHING, an effort of nature, by which the lungs are put into greater motion, and more dilated, so that the blood passes more freely, and in greater quantity, to the left auricle, and thence to the ventricle. Hence we learn how sighing increases the force of the blood, and proportionally cheers and relieves nature, when oppressed by its too slow motion, which is the case of those who are dejected and sad.

SIGNALS, NAVAL. When we read at our fire-side the account of an engagement, or other interesting operation of an army, our attention is generally so much engaged by the results, that we give but little to the movements which led to them, and produced them; and we seldom form to ourselves any distinct notion of the conduct of the day. But a professional man, or one accustomed to reflection, and who is not satisfied with the mere indulgence of eager curiosity, follows every regiment in its movements, endeavours to see their connection, and the influence which they have had on the fate of the day, and even to form to himself a general notion of the whole scene of action, at its different interesting periods. He looks with the eye of the general, and sees his orders succeed or fail.

But few trouble themselves farther about the narration. The movement is ordered; it is performed; and the fortune of the day is determined. Few think how all this is brought about; and when they are told that during the whole of the battle of Custrin, Frederick the Great was in the upper room of a country inn, whence he could view the whole field, whilst his aides-de-camp, on horseback, waited his orders in the yard below, they are struck with wonder, and can hardly conceive how it can be done, but, on reflection, they see the possibility of the thing. Their imagination accompanies the messenger from the inn yard to the scene of action; they hear the general's orders delivered, and they expect its execution.

But when we think for a moment on the situation of the commander of a fleet, confined on board one ship, and this ship as much, or more closely, engaged, than any other of the fleet; and when we reflect that here are no messengers ready to carry his orders to ships of the squadron at the distance of miles from him, and to deliver them with precision and distinctness, and that even if this were possible by sending small ships or boats, the vicissitudes of wind and weather may render the communication so tedious, that the favourable moment may be irretrievably lost before the order can be conveyed. When we think of all these circumstances, our thoughts are bewildered, and we are ready to imagine that a sea battle is nothing but the unconnected struggle of individual ships; and that when the admiral has once "cried havoc, and let slip the dogs of war," he has done all that his situation empowers him to do, and he must leave the fate of the day to the bravery and skill of his captains and sailors.

Signals a language to the eye.

Yet it is in this situation, apparently the most unfavourable, that the orders of the commander can be conveyed, with a dispatch that is not attainable in the operations of a land army. The scene of action is unincumbered, so that the eye of the general can behold the whole without interruption. The movements which it is possible to execute, are few, and they are precise. A few words are sufficient to order them, and then the mere fighting the ships must always be left to their respective commanders. This simplicity in the duty to be performed has enabled us to frame a language fully adequate to the business in hand, by which a correspondence can be kept up as far as the eye can see. This is the language of *signals*, a language by writing, addressed to the eye, and which he that runneth may read. As in common writing certain arbitrary marks are agreed on to express certain sounds used in speech, or rather, as in hieroglyphics, certain arbitrary marks are agreed on to express certain thoughts, or the subjects of these thoughts; so here certain exhibitions are made, which are agreed on to express certain movements to be executed by the commander to whom they are addressed, and all are enjoined to keep their eyes fixed on the ship of the conductor of the fleet, that they may learn his will.

It was so in ancient times.

It is scarcely possible for any number of ships to act in concert, without some such mode of communication between the general and the commanders of private ships. We have no direct information of this circumstance in the naval tactics of the ancient nations, the Greeks and Romans; yet the necessity of the thing is so apparent, that we cannot suppose it to have been omitted by the most ingenious and the most cultivated people who have appeared on the great theatre of the world; and we are persuaded that Themistocles, Conon, and other renowned naval commanders of Athens, had signals by which they directed the movements of their fleets. We read, that when Ægeus sent his son Theseus to Crete, it was agreed on, that if the ship should bring the young prince back in safety, a white flag should be displayed. But those on board, in their joy for revisiting their country after their perilous voyage, forgot to hoist the concerted signal. The anxious father was every day expecting the ship which should bring back his darling son, and had gone to the shore to look out for her. He saw her, but without the signal agreed on; on which the old man threw himself into the sea. We find, too, in the history of the Punic wars by Polybius, frequent allusions to such a mode of communication; and Ammianus Marcellinus speaks of the *speculatores* and *vexillarii*, who were on board the ships in the Adriatic. The coins both of Greece and Rome exhibit both flags and streamers. In short, we cannot doubt of the ancients having practised this hieroglyphical language. It is somewhat surprising that Lord Dudley, in his *Arcano del Mare*, in which he makes an ostentatious display of his knowledge of every thing connected with the naval service, makes no express mention of this very essential piece of knowledge, although he must, by his long residence in Italy, have known the marine discipline of the Venetians and Genoese, the greatest maritime powers then in Europe.

Also in modern times.

In the naval occurrences of modern Europe, mention is frequently made of signals. Indeed, as we have already observed, it seems impossible for a number of ships to act in any kind of concert, without some method of communication. Numberless situations must occur, when it would be impossible to convey orders or information by messengers from one ship to another, and coast and alarm signals had long been practised by every nation. The idea, therefore, was familiar. We find, in particular, that Queen Elizabeth, on occasion of the expedition to Cadiz, ordered her secretaries to draw up instructions, which were to be communicated to the admiral, the general, and the five counsellors of war, and by them to be copied and transmitted to the several ships of the navy, not to be opened till they should arrive in a certain latitude. It was on this occasion, says our historian Guthrie, "that we meet with the first regular sets of signals and orders to the commanders of the English fleet." But till the movements of a fleet have attained some sort of uniformity, regulated and connected by some principles of propriety, and agreed on by persons in the habit of directing a number of ships, we may with confidence affirm that signals would be nothing but a parcel of arbitrary marks, appropriated to particular pieces of naval service, such as attacking the enemy, landing the soldiers, and the like; and that they would be considered merely as referring to the final result, but by no means pointing out the mode of execution, or directing the movements which were necessary for performing it.

First for ed into a system b James I when Du of York.

It was James II. when Duke of York, who first considered this practice as capable of being reduced into a system, and who saw the importance of such a composition. He, as well as the king his brother, had always showed a great predilection for the naval service; and when appointed admiral of England, he turned his whole attention to its improvement. He had studied the art of war under Turenne, not as a pastime, but as a science, and was a favourite pupil of that most accomplished general. Turenne one day pointed him out, saying, "Behold one who will be one of the first princes and greatest generals of Europe." When admiral of England, he endeavoured to introduce into the maritime service all those principles of concert and arrangement which made a number of individual regiments and squadrons compose a great army. When he commanded in the Dutch war, he found a fleet to be little better than a collection of ships, on board of each of which the commander and his ship's company did their best to annoy the enemy, but with very little dependence on each other, or on the orders of the general; and in the different actions which the English fleet had with the Dutch, everything was confusion as soon as the battle began. It is remarkable that the famous pensionary De Witt, who from a statesman became a navigator and a great sea commander in a few weeks, made the same representation to the States General on his return from his first campaign.

In the memoirs of James II. written by himself, we have the following passage: "1665. On the 15th of March, the Duke of York went to Gunfleet, the general rendezvous of the fleet, and hastened their equipment. He ordered all the flag officers on board with him every morning, to agree on the order of battle and rank. In former battles, no order was kept, and this under the Duke of York, was the first in which fighting in a line and regular form of a battle was observed." This must be considered as full authority for giving the Duke of York the honour of the invention. For whatever faults may be laid to the charge of this unfortunate prince, his word and honour stand unimpeached. And we are anxious to vindicate his claim to it, because our neighbours the French, as usual, would take the merit of this invention, and of the whole of naval tactics, to themselves. True it is, that Colbert, the great and justly celebrated minister of Louis XIV. created a navy for his ambitious and vain-glorious master, and gave it a constitution which may be a model for other nations to copy. By his encouragement, men of the greatest scientific eminence were engaged to contribute to its improvement; and they gave us the first treatises of naval evolutions. But it must ever be remembered, that our accomplished, though misguided sovereign, was then residing at the court of Louis; that he had formerly acted in concert with the French as a commander and flag officer, and was at this very time aiding them with his knowledge of nautical affairs. In the memorable day at La Hogue, the gallant Russel, observing one of Tourville's movements, exclaimed, "There, they have got Pepys[1] amongst them." This anecdote we give on the authority of a friend, who heard an old and respectable officer, Admiral Clinton, say, that he had it from a gentleman who was in the action, and heard the words spoken; and we trust that our readers will not be displeased at having this matter of general opinion established on some good grounds.

It was on this occasion, then, that the Duke of York made the movements and evolutions of a fleet the object of his particular study, reduced them to a system, and composed that System of Sailing and Fighting Instructions, which has ever since been considered as the code of discipline for the British navy, and which has been adopted by our rivals and neighbours as the foundation of their naval tactics. It does great honour to its author, although its merit will not appear very eminent to a careless surveyor, on account of the very simplicity which constitutes its chief excellence. It is unquestionably the result of much sagacious reflection and painful combination of innumerable circumstances, all of which have their influence; and it is remarkable, that although succeeding commanders have improved the subject by several subordinate additions, no change has to this day been made in its general principles or maxims of evolution.

Till some such code be established, it is evident that signals can be nothing but arbitrary and unconnected hieroglyphics, to be learned by rote, and retained by memory, without any exercise of the judgment; and the acquisition of this branch of nautical skill must be a more irksome task than that of learning the Chinese writing. But such a code being once settled, the character in which it may be expressed becomes a matter of rational discussion.

Accordingly, the sailing and fighting instructions of the Duke of York were accompanied by a set of signals for directing the chief or most frequent movements of the fleet. These also were contrived with so much judgment, and such attention to distinctness, simplicity, and propriety, that there has hardly been any change found necessary; and they are still retained in the British navy as the usual signals in all cases when we are not anxious to conceal our movements from an enemy.

Notwithstanding this acknowledged merit of the Duke of York's signals, it must be admitted that great improvements have been made on this subject, considered as an art. The art military has, in the course of a century past, become almost an appropriate calling, and has therefore been made the peculiar study of its professors. Our rivals the French were sooner and more formally placed in this situation; and the ministers of Louis XIV. took infinite and most judicious pains to make their military men superior to all others by their academical education. A more scientific turn was given to their education, and the assistance of scientific men was liberally given them; and all the nations of Europe must acknowledge some obligations to them for information on everything connected with the art of war. They have attended very much to this subject, have greatly improved it, and have even introduced a new principle into the art; and by this means have reduced it to the most simple form of reference to the code of sailing and fighting instructions, by making the signals immediately expressive, not of orders, but of simple numbers. These numbers being prefixed to the various articles of the code of instructions, the officer who sees a signal thrown out by the admiral, reads the number and reports it to his captain, perhaps without knowing to what it relates. Thus simplicity and secrecy, with an unlimited power of variation, are combined. We believe that M. de la Bourdonnais, a brave and intelligent officer, during the war 1758, was the author of this ingenious thought.

We do not propose to give a system of British signals. This would evidently be improper. But we shall show our readers the practicability of this curious language, the extent to which it may be carried, and the methods which may be practised in accomplishing this purpose. This may make it an object of attention to scientific men, who can improve it; and the young officer will not only be able to read the orders of the commander-in-chief, but will not be at a loss, should circumstances place him in a situation where he must issue orders to others.

Signals may be divided into,

I. Day Signals.
II. Night Signals; and,
III. Signals in a Fog.

They must also be distinguished into, First, Signals of Evolution, addressed to the whole Fleet, or to Squadrons of the fleet, or to Divisions of these squadrons; secondly, Signals of Movements to be made by particular ships; and, thirdly, Signals of Service, which may be either general or particular.

During an engagement the signals of the admiral are repeated by frigates stationed out of the line.

The great extent of a large fleet, the smoke in time of battle, and the situation of the commander-in-chief, who is commonly in the midst of the greatest confusion and hottest fire, frequently makes it very difficult for the officers of distant ships to perceive his signals with distinctness. Frigates, therefore, are stationed out of the line, to windward or to leeward, whose sole office it is to observe the admiral's signals, and instantly to repeat them. The eyes of all the signal officers in the private ships of war are directed to the repeating frigates, as well as to the admiral; and the officers of the repeating frigate, having no other duty, observe the admiral incessantly, and, being unembarrassed by the action, can display the signal with deliberation, so that it may be very distinctly seen. Being minutely acquainted with the substitutions which must be made on board the admiral when his masts and rigging are in disorder, his perhaps imperfect signal is exhibited by the repeating frigate in its proper form, so as to be easily understood. And to facilitate this communication, the commanders of the different squadrons repeat the signals of the commander-in-chief, and the commanders of division repeat the signals of the commanders of their squadron.

Evolution signals are preceded by a signal of advertisement, and accompanied with a directive signal.

Every evolution signal is preceded by a signal of advertisement and preparation, which is general, and frequently by a gun, to call attention; and when all the signals have been made which direct the different parts of that evolution, another signal is made, which marks the close of the complex signal, and divides it from others which may immediately follow it: And as the orders of the commander-in-chief may relate either to the movements of the whole fleet, those of a single division, or those of certain private ships, the Executive Signal, which dictates the particular movement, is accompanied by a Directive Signal, by which these ships are pointed out, to which the order is addressed.

Answered by the commander.

The commander of a ship to which any signal is addressed, is generally required to signify by a signal, which is general, that he has observed it. And if he does not thoroughly understand its meaning, he intimates this by another general signal. And here it is to be observed, that as soon as the signal is answered by the ships to which it is addressed, it is usual to haul it down, to avoid the confusion which might arise from others being hoisted in the same place. The order remains till executed, notwithstanding that the signal is hauled down.

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[1] Pepys was secretary to the Duke of York.

Annulling signals.

It may happen that the commander who throws out the signal for any piece of service, sees reasons for altering his plan. He intimates this by a general annulling signal, accompanying the signal already given. This will frequently be more simple than to make the signals for the movements which would be required for re-establishing the ships in their former situation.

All these things are of very easy comprehension, and require little thought for their contrivance. But when we come to the particular evolutions and movements, and to combine these with the circumstances of situation in which the fleet may be at the time, it is evident that much reflection is necessary for framing a body of signals which may be easily exhibited, distinctly perceived and well understood, with little risk of being mistaken one for another. We shall take notice of the circumstances which chiefly contribute to give them these qualities as we proceed in describing their different classes.

I. *Of Day Signals.*

These are made by means of signals of different colours; but before we proceed to the description of the signals by means of colours, such as flags, banners, or triangular flags, pendants, or vanes, we must take notice of the ostensible distinctions of the various divisions and subdivisions of a fleet, so that we may understand how the same signal may be addressed to a squadron, division, or single ship or ships. We suppose it known that a fleet of ships of war is distributed into three grand divisions, which we shall term squadrons, called the van, centre, and rear. These denominations have not always a relation to the one being more advanced than the other, either towards the enemy or in the direction of their course.

Meaning of the terms van, centre, and rear, in the line of battle at sea.

In a land army, the position of every part is conceived from its reference to the enemy; and the reader, conceiving himself as facing the enemy, easily understands the terms van, centre, and rear, the right and left wing, and so forth. But the movements of a sea army having a necessary dependence on the wind, they cannot be comprehended unless expressed in a language which keeps this circumstance continually in view. The simplest and most easily conceived disposition of a fleet, is that in which it is almost indispensably obliged to form in order to engage an enemy. This is a straight line, each ship directly ahead of its neighbour, and close-hauled. This is therefore called the line of battle. In this position, the two extremities of the fleet correspond to the right and left wings of an army. Suppose this line to be in the direction east and west, the wind blowing from the north-north-west, and therefore the fleet on the starboard tack; the ships' heads are to the west, and the westermost division is undoubtedly the van of the fleet, and the eastermost division is the rear. And it is in conformity to this arrangement and situation that the list of the fleet is drawn up. But the ships may be on the same east and west line, close-hauled, with their heads to the west, but the wind blowing from the south-south-west. They must therefore be on the larboard tack. The same ships, and the same division, are still, in fact, the van of the fleet. But suppose the ships' heads to be to the eastward, and that they are close-hauled, having the wind from the south-south-east or the north-north-east, the ships which were the real van on both tacks in the former situation, are now, in fact, the rear on both tacks; yet they retain the denomination of the van squadron of this fleet, and are under the immediate direction of the officer of the second rank, while the other extremity is under the direction of the third officer. This subordination therefore is rather an arrangement of rank and precedence than of evolution. It is, however, considered as the natural order to which the general signals must be accommodated. For this reason, the division which is denominated van in the list of this fleet, is generally made to lead the fleet when in the line of battle on the starboard tack, and to form the weathermost column in the order of sailing in columns; and, in general, it occupies that station from which it can most easily pass into the place of the leading division on the starboard line of battle ahead. Although this is a technical nicety of language, and may frequently puzzle a landsman in reading an account of naval operations, the reflecting and intelligent reader will see the propriety of retaining this mode of conceiving the subordinate arrangement of a fleet, and will comprehend the employment of the signals which are necessary for re-establishing this arrangement, or directing the movements while another arrangement is retained.

How s- nals an dressed each of these sions.

This being understood, it is easy to contrive various methods of distinguishing every ship by the place which she occupies in the fleet, both with respect to the whole line, with respect to the particular squadron, the particular division of that squadron, and the particular place in that division. This may be done by a combination of the position and colour of the pendants and vanes of each ship. Thus the colour of the pendants may indicate the squadron, their position or mast on which they are hoisted may mark the division of that squadron, and a distinguishing vane may mark the place of the private ship in her own division. The advantages attending this method are many. In a large fleet it would hardly be possible for the commander-in-chief to find a sufficient variety of single signals to mark the ship to which an order is addressed, by hoisting it along with the signal appropriated to the intended movement. But by this contrivance one-third part of these signals of address is sufficient. It also enables the commander-in-chief to order a general change of position by a single signal, which otherwise would require several. Thus, suppose that the fore, main, and mizen masts, are appropriated, with the proper modifications, for exhibiting the signals addressed to the van, the centre, and the rear squadrons of the fleet, and that a red, a white, and a blue flag, are chosen for the distinguishing flags of the officers commanding these squadrons; then, if the commander-in-chief shall hoist a red flag at his mizen topgallant mast-head, it must direct the van squadron to take the position then occupied by the rear squadron, the evolution necessary for accomplishing this end being supposed known by the commander of the squadron, who will immediately make the necessary signals to the squadron under his particular direction. In the same manner, the distinguishing signal for the leading ship of a squadron being hoisted along with the signal of address to the whole fleet, and the signal for any particular service, will cause the three or the nine leading ships to execute that order.

All that has been said hitherto may be considered as so many preparations for the real issuing of orders by the commander-in-chief. The most difficult part of the language remains, viz. to invent a number of signals which shall correspond to that almost infinite variety of movements and services which must be performed.

Essen qualit signal distin ness.

Distinctness, simplicity, and propriety, are the three essential qualities of all signals. A signal must be some object easily seen, strongly marked, so that it may be readily understood, with little risk of its being mistaken for another. When made by flags, banners, or pendants, they must be of the fullest colours, and strongest contrasts. The ships are frequently at a very great distance, so that the intervening air occasions a great degradation of colour. They are seen between the eye and a very variable sky; and in this situation, especially in the morning or evening, or a dark day, it is not easy to distinguish one full colour from another, all of them approaching to the appearance of a black. At the distance of a very few miles hardly any full colours can be distinguished but a scarlet and a blue. Red, blue, yellow, and white, are the colours which can be distinguished at greater distances than any others, and are therefore the only colours admitted as signals. Even these are sometimes distinguished with difficulty. A yellow is often confounded with a dirty white, and a blue with a red. All other dark colours are found totally unfit. But as these afford but a small variety, we must combine them in one flag, by making it striped, spotted, or chequered, taking care that the opposition of colour may be as great as possible, and that the pieces of which the flags are made up may not be too minute. Red must never be striped nor spotted with blue; and the stripes, spots, or chequers, should never be less than one-third of the breadth of the flag.

Difference of shape, as flags, banners, or pendants, is another distinction by which the expression may be varied. And in doing this, we must recollect, that in light winds it may be difficult to distinguish a flag from a banner, as neither are fully displayed for want of wind to detach the fly from the staff.

Lastly, signals may be varied by their position, which may be on any lofty and well detached part of the masts, yards, or rigging.

Simplicity.

Simplicity is an eminent property in all signals. They are addressed to persons not much accustomed to combinations, and who are probably much occupied by other pressing duties. It were to be wished that every piece of service could be indicated by a single flag. This is peculiarly desirable with respect to the signals used in time of battle. The rapid succession of events on this occasion call for a multitude of orders from the commander-in-chief, and his ship is frequently clad over with flags and pendants, so that it is exceedingly difficult for the signal officer of a private ship to distinguish the different groups, each of which make a particular signal.

Propriety.

These considerations are the foundation of a certain propriety in signals, which directs us to a choice amongst marks which appear altogether arbitrary. Signals which run any risk of being confounded, on account of some resemblance, or because their position hinders us from immediately perceiving their difference, should be appropriated to pieces of service which are hardly possible to be executed, or can hardly be wanted, in the same situation. No bad consequence could easily result though the signal for coming to closer action should resemble that for unmooring, because the present situation of the ships makes the last operation impossible or absurd, Such considerations direct us to select for battle signals, those which are of easiest exhibition, are the most simple, and have the least dependence on the circumstance of position; so that their signification may not be affected by the damages sustained in the masts or rigging of the flag-ship. Such signals as are less easily seen at a distance, should be appropriated to orders which can occur only in the middle of the fleet. Signals which are made to the admiral by private ships may be the same with signals of command from the flag-ship, which will considerably diminish the number of signals perfectly different from each other.

With all these attentions and precautions a system of signals is at last made up, fitted to the code of sailing and fighting instructions. It is accompanied by another small set for the duty of convoys. It must be engrossed in two books; one for the officer of the flag-ship, who is to make the signals, and the other is delivered to every private ship. In the first, the evolutions, movements, and other operations of service, are set down in one column, and their corresponding signals in another. The first column is arranged, either alphabetically, by the distinguishing phrase, or systematically, according to the arrangement of the sailing and fighting instructions. The officer whose duty it is to make the signals turns to this column for the order which he is to communicate, and in the other column he finds the appropriated signal.

In the other book, which is consulted for the interpretation of the signals, they are arranged in the leading column, either by the flags, or by the places of their exhibition. The first is the best method, because the derangement of the flag-ship's masts and rigging in time of action may occasion a change in the place of the signal.

The art of signals much improved.

The *Tactique Navale* of the Chevalier de Morogues contains a very full and elaborate treatise on signals. We recommend this work to every sea-officer, as full of instruction. The art of signals has been greatly simplified since the publication of this work, but we cannot but ascribe much of the improvements to it. We believe that the author is the inventor of that systematic manner of addressing the order or effective signal to the different squadrons and divisions of the fleet, by which the art of signals is made more concise, the execution of orders is rendered more systematic, and the commanders of private ships are accustomed to consider themselves as parts of an army, with a mutual dependence and connection. We are ready enough to acknowledge the superiority of the French in manœuvring, but we affect to consider this as an imputation on their courage. Nothing can be more unjust; and dear bought experience should long ere now have taught us the value of this superiority. What avails that courage which we would willingly arrogate to ourselves, if we cannot come to action with our enemy, or must do it in a situation in which it is almost impossible to succeed, and which needlessly throws away the lives of our gallant crews? Yet this must happen, if our admirals do not make evolutions their careful study, and our captains do not habituate themselves, from the first hoisting a pendant, to consider their own ship as connected with the most remote ship in the line. We cannot think that this view of their situation would in the least lessen the character which they have so justly acquired, of fighting their ship with a courage and firmness unequalled by those of any other nation. And we may add, that it is only by such a rational study of their profession, that the gentleman can be distinguished from the mercenary commander of a privateer.

II. *Night Signals.*

It is evident, that the communication of orders by night must be more difficult and more imperfect than by day. We must, in general, content ourselves with such orders as are necessary for keeping the fleet together, by directing the more general movements and evolutions which any change of circumstances may render necessary. And here the division and subordinate arrangement of the fleet is of indispensable necessity, it being hardly possible to particularise every ship by a signal of address, or to see her situation. The orders are therefore addressed to the commanders of the different divisions, each of whom is distinguished by his poop and top-lights, and is in the midst of, and not very remote from, the ships under his more particular charge. Yet even in this unfavourable situation, it is frequently necessary to order the movements of particular ships. Actions during the night are not uncommon. Pursuits and rallyings are still oftener carried on at this time. The common dangers of the sea are as frequent and more disastrous. The system of signals therefore is very incomplete till this part be accomplished.

Night signals must be made by guns, or by lights, or by both combined.

How gun-signals may be varied.

Gun-signals are susceptible of variety both in number and in disposition. The only distinct variation which can be made in this disposition, is by means of the time elapsed between the discharges. This will easily admit of three varieties, slow, moderate, and quick. Half-minute guns are as slow as can easily be listened to as appertaining to one signal. Quarter-minute guns are much better, and admit of two very distinct subdivisions. When the gunners, therefore, are well trained to this service, especially since the employment of firelocks for cannon, intervals of fifteen or twelve seconds may be taken for slow firing, eight or ten seconds for moderate, and four or five seconds for quick firing. If these could be reduced to one-half, and made with certainty and precision, the expression would be incomparably more distinct. A very small number of firings varied in this way will give a considerable number of signals. Thus five guns, with the variety of only quick and moderate, will give twenty very distinguishable signals. The same principle must be attended to here as in the flag-signals. The most simple must be appropriated to the most important orders, such as occur in the worst weather, or such as are most liable to be mistaken. Quick firing should not make part of a signal to a very distant ship, because the noise of a gun at a great distance is a lengthened sound, and two of them, with a very short interval, are apt to coalesce into one long-continued sound. This mode of varying gun-signals by the time must therefore be employed with great caution, and we must be very certain of the steady performance of the gunners.

Note, that a preparatory signal or advertisement that an effective signal is to be made, is a very necessary circumstance. It is usual, at least in hard weather, to make this by a double discharge, with an interval of half a second, or at most a second.

Gun-signals are seldom made alone, except in ordinary situations and moderate weather; because accident may derange them, and inattention may cause them to escape notice, and, once made, they are over, and their repetition would change their meaning. They are also improper on an enemy's coast, or where an enemy's cruisers or fleets may be expected.

Signals by lights.

Signals by lights are either made with lights simply so called, that is, lanthorns shown in different parts of the ship, or by rockets. Lights may differ by number, and by position, and also by figure. For the flag ship always carrying poop or top-lights, or both, presents an object in the darkest night, so that we can tell whether the additional lights are exhibited about the mainmast, the foremast, the mizenmast, and the like. And if the lights shown from any of these situations are arranged in certain distinguishable situations in respect to each other, the number of signals may be greatly increased. Thus three lights may be in a vertitical line, or in a horizontal line, or in a triangle; and the point of this triangle may be up or down, or forward, or aft, and thus may have many significations.

Lights are also exhibited by false fires or rockets. These can be varied by number, and by such differences of appearance as to make them very distinguishable. Rockets may be with stars, with rain fire, or simple squibs.

These two species of signals may be combined.

By varying and combining these, a very great number of signals may be produced, fully sufficient to direct every general movement or evolution, or any ordinary and important service. The Chevalier de Morogues has given a specimen of such a system of night signals, into which he has even introduced signals of address or direction to every ship of a large fleet; and has also given signals of number, by which depths of soundings, points of the compass, and other things of this kind, may be expressed both easily and distinctly. He has made the signals by rockets perfectly similar in point of number to those by lanthorns, so that the commander can take either; a choice which may have its use, because the signals by rockets may cause the presence of a fleet to be more extensively known than may be convenient.

Genera observa tions c cerning night s nals.

The commander-in-chief will inform the fleet by signal, that guns, or perhaps rockets, are not to be used that night. This signal, at the same time, directs the fleet to close the line or columns, that the light signals may be better observed.

It is indeed a general rule to show as few lights as possible; and the commander frequently puts out his own poop and top-lights, only showing them from time to time, that his ships may keep around him.

The signal lanthorns on board the flag ship, and a lanthorn kept in readiness on board of every private ship, to answer or acknowledge signals from the commander-in-chief, are all kept in bags, to conceal their lights till the moment they are fixed in their places, and the preparatory or advertising signal has been made. The commander-in-chief sometimes orders by signal every ship to show a light for a minute or two, that he may judge of the position of the fleet; and the admiral's signal must always be acknowledged by those to whom it is addressed.

It is of particular importance that the fleet be kept together. Therefore the leading ships of the fleet, on either tack, are enjoined to acknowledge the signals of the commander-in-chief by a signal peculiar to their station. Thus the commander-in-chief learns the position of the extremities of his fleet.

In framing a set of night signals, great attention must be given to their position, that they be not obscured by the sails. The nature of the order to be given will frequently determine this. Thus, an order for the rear ships to make more sail, will naturally direct us to exhibit the signal at the mizen peek; and so of other pieces of service. Lanthorns exposed in groups, such as triangles, lozenges, and the like, are commonly suspended at the corners of large frames of laths, at the distance of a fathom at least from each other. Attempts have been made to show lights of different colours; but the risk of mistake or failure in the composition at the laboratory, makes this rather hazardous. Coloured lanthorns are more certain; but when the glasses are made of a colour sufficiently intense, the vivacity of the light, which at no time is very great, is too much diminished. Besides, the very distance changes the colour exceedingly and unaccountably.

III. *Of Signals in a Fog.*

By o ing c tain ral r signa durin fog a many unne sary.

These can be made only by noises, such as the firing of cannon and muskets, the beating of drums and ringing of bells. Fog signals are the most difficult to contrive of any, and are susceptible of the least variety. The commander-in-chief is principally concerned to keep his fleet together; and unless something very urgent requires it, he will make no change in his course or rate of sailing. But a shift of wind or other causes may make this necessary. The changes which he will order, it will be prudent to regulate by some fixed rule, which is in general convenient. Thus, when a fleet is in the order of sailing upon a wind, and a fog comes on, the fleet will hold on the same course. If the wind should come a little more on the beam, the fleet will still keep close to the wind. Certain general rules of this kind being agreed on, no signals are necessary for keeping the fleet together; and the ships can separate or run foul of each other only by difference in their rate of sailing, or by inaccurate steerage. To prevent this, the commander-in-chief fires a gun from time to time, and the ships of the fleet judge of his situation and distance by the sound. The commanders of divisions fire guns, with some distinction from those of the commander-in-chief. This both informs the commander-in-chief of the position of his squadrons, and enables the private ships of each division to keep in the neighbourhood of their own flag ship. On board of every private ship the drum is beaten, or the bell is chimed every quarter of an hour, according as the ship is on the starboard or larboard tack. By such contrivances, it is never difficult to keep a fleet in very good order when sailing on a wind. The wind is almost always moderate, and the ships keep under a very easy sail. It is much more difficult when going large, and separation can be prevented only by the most unwearied attention. The greatest risk is the falling in with strange ships steering another course. But evolutions and other movements are frequently indispensable. The course must be changed by tacking or wearing, and other services must be performed. None, however, are admitted but the most probable, the most simple, and the most necessary.

The commander-in-chief first informs the fleet by the preparatory fog signal, that he is about to order an evolution, and that he is to direct it by fog signals. This precaution is indispensable to prevent mistakes. Along with this advertising signal he makes the signal of the movement intended. This not only calls the attention of the fleet, but makes the ships prepare for the precise execution of that movement. The commanders of divisions repeat the advertising signal, which informs their ships of their situation, and the private ships beat their drums or chime their bells. Thus the whole ships of the fleet close a little, and become a little better acquainted with their mutual position. It is now understood that a movement is to be made precisely a quarter of an hour after the advertisement. At the expiration of this time, the effective signal for this movement is made by the commander-in-chief, and must be instantly repeated by the commanders of divisions, and then the movement must be made by each ship, according to the sailing and fighting instructions. This must be done with the utmost attention and precision, because it produces a prodigious change in the relative position of the ships; and even although the good sense of the commander-in-chief will select such movements for accomplishing his purpose as produce the smallest alterations, and the least risk of separation or running foul of each other; it is still extremely difficult to avoid these misfortunes. To prevent this as much as possible, each ship which has executed the movement, or which has come on a course thwarting that of the fleet, intimates this by a signal properly adapted, often adding the signal of the tack on which it is now standing, and even its particular signal of recognizance. This is particularly incumbent on the flag ships and the leading ships of each division. After a reasonable interval, the commander-in-chief will make proper signals for bringing the fleet to a knowledge of their reunion in this new position.

This must serve for a general account of the circumstances which must be attended to in framing a code of signals. The arbitrary characters in which the language is written must be left to the sagacity of the gentlemen of the profession. It must be observed, that the stratagems of war make secrecy very necessary. It may be of immense hazard if the enemy should understand our signals. In time of battle it might frequently frustrate our attempts to destroy them, and at all times would enable them to escape, or to throw us into disorder. Every commander of a squadron, therefore, issues private signals, suited to his particular destination; and therefore it is necessary that our code of signals be susceptible of endless variations. This is exceedingly easy, without any increase of their number. The commander needs only intimate that such and such a signal is so and so changed in its meaning during his command.

We cannot leave this article without returning to an observation which we made almost in the beginning, viz. that the system of signals, or, to speak more properly, the manner of framing this system, has received much improvement from the gentlemen of the French navy, and particularly from the most ingenious thought of M. de la Bourdonnais, of making the signals the immediate expressions of numbers only, which numbers may be afterwards used to indicate any order whatever. We shall present our readers with a scheme or two of the manner in which this may be done for all signals, both day, night, and fog. This alone may be considered as a system of signals, and is equally applicable to every kind of information at a distance. Without detracting in the smallest degree from the praise due to M. de la Bourdonnais, we must observe, that this principle of notation is of much older date. Bishop Wilkins, in his *Secret and Swift Messenger*, expressly recommends it, and gives specimens of the manner of execution; so does Dr. Hook in some of his proposals to the Royal Society. Gaspar Schottus also mentions it in his *Technica Curiosa;* and Kircher, amongst others of his *Curious Projects.*

M. de la Bourdonnais's method for doing this

M. de la Bourdonnais's method is as follows:—He chooses pendants for his effective signals, because they are the most easily displayed in the proper order. Several pendants, making part of one signal, may be hoisted by one halyard, being stopped on it at the distance of four or six feet from each other. If it be found proper to throw out another signal at the same time and place, they are separated by a red pendant without a point. His colours are chosen with judgment, being very distinctly recognised, and not liable to be confounded with the addressing signals appropriated to the different ships of the fleet. They are, for

No.	No.
1. Red.	6. Red, with blue tail.
2. White.	7. White, with blue tail.
3. Blue.	8. White, with red tail.
4. Yellow.	9. Blue, with yellow tail.
5. Red, with white tail.	10. Yellow, with blue tail.

Three sets of such pendants will express every number under a thousand, by hoisting one above the other, and reckoning the uppermost hundreds, the next below it tens, and the lowest units. Thus the number 643 will be expressed by a pendant red with blue tail, a yellow pendant below it, and a blue one below the last.

This method has great advantages. The signals may be hoisted in any place where best seen, and therefore the signification is not affected by the derangement of the flag-ship's masts and rigging. And by appropriating the smaller numbers to the battle signals, they are more simple, requiring fewer pendants.

It might be rendere much simpler.

As this method requires a particular set of colours, it has its inconveniences. An admiral is often obliged to shift his flag, even in time of action. He cannot easily take the colours along with him. It is therefore better to make use of such colours as every private ship is provided with. One set of 11 will do, with the addition of three, or at most of four pendants, of singular make, to mark 100, 200, 300, 400. Two of these flags, one above the other, will express any number under 100, by using the 11th as a substitute for any flag that should be repeated. Thus the 11th flag, along with the flag for eight or for six, will express the number 88 or 66. Thus we are able to express every number below 500, and this is sufficient for a very large code of signals.

And in order to diminish as much as possible the number of these compound signals, it will be proper that a number of single flag signals be preserved, and even varied by circumstances of position, for orders which are of very frequent occurrence, and which can hardly occur in situations where any obstructions are occasioned by loss of masts or otherwise. And farther, to avoid all chance of mistake, a particular signal can be added, intimating that the signals now exhibited are numerary signals; or, which is still better, all signals may be considered as numerary signals; and those which we have just now called single flat signals may be set down opposite to, or as expressing the largest numbers of the code.

This method requires the signal of advertisement, the annulling signal, the signal of address to the particular ship or division, the signal of acknowledgment, the signal of indistinctness, of distress, of danger, and one or two more, which in every method must be employed.

Another method of expressing numbers by fewer colours.

Another method of expressing numbers with fewer colours is as follows: Let the flags be A, B, C, D, E, F, and arrange them as follows:

	A	B	C	D	E	F
	1	2	3	4	5	6
A	7	8	9	10	11	12
B	13	14	15	16	17	18
C	19	20	21	22	23	24
D	25	26	27	28	29	30
E	31	32	33	34	35	36
F	37	38	39	40	41	42

The number expressed by any pair of flags is found in the intersection of the horizontal and perpendicular columns. Thus the flag D, hoisted along with and above the flag F, expresses the number 40, &c. In order to express a greater number, (but not exceeding 84), suppose 75, hoist the flag $\genfrac{}{}{0pt}{}{C}{E}$, which expresses 33, or 75 wanting 42, and above them a flag or signal G, which alone expresses 42.

This method may be still farther improved by arranging the flags thus:

	A	B	C	D	E	F
	1	2	3	4	5	6
A	7	8	9	10	11	12
B	—	13	14	15	16	17
C	—	—	18	19	20	21
D	—	—	—	22	23	24
E	—	—	—	—	25	26
F	—	—	—	—	—	27

In this last method the signification of the signal is totally independent of the position of the flags. In whatever parts of the ship the flags D and E are seen, they express the number 23. This would suit battle signals.

A third method.

Another method still may be taken. Flags hoisted anywhere on the foremast may be accounted units, those on the mainmast tens, and those on the mizenmast hundreds. Thus numeral signals may be made by a ship dismasted, or having only poles in their place. Many other ways may be contrived for expressing numbers by colours, and there is great room for exercising the judgment of the contriver. For it must always be remembered, that these signals must be accompanied with a signal by which it is addressed to some particular ship or division of the fleet, and it may be difficult to connect the one with the other, which is perhaps shewn in another place, and along with other executive signals.

Advantages of numeral signals.

One great advantage of these numeral signals is, that they may be changed in their signification at pleasure. Thus, in the first method, it can be settled, that on Sundays the colours A, B, C, D, &c., express the cyphers 1, 2, 3, 4, &c., but that on Mondays they express the cyphers 0, 1, 2, 3, &c., and on Tuesdays the cyphers 9, 0, 1, 2, &c., and so on through all the days of the week. This mean of secrecy is mentioned by Dr. Hooke for the coast and alarm signals, where, by the bye, he shews a method for conveying intelligence over land very similar to what is now practised by the French with their telegraph.

Numbers may be also expressed by night signals.

It is equally easy to express numbers by night signals. Thus M. de la Bourdonnais proposes that one discharge of a great gun shall express 7, and that 1, 2, 3, 4, 5, 6, shall be expressed by lights. Therefore to express 24, we must fire three guns, and shew three lights. This is the most perfect of all forms of night and fog signals. For both the manner of firing guns and of exhibiting lights may be varied to a sufficient extent with very few guns or lights, and with great distinctness.

Thus, for guns. Let F mark the firing of a single gun at moderate intervals, and *ff* a double gun, that is, two discharged at the interval of a second. We may express numbers thus:

1	F.
2	F, F.
3	F, F, F.
4	F, F, F, F.
5	F, *ff*.
6	F, F, *ff*.
7	F, *ff*, F.
8	F, *ff*, FF.
9	F, *ff*, F, *ff*.
10	*ff*.
100, &c.,	*ff*, *ff*, or *fff*.

It might be done with fewer guns if the *ff* were admitted as the first firing. But it seems better to begin always with the single gun, and thus the double gun beginning a signal distinguishes the tens, &c.

In like manner, a small number of lights will admit of a great variety of very distinct positions, which may serve for all signals to ships not very remote from the commander-in-chief. For orders to be understood at a very great distance, it will be proper to appropriate the numbers which are indicated by signals made with rockets. These can be varied in number and kind to a sufficient extent, so as to be very easily distinguished and understood. It is sufficient to have shewn how the whole, or nearly the whole notation of signals, may be limited to the expression of numbers.

Conclu remark

We have taken little notice of the signals made by private ships to the commander-in-chief. This is a very easy business, because there is little risk of confounding them with other signals. Nor have we spoken of signals from the flag ships whose ultimate interpretation is number, as when ships are directed to change their course so many points. Those also are easily contrived in any of the methods already described; also when a private ship wishes to inform the commander-in-chief that soundings are found at so many fathoms. In like manner, by numbering the points of the compass, the admiral can direct to chace to any one of them, or may be informed of strange ships being seen in any quarter, and what is their number. (B. B. B.)

Of late years, that is, within this century, a great improvement has taken place in the signal department of the Royal Navy. The following brief memorandum on the subject will give as general an idea on the subject as could be given without the introduction of coloured plates, and more copious explanations than are consistent with the plan of this work.

There are three volumes of signals in use in the navy; one is called "General Signals," the other "Night and Fog Signals," the other "Vocabulary Signals, for the use of her Majesty's fleet." The *General Signals* consist of a set of numerical references, from 1 to 999, and contain all the most general orders relating to action, sailing, manœuvring, and every other evolution in use, either at sea or at anchor. All these signals are made by means of a set of numeral flags, from 1 to 9, with the addition of zero; a set of divisional flags, to distinguish the different parts of a fleet; flags to affirm signals, to annul them, and to prepare measures; interrogative, answering, compass, geographical, and horary pendants. These, with the union jack, compose the flags in use when the general signal-book is employed. All these flags and pendants depend upon their form and colour for their distinction, and are hoisted at the most conspicuous places for being seen, but seldom more than three at a time. Besides these, distant signals are made with square and triangular flags and pendants, without any regard to their colour. They are numeral, and each has its signification attached to its number in the general signal-book. The distinctive mark of a distant signal is a ball, which is used as a preparative, a stop, or an answer.

In the general signal-book are detailed sets of instructions relative to the line of battle and order of sailing, each signal for a specific evolution being accompanied by a plate, explanatory of the measure contemplated.

The *Night Signals* are made with lanterns, rockets, blue lights, and guns. The numbers are not many, and care is taken to confine the signals to those objects of the most general application in practice, so as not to complicate or confuse; for it may be observed, that night signals are almost always very difficult both to make and to interpret.

The *Vocabulary Signals* are made by means of twenty-one symbols, named A, B, &c., to Y inclusive, (all the alphabet, omitting J, U, W, X, and Z, but retaining I and V). There are no numeral flags used in this code, and no more than three symbols are used at one time. These symbols are made with square and triangular flags, with the occasional use of pendants, to distinguish the alphabetical, the military, and the geographical, parts of the vocabulary from one another. The vocabulary signals, with their significations, are arranged in the following order: words and sentences, alphabet, military phrases and terms, geographical table, and list of the navy. The words and sentences are placed together, the words being arranged in alphabetical order, the sentences immediately following their most prominent words. This book is divided into three parts, but as the number of words required to be used would exceed the power of combination of three symbols, a distinctive pendant is used, to signify which portion of the book is to be referred to, and in this way the same combinations may be used several times over. The military table consists of such technical terms and phrases as are likely to occur on general service. The geographical table contains the names of places, while the body of the volume consists of words and sentences for universal use.

A code of signals for the use of the mercantile marine was published by Captain Marryat, of the Royal Navy, in 1817; it has, we believe, been in general use ever since, and has run through many editions.

The flags and pendants used in Captain Marryat's mercantile code of signals are fifteen, exclusive of the Union Jack, which, by order in Council, when used in the merchant service, is to have a white border all round, such border being one-fifth of the breadth of the Jack itself without the border.

There are ten numerical flags, which represent the figures in arithmetic, and are used throughout the whole of Captain Marryat's code of signals.

The Union Jack, as above distinguished from that used by men of war, which Jack, we may mention, viz. that with the white border, is now used in the navy only as a signal for a pilot.

The *first distinguishing pendant* is hoisted over the number, or at some other mast-head, when the number of a merchant ship is shown in part *second* of the code.

The *rendezvous flag* is hoisted over the number of the port in part *third*.

The sentences in part *fourth* are expressed by the *numerical flags* alone.

The *second distinguishing pendant* is hoisted over the numbers in the first division of the vocabulary.

The *telegraph flag* is hoisted at some other mast-head, when the numbers in the second division of the vocabulary are shown.

The *numerical pendant* is hoisted over a number, when merely the figures are intended to be shown.

The code of signals consists of six parts.

1st, A list of the names of men-of-war.

2d, A list of the names of merchant ships, copied from Lloyd's Register.

3d, A list of ports, headlands, rocks, reefs, shoals, &c.

4th, A selection of sentences.

5th, The first division of the vocabulary consists of compass signals, ships' stores, auxiliary verbs, and final terminations, to assist in spelling words.

6th, The second division of the vocabulary consists of the alphabet, and words most likely to be used in commercial and maritime affairs. The alphabet is introduced for the purpose of spelling words which are not found in the vocabulary.

It is certainly much to be wished, that every means should be used to induce merchant ships to adopt some code of signals; and we trust the gallant and accomplished author, who is so well known in other walks of literature, will not relax his exertions in this humble but very useful department of writing, but that he will study, by fresh editions, to keep his code always up to the wants of the day.

For the rest, we are of opinion that the subject of signals, both in the navy and in the merchant service, is one which requires more attention than it has yet met with. It would seem highly desirable, for instance, that a universal code, sanctioned by their respective governments, should be adopted amongst all the trading nations of the world. If the great maritime countries were to promulgate one grand code, it would speedily be adopted by all, and every ship would then be able to communicate with any other at sea, without the necessity of coming within hail, which is always troublesome, and often impossible. We all now use the same or similar charts; we all use the same methods of navigating our ships, by chronometers, lunars, and so forth; the manipulations of our seamanship are all alike; and why should not our means of communicating by signal be the same? (B. T.)

SIGNATURE, in *Printing*, is a letter put at the bottom of the first page at least, in each sheet, as a direction to the binder in folding, gathering, and collating them. The signatures consist of the capital letters of the alphabet, which change in every sheet; and if there be more sheets than letters in the alphabet, a figure is placed before the signature, as 2 A, 2 B, &c., which are repeated as often as necessary.

SIGNET, one of the king's seals, made use of in sealing his private letters, and all grants that pass by bill signed under his Majesty's hand. It is always in the custody of the Secretaries of State.

SILBERBERG, a town of the Prussian province of Silesia, in the circle of Frankenstein. It is an open town in a mining district in a narrow valley, surrounded with hills, on whose sides the streets are built, but the valley is 1350 feet above the level of the sea. The inhabitants are occupied in making cloth, and in exploring the mines. It is chiefly remarkable from fortified points on five hills, which overlook the town, and which are so connected with each other by works, as to form a most complete citadel, which is surrounded by a ditch seventy feet in depth, and which has within its barracks a natural cavern, sufficiently commodious to lodge securely a garrison of 5000 men. When, in the campaigns of 1806 and 1807, the whole of Prussia was subdued by the French, this place alone defended itself up to the conclusion of the peace of Tilsit.

SILESIA, a large tract of country, now divided between Austria and Prussia. In ancient times, it was inhabited by two rude tribes, called the Lygiern and the Quadi, who were subdued in the sixth century by the Sclavonians, by which it became subject to Poland. Their manners and language, as well as the Christian religion, were introduced by the conquerors. The first bishopric was founded in 966, at Schmogen, from whence it was subsequently removed to the city of Breslau.

In the year 1138, Boleslaus the III., regent of Poland, divided his states amongst his sons, and gave over to his eldest, Wladislaus, Silesia, with some other estates, and the greatest authority in the government. His brothers, however, conspired against him, and succeeded in expelling him from the country. The three brothers divided the land into portions to each, who thus became the founders of the three dukedoms of Silesia, belonging to the race of the Piastis. As the progeny of these dukes multiplied, their respective portions were subdivided, and thus gave rise to the great number of principalities of which the country consists. Besides these, there were other princes, especially in Upper Silesia, who were the descendants of Ottohar, king of Bohemia, who died in 1278, after establishing the dukes of Troppau, Jagendorf, and Raliber. When king John had succeeded to the throne of Bohemia, he was anxious to unite all the power in his own hands, under the pretext of restoring tranquillity to the country, which had been weakened by internal quarrels and hostility He was so far enabled to succeed, in 1327, in persuading the several princes to receive their lands as a feud from him, that two only of the whole number, the prince of Jauer, and the prince of Schweidnitz, declined compliance. In the next reign, when John was succeeded by his son, the emperor Charles IV. of Germany, these two principalities came into his possession by marriage; and Silesia was thus formed into one dukedom, in connexion with the kingdom of Bohemia, in the year 1355. At this time, the king of Poland relinquished all claim over Silesia, and renewed his renunciation by a subsequent treaty in 1372.

Under the Bohemian monarchy, the religious tenets of Huss, Luther, Calvin, and Swenkfeld, spread themselves over the whole country, and the adherents to them were, under some restrictions, permitted to exercise their own forms of worship.

In 1498, a kind of constitution was imparted to the country, which, whilst it gave consistency to it as a whole, lessened the power of the nobility, and increased that of the king, Wladislaus, who then filled the throne. Under him, as well as under his predecessors, since the Polish renunciation, the language and manners of the Poles were gradually exchanged for those of the Germans, and industry, and commerce, and with them, the arts and sciences, were gradually extended. They, however, received a severe check by the persecution of the protestants which was barbarously carried on by the successive princes of the house of Austria. The tremendous scourge of religious and civil war extended from Bohemia to Silesia.

The peace of Westphalia gave tranquillity to the country, for though that treaty was less productive of religious toleration in the dominions of Austria, than in the other divisions of Germany, yet a degree of it was allowed to the protestants, though with imperfect securities for its continuance. Under that house, however, to which it passed, in the early part of the sixteenth century, it was tolerably prosperous; manufactures were introduced, the land was well cultivated, and a degree of ease enjoyed by the inhabitants, to which their ancestors had been utter strangers.

After a century of increasing advancement, Silesia became the theatre of a tremendous war. The death of the emperor Charles VI., when the throne devolved on a female, revived a long dormant and certainly fictitious claim to the western part of Silesia, by Frederick of Prussia, commonly surnamed the great. No justification of his conduct could be made; indeed, in his memoirs his ambition is avowed. He and Bavaria made attacks on Austria on each side, which received some aid both from England and France. The contest was carried on with alternate success, and terminated by the cession of Silesia to Prussia. But the proud house of Austria had no intention of definitively relinquishing such a valuable province. A war commenced in 1756, when France, Saxony, Russia, and Sweden, formed an alliance against Prussia, which brought the king and his country to the brink of ruin, from which it was saved by the talents of the monarch, and some aid from England. After seven years of hostilities, the peace of Hubertsburg was concluded in 1763, by which Silesia was finally settled under the government of Frederick, and has remained subject to his successors to the present time.

Prussian Silesia, according to its present limits, (for a portion of Silesia is still retained by Austria,) extends in north latitude, from 49° 49′ to 52° 1′; and in east longitude, from 14° 20′ to 19° 17′, and comprehends 15,945 square miles. It is bounded on the north-west by Brandenburg, on the north-east by Posen, on the east by Poland, on the south-east by Cracow and Galicia, on the south by Moravia, and on the south-west by Bohemia.

It is divided into the governments, taking their names from the cities where the administrative boards are fixed, viz. Breslau, Oppeln, and Liegnitz. In these, are 186 cities and towns, and 5355 villages and hamlets. It is the most densely peopled of any portion of the Prussian dominions; and it appeared by the census of 1831, that the number of inhabitants was 2,464,413; the births exceeding the deaths at the rate of 100,000 annually. Nearly one half the inhabitants are Catholics, the others are chiefly Lutherans, with about four or five thousand Calvinists, some Menonites, Hussites, and Hernhutters, and about 17,000 Jews. Each of these sects have their establishments for education, and a University in Breslau, open to all, without distinction of religious opinions.

The river Oder runs from south to north, and divides the province into two parts of different character, as to the face of the country. On the east, it presents a flat sandy plain of rather a sterile appearance. On the eastern or German side, the land is rather mountainous, presenting much variety of scenery, with a good soil, though intermixed with extensive tracts of sandy land.

In the part of the province where it touches on Bohemia is a mountainous range, some of whose peaks are very lofty. The Reisenkoppe is 4950 feet, the Grasse-Rad 4070, and several others above 4000.

The state of agriculture is much improved, and the land produces a sufficiency, in some years a surplus, of corn, consisting chiefly of rye, with about one-fifth as much wheat. The cultivation of flax is, however, the employment to which the greatest skill is directed, and in some years 17,000,000 pounds have been raised, the greater part of which was used in the manufactures of the province. Tobacco, fruit, and culinary vegetables are abundant, and in the southern part, some moderate wine is made. The mines are considerable, and yield still a little gold and silver, and abundance of copper, lead, iron, calamine, arsenic, vitriol, sulphur, zinc, and cobalt. This country has been long celebrated for its manufactures of fine linen; their shirtings are exquisite, both for strength and fineness, and no other table linen has yet been made that can rival theirs. Of late years the cotton trade has been introduced, and is increasing. The chief commerce is in manufactures, and the exportation of pitch, tar, and turpentine. The imports of foreign goods reach them by the way of the Oder from Stettin, or by the Elbe from Hamburg.

Breslau, the capital, contains 90,000 inhabitants.

The portion of Silesia left to Austria by the peace of Hubertsburg, has been incorporated with Moravia, and makes a part of the government of Bran. It is formed into the following circles, viz. Teschen, Bielitz, Freudenthal, Freistadt, Friedeck, Deutchleuthen, Reschenwaldau, and Roy, each named from the chief city of the district.

It is bounded by Prussian Silesia, by Galicia, by Moravia, and Hungary. It comprises 27 cities, 4 towns, and 646 villages, with about 380,000 inhabitants. The country is mountainous; the Carpathian range is partly on the eastern side of it, and the Moravian on the west. Much of the land is very productive in corn, pasture, and wood. The people are mostly of Sclavonian origin, and speak the Polish language more than the German. In the city of Bielitz are manufacturers of woollen goods, and in all parts linen is made from flax grown near them, which is both good and abundant. There are good grammar schools in Teschen, Troppau, and Weisswassen.

SILICERNIUM, amongst the Romans, was a feast of a private nature, provided for the dead some time after the funeral. It consisted of beans, lettuces, bread, eggs, and other things. These were laid upon the tomb, as a repast for the dead.

SILIUS ITALICUS, CAIUS, a celebrated Roman poet, and author of an epic poem in seventeen books, which contains a history of the second Punic war, was born in the reign of Tiberius, and is supposed to have derived the name of *Italicus* from the place of his birth; but whether he was born at Italica in Spain, or at Corfinium in Italy, which, according to Strabo, had the name of *Italica* given it during the Social war, is a point which is unascertained. When he came to Rome, he applied himself to the bar; and, by a close imitation of Cicero, succeeded so well, that he became a celebrated advocate, and a most accomplished orator. His merit and character recommended him to the highest offices in the republic, even to the consulship, of which he was possessed when Nero died. He is said to have lent his assistance in accusing persons of high rank and fortune, whom that wicked emperor had devoted to destruction; but he retrieved his character afterwards by a long and uniform course of virtuous behaviour. Vespasian sent him as proconsul into Asia, where he behaved with clean hands and unblemished reputation. After having thus spent the best part of his life in the service of his country, he resolved to consecrate the remainder to retirement and the muses. He had several fine villas in the country; one at Tusculum celebrated for having been Cicero's, and a farm near Naples, said to have been Virgil's, at which was his tomb, which Silius often visited.

He has imitated Virgil, and though he falls infinitely short of him, yet he has discovered a great and universal genius; which would have enabled him to succeed in some degree in whatever he undertook. Having been for some time afflicted with an imposthume, which was deemed incurable, he grew weary of life, to which, in the language of Pliny, he put an end with determined courage. There have been many editions of Silius Italicus. A neat and correct one was published at Leipsic in 1696, in 8vo, with short and useful notes by Cellarius; but the best are those *cum notis integris Variorum et Arnoldi Drakenborch*. Traject. ad Rhenum, 1717, in 4to.; and *cum notis Ruperti*, 2 vols. 8vo. Gott. 1795.

SILK. Under the head SILK-WORM, will be found an account of the first introduction of the insect, and the commencement of the manufacture in the western empire. From thence it spread into Sicily and Italy; and during the time that the French occupied Milan (1521), artizans were conveyed by Francis I. to Lyons, and under his protection, the manufacture of silk made great progress.

When the Duke of Parma took and plundered the city of Antwerp in 1585, a great proportion of the merchants and artizans took refuge in England; these introduced the silk manufacture into this country, which was fostered and encouraged by the English government. Before this period the produce of the silk-worm had been little seen in England.

The climate of England has not been found favourable for the rearing of silk-worms; repeated attempts have been made from time to time to cultivate the breed, but they have always failed. It was supposed that the British settlements in America would prove more favourable for this purpose, and in several of them the experiment was made, but from some cause or other, these were not more successful than those of the mother country.

The manufacture of silk goods has been the object of solicitous care to the British government, and various enactments were made by successive monarchs, with the view of encouraging it in this country. It received a great stimulus in 1685, when the revocation of the edict of Nantes banished from France multitudes of her most industrious and skilful artificers, which greatly benefited the countries that sheltered the injured emigrants. About 70,000 took refuge in England and Ireland, and transplanted various branches of the useful arts to different districts of this country. A large body of silk weavers settled in Spittalfields, where descendants of many of them may still be found.

England was, however, entirely dependent on foreigners for organzine silk thread, till Mr. Lombe of Derby, in the year 1718, having gone to Italy in the disguise of a common workman, took drawings of the silk-throwing machinery in Piedmont, and, on his return, erected a large mill on the river Derwent at Derby. The extensive and powerful machinery of this mill contained 26,586 wheels, and 97,746 movements, which worked 73,726 yards of organzine silk thread, by every revolution of the water-wheel, which revolved three times in the minute, and thus produced 318,504,960 yards of organzine per day.

The silk manufacture continued to increase in England, though the workmen were constantly clamouring against the importation of foreign goods. With a view to encourage the manufacture, an act was passed (3 Geo. I. cap. 15) for granting bounties on the exportation of silk fabrics; this was, however, no more than a drawback of part of the duties paid on the importation of the raw silk. In 1741, permission was given to the Russia Company to import the raw silk of Persia at the same rate of duty as from the Levant; and, in 1749, the same reduction was made on the duties on raw silk imported by the East India Company from China. In 1764, the fashion of the times running in favour of French silks, and the wages of the English weavers being low, and work scarce, the operatives assembled in great multitudes, and in a tumultuous manner presented petitions to Parliament praying for the total prohibition of foreign wrought silks. By the representation which the operatives made of their sufferings, Parliament was induced to reduce the duties on raw and thrown silk, and entirely to prohibit the importation of certain articles of manufactured silk goods. The operative weavers did not, however, derive those benefits from the prohibitions against importation, which they expected, and they had frequently recourse to combinations to force their masters to raise their wages. These disputes between the masters and workmen having led to violence and riot, an act was passed in 1773, and confirmed by two subsequent acts, empowering the aldermen of London, and the magistrates of Middlesex to fix the wages of the Spittalfields weavers. But it is unnecessary to recapitulate the applications of the operatives and manufacturers for protection against foreign competition, and the attempts of the legislature to encourage the manufacture by restrictive and prohibitory enactments from 1773 to 1824; the silk trade in England, from the futile attempts to bolster it up, was kept in an artificial and languishing state. The manufacturer, depending upon the protection of Parliamentary restrictions on foreign competion, rather than on his own skill and exertions, was not anxious to discover and introduce improvements into the manufacture. Since the change of system, the imports of the raw material, and the exports of the manufactured article have rapidly increased; at present the value of the manufacture is supposed to exceed L.10,000,000 annually, and considerable quantities of manufactured silk are exported to France itself.

The following Table shows the Quantities of Raw and Manufactured Silk, Imported, Exported, and retained for Consumption, during the years 1836 *and* 1837, *with the Rates of Duty.*

DESCRIPTION.	Quantities Imported.		Quantities Exported.		Quantities retained for consumption.		Rates of Duty.
	1836.	1837.	1836.	1837.	1836.	1837.	1836-7.
Silk, Raw, viz.							
From India, ...lbs.	1,420,961	1,261,997	...	...	...	...	... ...
Cape of Good Hope, „	...	27,011	...	...	...	...	... ...
China, ... „	1,277,027	1,754,252	...	...	...	...	... ...
Turkey, Syria, and Egypt, ... „	677,839	371,561	...	...	...	...	... ...
Italy, ... „	180,749	111,003	...	...	..	...	... ...
France, ... „	816,581	556,882	...	...	...	...	... ...
Other countries, ... „	79,924	63,835	...	...	...	...	... ...
Total of Raw Silk, ... „	4,453,081	4,146,481	...	...	...	...	1d. ℔ lb.
Silk, Waste, Knubs, and Husks, viz.							
From India, ...lbs.	32,490	41,349	...	...	...	...	... ...
China, ... „	224	5,960	...	...	...	...	... ...
Italy, ... „	286,544	180,288	...	...	...	...	... ...
France, ... „	1,202,030	692,851	...	...	...	...	... ...
Other countries., ... „	87,001	22,833	...	...	...	...	... ...
Total of Waste, Knubs, and Husks, ... „	1,608,289	943,281	...	...	...	..	1s. ℔ cwt.
Silk, Thrown, viz.							
From Italy, ...lbs.	12,040	382	Foreign	Thrown.	...	...	5s. 2d. on organzine and crape, and 3s. on tram and singles dyed; 3s. 6d. on organzine and crape; 2s. 6d. on tram; and 1s. 6d. on singles, not dyed.
France, ... „	345,316	171,531	24,061	29,974	...	...	
			British	Thrown.	...	...	
Other countries, ... „	39,304	59,290	Nil.	Nil.	...	...	
Total of Thrown Silk, „	396,660	231,203	24,061	29,974	...	...	
Silk Manufactured Goods, viz.							
Manufactures of Europe, Silk or Satin, and Silk or Satin Ribbons, lbs.	137,052	121,046	7,595	6,789	127,749	114,234	Per lb. Plain, 11s.; figured, 15s.
Gauze, and Gauze Ribbons, ... „	15,150	23,292	735	606	14,470	22,864	Plain, 17s.; figured, 27s. 6d.
„ Tissue Foulards, „	15,399	8,165	27	71	15,397	8,165	L.30 ℔ cent. *ad valorem.*
Crape, ... „	3,251	4,862	121	91	3,130	4,608	Crape, 16s.; lisse or China, 18s.
Velvet, and Velvet Ribbons, ... „	16,506	18,555	992	1,581	15,117	16,967	Plain, 22s.; figured, 27s. 6d.
Ribbons embossed or figured with velvet, „	552	1,878	12	66	540	1,563	17s.
Fancy Silk, Net or Tricot, ... „	3,450	4,269	61	23	3,390	4,245	24s.
Silk mixed with metal, „	322	382	30	175	285	214	27s.
Total, entered by weight, „	191,682	182,359	9,573	9,402	180,078	172,860	
Plain Silk, Lace, or Net, called Tulle, ... sq. yds.	12,028	11,790	2,000	710	10,028	10,555	1s. 4d. per square yard.
Millinery,—							
Turbans or Caps, number.	433	564	108	61	336	357	15s. each, or L.40 ℔ cent. *ad val.*
Hats or Bonnets, „	762	641	254	251	478	458	25s. each, or L.40 ℔ cent. *ad val.*
Dresses, ... „	203	323	57	189	143	113	50s. each, or L.40 ℔ cent. *ad val.*
Entered at value, ...L.	6	21	...	...	6	21	L.40 ℔ cent. *ad valorem.*
Manufactures of Silk, or of Silk and other materials, not particularly enumerated, ... „	93,512	91,302	7,082	6,459	86,430	84,483	L.30 ℔ cent. *ad valorem.*
Manufactures of India,							
Bandanoes, Romals, and Silk Handkerchiefs, pieces.	351,066	561,398	220,785	322,515	130,114	134,249	L.20 ℔ cent. *ad valorem.*
Silks and Crapes in pieces,	3,943	18,383	4,615	8,300	1,314	1,354	
Crape shawls, scarfs, and handkerchiefs, num.	8,119	12,214	4,587	10,325	3,648	754	

Nothing more fully demonstrates the folly of attempting to encourage manufactures by prohibiting importation than the history of the silk trade. The greatest importation of raw and thrown silk which took place in any one year, previously to the repeal of the prohibitory system, was in 1833, when the quantity imported was 2,432,286 lbs.; while, by the foregoing table, it appears that 5,320,965 lbs. were imported in 1837, at the same time that the official value of our silk manufactures exported during the same period, was L.140,520 during 1823, and L.503,673 during 1837; of which, the proportion exported to France was L.43,144.

Those who are best qualified to form an opinion, consider the duty of 30 per cent. on the importation of silk goods still too high, and that the duty should be reduced to 15 or 10 per cent.

In no country has the silk manufacture made more rapid advances of late years than in Prussia. In 1831, the number of looms was 8,956; in 1834, they had increased to 12,044; and in 1837, to 14,111.

The following table shows the excess of exports from Prussia over the amount of the imports:—

	Silk Goods.			Mixed Silk Goods.		
	Imports.	Exports.	Excess of Exports.	Imports.	Exports.	Excess of Exports.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1834	254,985	559,079	304,094	106,950	320,266	213,316
1835	201,981	762,004	560,023	106,596	371,971	265,375
1836	225,581	847,826	622.245	121,236	404,435	283,199

The duty on the importation of silk goods into Prussia, is 110 dollars per centner, or 2s. 9d. per lb., which is almost five per cent. on the value of the goods. The import duty on mixed silk goods is 55 dollars per centner, which is equal to 1s. 4½d. per lb., or almost nine per cent. *ad valorem.*

Silk *Manufacture.* The processes of silk manufacture fall under two great divisions. The one, comprehending all those operations undergone by the silk in its preparation for textile or other purposes; and the other, those by which the prepared silk is formed into the various beautiful creations of the loom. The operations comprehended in the first division being for the most part peculiar to this manufacture, are those which will here occupy our attention; while those of the second division, being common to the various textile substances, will be found described under the general head Weaving.

In other textile substances, the manufacturer operates upon bundles of short fibres, which, by drawing out and twisting together, he forms into continuous threads; but in the case of silk, a very different treatment is for the most part required. Here the silk-worm is the spinner, and art is called in, not to join short filaments, but so to strengthen the delicate threads of the worm by combination, as to fit them to endure the manipulations to which they are afterwards subjected. We have said for the most part, for this reason, that, from the manner in which the worm labours, there arises a necessity for two modes of operating, one of the nature already described, the other analogous to that of the cotton-spinner; and that the reader may be prepared to understand the reason for this, and many other peculiarities arising from the same cause, we shall here present him with a sketch of the manner in which the worm produces the material to be operated upon; and this sketch needs to be but brief, as in the article Silk-Worm, immediately sequent, the fullest information will be found. When the silk-worm has arrived at that stage of its existence at which it begins to spin, it ceases to feed, grows restless, and moves about, seeking a place wherein to commence its labours. When it has found a corner or hollow fit for its purpose, it attaches long threads from side to side, to form supports for its work; these it does not dispose in any regular manner, but crosses and recrosses them in such a way, as to make its work as strong as the situation will admit of. In plying its labours, the little creature by degrees narrows their sphere, and when it has enclosed a space of about the size of a pigeon's egg, its work assumes a more regular character, and shortly presents the appearance of a loose silken ball of an oval shape, with the worm labouring inside of it. In a little while, the increasing compactness of the ball renders the labours of the worm no longer evident to the eye, and that it continues to work can only be known by the noise within. When all sound has ceased, the formation of silk has also ceased. Although from the compactness of the ball, the worm labours unseen, we can yet tell by after dissection, and by the unwinding of the thread, that it does not lay its thread regularly round the inside of the ball, but to and fro from one spot to another, for many times, gradually shifting its position, until it has gone over the whole surface, and so gradually, that a great many yards of thread may be unwound without once turning the ball. The substance of which the thread of the silk-worm is composed, is secreted by the animal in the form of a fine yellow transparent gum, and exuded by two minute orifices beneath its jaw; hence the thread is a twin one, formed of two threads proceeding from these orifices, cemented together by a gummy substance, similar to that of which they are formed; and when the worm has finished its labour of spinning, it smears over the whole interior surface of its work with the same gum, doubtless for the purpose of protecting it in its chrysalis state from rain. If we examine the finished work of the worm, we shall find it to consist first of those filaments used as supports, and next of a ball of a loose texture and irregular construction, serving as an envelope for another ball, compact in its nature, and regular in its formation, within which the worm lies enshrouded. This compact ball is called a *cocoon*, and its soft envelope *floss silk.* The thread of the cocoon, from the regularity of its deposition, can be unwound to the end, and the operations to which it is subjected are those of doubling, twisting, twining, and their accessories, classed under the name of silk throwing. The floss silk, with the additions afterwards to be noticed, is not unwound, but, under the name of waste, has its filaments hackled, combed, and reduced to short lengths, and then carded and spun in a manner analogous to those of cotton.

When the spinning of the cocoons is accomplished, a selection of those that are to be kept for breeding is made, and the remainder are assorted according to their qualities. These are generally reckoned nine, and are as follows:

1st, Good cocoons; these are strong, firm, and nearly equally round at both ends, not very large, but free from spots.

2d, Calcined cocoons, in which the worm has died, and been reduced to powder by a disease which sometimes attacks them after having completed their work.

3d, Cocalons, larger and less compact than the good cocoons.

4th, Choquettes, cocoons in which the worm had died before it had finished spinning; the silk is fine, but apt to furze in winding.

5th, Dupion, or double cocoons, containing two or more larvæ; these are difficult to unwind, and are often kept for seed.

6th, Soufflon, cocoons of so loose and soft a texture, as to be almost transparent; these cannot be unwound.

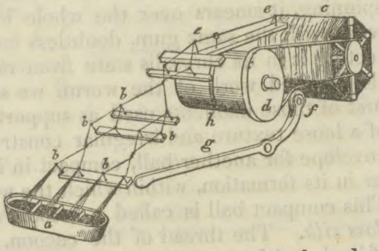
7th, Pointed cocoons. In these one end rises in a point, which breaks off after a little silk has been unwound, and so spoils the thread.

8th, Perforated cocoons, from which the moth has made its way out.

9th, Bad choquettes, in which the silk is spotted, rotten, and blackish in colour.

The first operation to be performed, preparatory to the unwinding of the silk from the cocoon, is to destroy the vitality of the contained worm. The means used for this is heat, either natural or artificial; sometimes simple exposure to the solar rays will effect this object; but in climates where these have not power, some artificial heat must be employed, such as the heat of steam or of an oven, but more generally that of the latter. In this case, the heat should not be greater than what is usual in the oven after the bread has been withdrawn. Long shallow baskets are taken and filled nearly to their tops with cocoons, and are covered over, first with paper, and then with a cloth. In these baskets, the cocoons are exposed to the heat of the oven for nearly an hour, and on being withdrawn, several cocoons are chosen from the part of the basket least exposed to the heat, and the chrysalides in them stripped and pricked with a needle. If upon being pricked, they give no sign of animation, it may be fairly presumed that the destruction of the creatures has been accomplished. Before the silk of the cocoons can be reeled off, it is necessary to separate them from the floss in which they are enveloped; this is effected by opening the floss covering at one end, and protruding the cocoon. It is of the greatest importance in the reeling process, that all the cocoons reeled together be of one class.

Fig. 1.



The apparatus for reeling is sketched in fig. 1, and to avoid confusion, the working parts only are shewn: *a a* is a bath or vessel of water, which, when of the best construction, is heated by steam. Into this the cocoons are put, that the gum which retains the thread in its place may be so much softened as to permit the thread to be unwound; the bath is usually divided by three partitions into four divisions, each of which may contain about five cocoons; *b b b* are wires with eyelets at their ends, through which the filaments from the cocoons are put. In their upward progress towards the reel, the groups of filaments are made to cross and recross each other, before their final combination at the last eyelet, and by the friction thus produced, they are freed from adhering impurities; *c* is the reel driven by a belt from the pulley *d*, which is itself driven by the prime mover, whatever that may be; *f* is a tumbler, whose end carries a pulley, which presses on the belt that drives the reel; by lifting up the long end of the tumbler, the belt is slackened, and the reel stops. The filaments, when combined at the upper eyelet, pass along the guide *e e*, and through eyelets at its ends; this guide has a pin projecting from its under side, working in a spiral groove cut round the barrel *h*; by this it receives a reciprocating motion, and so spreads the filaments equally over the reel.

The filaments, in their passage from the bath to the reel, must necessarily traverse a considerable space, to allow their softened gum to be again hardened by the air, that they may not afterwards adhere together.

In the place where the reeling of silk is performed, many of these machines are arranged along the building, and driven by the moving power through a shaft extending the whole length, carrying on it pullies at the proper intervals. In working the apparatus, the reeler, who is generally a woman, sits at the bath, and having taken a number of cocoons, immerses them in the water. When their gum is sufficiently softened to permit the thread to come off, the reeler takes a whisk formed of fine twigs bound together, and cut off evenly at the ends at about six inches long, and with it she gently presses and stirs the cocoons, and entangles their loose threads on its points; she then raises her whisk with the threads attached to it, disengages them from it, and draws their ends through her fingers, to remove any adhering floss or impurity; this cleaning process is called *battue*. Having thus freed the ends of such a number of the filaments as she means to use, she passes them through the various eyelets in the manner previously mentioned, and attaches them to the reel; when this is accomplished, the reel is put in motion by dropping the end of the tumbler, and the filaments are drawn from the cocoons. It is the province of the reeler so to regulate the motion of the reel, and the heat of the water, that the silk may come off the cocoons regularly, not in lumps, which shows that the water is too hot; nor in such a manner as that the cocoon shall be tossed out of the bath, which shows that the silk is yielded with difficulty, from the water being too cold sufficiently to soften the gum.

From the threads of the cocoons being finer near their termination than at their commencement, it becomes necessary for the reeler to add other cocoons before the first set is quite exhausted; and it is her care to do so in such a manner, as that the requisite thickness of the compound thread may be kept up throughout. It is generally considered that the filaments of three fresh cocoons added to two half-wound ones, make a thread equal to that from four fresh cocoons.

The cocoons are not entirely wound off, but the husk, or *bairré*, in which the worm lies, is left, and used along with the floss silk, under the name of waste.

Every eleven or twelve pounds of cocoons generally yield one pound of reeled silk; and as it takes from 240 to 250 cocoons to weigh one pound, the number of cocoons necessary to produce one pound of silk, may be reckoned to be 2817½; some cocoons may yield about 625 yards of silk, but the average is stated to be 300 yards, consequently the pound of silk filament, as produced by the worm, would, if stretched out, reach the amazing length of 480 miles.

When a sufficient quantity of silk is reeled off, it is doubled into a hank for use or sale; and it is in this state that it generally comes to be operated upon by our manufacturers,—the hanks by the silk throwster, the waste by the silk spinner.

It is of the utmost importance in the succeeding manufacture, that this reeling process should be well performed. Sometimes from the temperature of the water used to soften the gum being too high during the reeling, the parts of the hank of silk that lie on the spokes of the reel become very hard, and occasion the breaking of the thread in the after processes. Sometimes, too, when in the reeling process the threads happen to break, the ends are again only laid upon one another, and not connected by tying; the threads consequently come off the hanks in short lengths, and much trouble and loss of time is experienced in searching for the other end; and sometimes the reelers, either from inattention or design, reel off the whole of the thread of the cocoons, by which an exceedingly foul silk is produced. Not unfrequently, also, coarse and fine silks are reeled together in the same hank; and, what is of common occurrence, the hanks when reeled are twisted up so tight, that the untwisting of them greatly damages the silk. But the greatest injury to the manufacturer arises from dishonesty on the part of those who produce the reeled silk; and this remark applies especially to the coarser descriptions of the *Brutia* silk. To get rid of their waste the producers of this silk roll up the refuse of the cocoon into what are here technically called *dollies*, and insert these into the hanks in such a manner, that they cannot be discerned by the purchaser; they also have a method of mixing their waste with the good silk while it is being reeled, and as it cannot again be separated from it without great injury, this mode of vitiating the silk is more

Manu- ure.

objectionable than the other. But dishonest practices are unfortunately not confined to the description of silk above mentioned; it is too common in all hanks to find some coarse inferior quality of silk artfully prepared with a covering of a much finer kind, to enhance its value.

The loss of capital, which careless reeling, and the base practices we have alluded to, entail on the manufacturer, is immense; for if an establishment be formed, with machinery and workers sufficient to throw a given quantity of good silk; take, for example, the Italian silk, called *Fossombrone*, which, of all the raw silks, is the easiest manufactured, and if, in place of some of the *Fossombrone*, the machines and workers come to be employed on some silks vitiated as we have described, or reeled in a careless manner, then, from the foulness and unevenness of the thread, the number of workers will, in all probability, not be sufficient to attend to above one-third of the machines, one winder being able in a given time to wind five times as much of the *Fossombrone* as of some of the *Bengalese* silks.

From what we have said it may be inferred, that it is a matter of great difficulty for the manufacturer to determine the number of machines and workers in the various processes; and that, from the ever varying nature of the silk, he will seldom have the whole of his machinery employed.

If the preparation of the raw silk, as reeled silk is termed, were conducted by persons conversant with the processes of the silk filature, who would adapt their mode of working to suit the various purposes to which the article prepared by them was to be applied; or, if the whole of the operations were under the conduct of an instructed agent of the manufacturers, the evils on which we have animadverted would be removed, and a better and a cheaper article would be furnished to the consumer.

The operations which succeed the reeling are those of silk throwing, and are as follows:

1st, *Winding* the silk from the hanks upon bobbins, to fit it for the further processes.

2d, *Cleaning*, consisting in the silk being unwound from the bobbins of the winding machine, and wound upon another set of bobbins; and, in its passage between, made to pass through an opening between two metal plates, by which any inequality, caused by knots or adhering substances, is removed.

3d, *Spinning*, consisting in twisting the cleaned thread.

4th, *Doubling*, consisting in laying together on one bobbin the threads of several bobbins, so that they may be afterwards combined by being twisted together.

5th, *Throwing*, the name by which the operation of twisting the doubled silk is known, and also the name by which the whole class of operations is distinguished.

It has been conjectured, that the name *throwing* is derived from the swinging and tossing of the threads and cocoons while reeling, but we need not travel out of the way for its derivation, as the operation of twisting is in many other arts called throwing. The ropemaker *throws* twist into his ropes; and the little instrument used in the farmyard for twisting straw ropes, is called a *throw-crook.*

6th, *Reeling*, consisting in forming into hanks suited for undergoing the processes of scouring, dyeing, and bleaching the silk which has undergone some or all of the previous operations.

7th, After the scouring, bleaching, or dyeing processes have been performed on the hanks, these have again to be wound on bobbins, for the use of the warper or weaver.

It is not to be understood, that silk in every case undergoes all the operations we have mentioned, but that, when it does so, these succeed each other in the order described.

It is sometimes merely wound and cleaned, and is in this state under the name of dumb *singles*, used for Bandana handkerchiefs, and, when bleached, for gauze, and similar fabrics.

Silk Manufacture.

It may be wound, cleaned, and thrown, and is then called *thrown singles,* and used for ribbons and common silks.

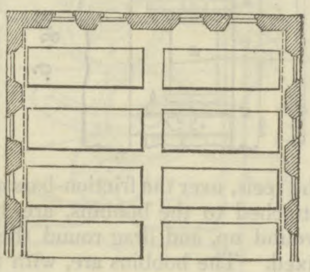
If wound, cleaned, doubled, and thrown, which twists it into one direction, it is called *tram*, and is used for the woof or shute of Gros de Naples, velvets, and flowered silks.

If wound, cleaned, spun, doubled, and then thrown, so as to be of the nature of twine, or the strand of a rope, it is called *organzine*, which, from its strength, is used for warp.

Silk, in any of these states, before being subjected to the operation of scouring, is termed *hard*, but after it is by scouring deprived of its stiffening-gum, it is called *soft.*

The operations of the throwster are generally carried on in a building which admits of an apartment being allotted to each description of machines, and these apartments are generally in stories. All the machines used in the processes are each made up of a repetition of the same parts, each part being a distinct and separate apparatus, capable of performing its work independent of its fellows; and these are arranged in juxtaposition in the *machine*, in order that the moving power may be conveniently applied to a long series of them. The length of the machines is regulated by the extent of the building, and the manner of their arrangement. A manner of arranging them is here sketched (fig. 2.) The apartment is supposed to be about thirty-eight feet wide, and the machines are placed athwart the room, so as to afford a passage four feet in width along the centre, and at such a distance lengthways, as to give room for the workers to attend to their charge. Two shafts traverse each apartment in the direction of the dotted lines, and carry on them pullies, or toothed wheels, opposite to each machine; a belt from each pulley is carried over a corresponding pulley on the end of the main shaft of each machine, or the toothed wheels are connected by proper gearing with the shafts of the machines, and so motion is given to the whole.

Fig. 2.

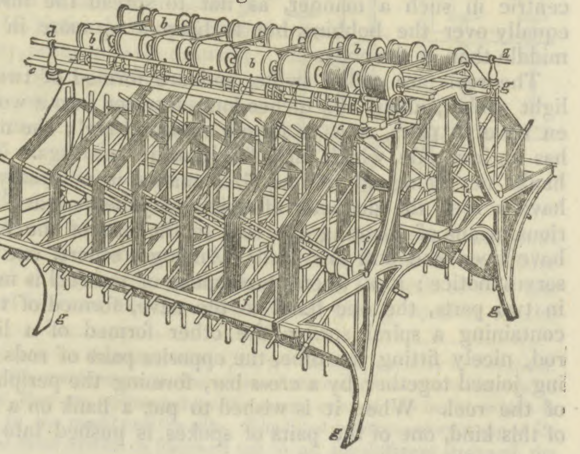


The rooms are generally heated by steam, and the temperature of the apartments, when above the minimum of 50°, is regulated more by a regard to the health of the workers, than from any necessity for a particular temperature in the operations; but these cannot be performed with advantage when the temperature is allowed to fall below 50°.

Winding.

The first machine or apparatus used is the winding-machine, or that by which the reeled hanks are wound on bobbins, to prepare them for the subsequent processes. A perspective sketch of this machine is shewn in fig. 3. Along

Fig. 3.



each side of the machine, at *a a*, directly under the line of bobbins *b b*, run two shafts, called frame shafts, or frame friction-shafts; on these shafts at each bobbin are fixed two friction pullies, of about 4½ inches diameter; and on the axis of each bobbin are fixed two corresponding pullies, about 1⅛ inch diameter. The friction-pullies of the bobbins rest upon those of the shaft, and receive motion from them. Opposite to each bobbin is a wire, with an eyelet at its end, fixed to a bar of wood *c c*, called the traverse bar. This bar, with the eyelets attached, has an alternating motion, right and left, through a space equal to the length of that part of a bobbin on which the silk is to be wound. In front of these eyelets are fixed the guide-rods, or friction rods, *d d d d*, over which the threads glide in their passage from the reel to the bobbins, and which are formed of polished iron, and in front of these the reels *e e e e*, are placed on their bearers *f f*. At every seventh bobbin or so is placed a main frame, like *g g*, and between these stretch bars of wood, for the support of the bobbin and reel bearers. Motion is given to the bobbins, we have said, by the lying shafts bearing friction-pullies, and the threads being passed from the reels, over the friction-bars *d d*, through the eyelets, and attached to the bobbins, are, by the motion of the latter, wound up, and drag round the reel on which the hank is fixed. The bobbins are, with their friction-pullies, represented in figs. 4, 5, and 6. Fig. 4, a section; fig. 5, a front view, and fig. 6, a plan: *a* is the lying-shaft, with one of its friction-pullies *b b*, and on this rests the friction-pulley *c*, of one of the bobbins *d;* the axis of the bobbin is confined laterally by working in the groove *e* of the bearer, but has perfect freedom of motion up and down, so that its friction-pulley may remain in contact with that of the shaft. If, during the process, a thread happens to break, the bobbin is lifted out of its working-groove and placed in the higher groove *f*, by which its friction-pulley is kept from touching the friction-pulley of the shaft, and it consequently remains at rest; but when, after the damage has been repaired, it is lifted into its former position, its motion is immediately resumed. In front of the bobbin is seen the traverse bar *g*, carrying the wire *h*, with its eyelet for the thread; this traverse bar is moved by an eccentric in such a manner, as not to spread the thread equally over the bobbins, but to heap it up more in the middle than at the ends.

Fig. 4.

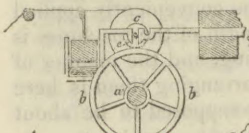
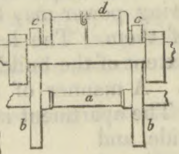


Fig. 5.



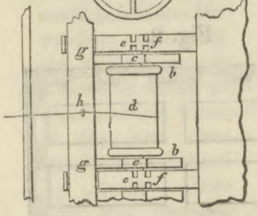


Fig. 6.

The reels are called swifts, and are formed of twelve light spokes, about 16½ inches long, inserted into a wooden nave in pairs, so as to form a six-sided reel; the nave has an iron axle, which turns freely on its bearings. The hanks not being all of one size, makes it necessary to have a reel, the diameter of which may be varied. Various means of adapting the reel to the size of the hank have been and still are used. Amongst others, one deserves notice; it is, where each spoke of the reel is made in two parts, the one fixed to the nave, formed of tube containing a spiral spring, the other formed of a light rod, nicely fitting the tube, the opposite pairs of rods being joined together by a cross bar, forming the periphery of the reel. When it is wished to put a hank on a reel of this kind, one of the pairs of spokes is pushed into the tubes, and the hank slipped on; the spiral springs now exert their force, and throw out the pressed-in spokes with such a force, as to keep the reel in a proper state of tension. But the method generally adopted, if not so elegant, is more simple. The spokes in this case are formed of lance-wood, and the outer extremity of each pair are rather farther asunder than the ends which are inserted into the nave, and are connected together by a band of small cord passed several times round them; on these bands the hank or skein of silk rests, and, by slipping the bands along the spokes nearer to or further from the centre, the diameter of the reel can be adapted to the size of the hank; and when the hank is stretched the bands can be moved in any way, so as to balance the hank, which, as will be afterwards seen, is a matter of considerable importance. Each pair of spokes, it has been mentioned, slightly diverge as they proceed from the nave; and, as they are again slightly drawn towards each other by the bands, the tendency to return to their natural position effectually retains the band in any place to which it may be slipped. It has been said, that the reels turn freely on their supports, but it is necessary to create such a friction as will prevent them giving off the silk faster than it can be taken up by the bobbins; this is sometimes done by a spring being made to press upon the nave of the reel, but more commonly by hanging on its centre a wooden ring, to which weights may be hung, so as to create such a degree of friction on the reel, and, consequently, of tension upon the thread, between the reel and the bobbin, as may be desired. The subjoined sketch (figs. 7 and 8.) shews the reel as it has been described: *a* is the nave, *b b* the lance-wood spokes, *c c* the bands of cords forming the periphery of the reel, *d* the friction-ring, with the weight hanging on it.

Fig. 7.

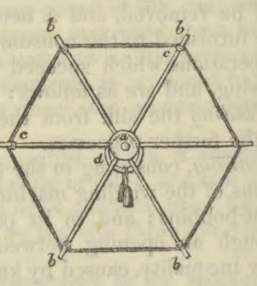
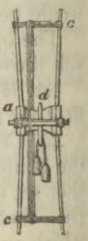


Fig. 8.



Referring again to fig. 3, it will be seen, that in front of the swifts are bars of wood, extending along both sides of the machine; their use is to support the bars which carry the swifts, and to prevent the persons of those who work the machines from coming in contact with the reels; from this last use they are termed knee-rails.

Previous to the hanks being put upon the swifts, they are washed in a solution of soap and water, which cleans the silk without depriving it of its gum. In putting the hanks on the reel care is taken to balance them, as, were one side heavier than another, it would be apt to fall suddenly, after having passed the highest point, in turning, and thereby injure the thread.

The winding-machines, under the general superintendence of a man called a steward, are tended by girls, who are termed *denters* and *winders;*' the denters put the hanks on the reel, and the winders, or piecers as they are also called, tie the ends of the threads and exchange the bobbins. When the bobbins are filled with thread they are conveyed from the winding-machine room to the warehouse, to be assorted or separated into finer or coarser qualities, which are kept apart throughout the remaining processes. To carry the bobbins, a board, called a *doffing-board*, is made use of; this consists of a piece of deal, about a foot wide, and rather more than two feet long, having a number of wires corresponding to the number of bobbins in one side of a frame, and about four inches long, inserted into its surface; on these wires the bobbins are put. When the separation of the qualities has been made, the bobbins are carried to another machine-room, where the thread undergoes the operation of cleaning.[1]

Cl ing.

The *cleaning*, *drawing*, or *picking-machine*, as it is variously called, is represented in fig. 9. In this, as in the last machine, motion is communicated to the bobbins by a friction shaft. The bobbins, *a a*, from the winding-frame are fixed on plain spindles, and placed in a horizontal position between their supports. The threads are carried from the bobbins over the iron or glass rod, *b b*, and each thread is passed through an adjustable opening, between the two iron blades of an instrument called the *cleaner*, *c c*, which is fixed to a bar of wood running along the machine, immediately behind the friction-rods. The *cleaner* is here represented on a larger scale, (figs. 10, 11); *a* is the bar of wood to which the instrument is fastened; *b*, *b*, are the blades, which are held together at the bottom by the screw *c*; *d* is the opening through which the thread is made to pass, the width of this opening being adjusted by means of a screw *e*, the key of which is kept by the steward of the room. The tops of the blades are curved outwards, so as readily to guide the thread into the slit. The threads, after having been passed through the opening of the cleaner, are put through the eyelet *d*, of the traverse bar, which is, in every respect, like that of the former machine, and then attached to the bobbins *e e*. When the machine is put in motion, the bobbins *e e* drag the thread from the bobbins through the cleaner; and, as the cleaner is adjusted to a certain size, all impurities and irregularities are removed, and the thread thus rendered equal.

Fig. 9.

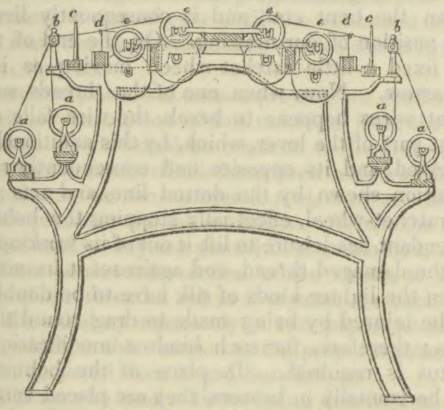


Fig. 10.

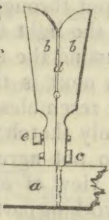
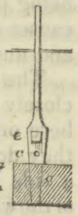


Fig. 11.



Spin g.

The process which succeeds that of cleaning is called spinning, although, as we have already observed, it is only twisting. The spinning-machine is represented in fig. 12. This, like the two former machines, consists of a series of frames placed at wide intervals, and connected by bars of wood, which serve as supports for the different parts of the machinery. The spinning machine contains sometimes two but generally three tiers of working apparatus in height. The bobbins on which the twisted silk is to be wound, are seen in the figure at *a a a*, placed horizontally along the machine; in this case they are not driven by friction-rollers, but by toothed wheels, fixed on the extremity of the axis of each bobbin, and corresponding ones on the shafts *b*, *b*, *b*. The bobbins are, as before, suspended by their axis in little grooves; each bobbin-bearer contains two such grooves, one higher than the other, so that, on the bobbin being lifted from the lower to the higher groove, its toothed wheel is thrown out of gear with the wheel of the shaft *b*, *b*, and it remains at rest. Under each bobbin is seen the twisting-apparatus. This consists of a bobbin *c*, fixed on an upright spindle *d*, to which motion is communicated by a belt from the drum *f*, fixed on a horizontal shaft *g*, passing over a pulley on the bobbin spindle. The silk threads from these vertical bobbins are wound three or four times round a bent wire *h*, fixed to a bar, extending along the machine, passed through an eye in the end of each of these wires, carried through the eyes of the traverse-guides, and attached to the horizontal bobbins. On motion being given to the machinery, the vertical bobbins are made to revolve with a greater or less velocity, and the horizontal ones with a velocity so proportioned to the others, that they may only draw away the thread as it is twisted in the due degree. In figs. 13 and 14, we have represented, on a larger scale, a section and front view of these working parts: *a*, *a* is the bobbin from the cleaning-machine, *b* the fixed wire-guide round which the thread is carried, *c* the traverse-guide for spreading the thread over the bobbin, *d* the bobbin for receiving the twisted thread.

Fig. 12.

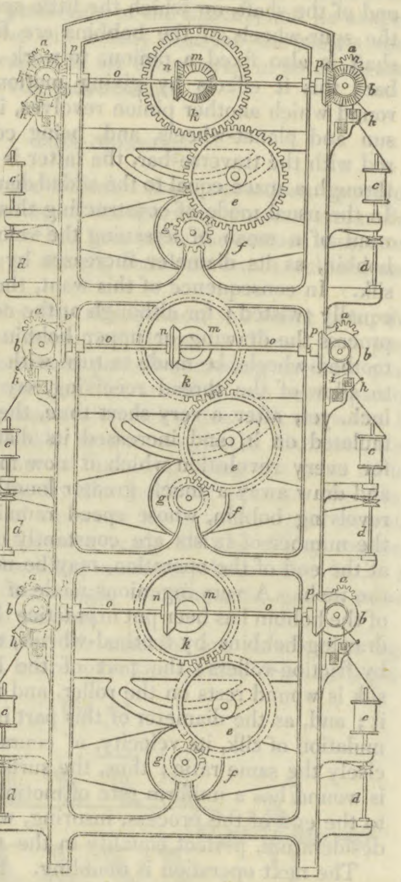


Fig. 13.

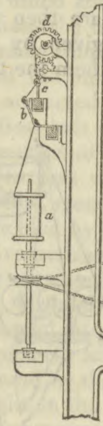
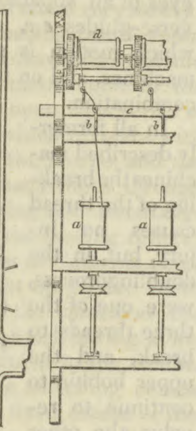


Fig. 14.



Motion is communicated to the different parts thus: On one end of the drum-shaft *g*, (fig. 12,) is fixed a fast and loose pulley, not seen in the drawing, driven by a belt from the main shaft which traverses the apartment; belts from the drum on the drum-shaft pass over the pullies of the vertical spindles *d*, and so give motion to the bobbins *c*; on the hither end of the drum-shaft is fixed the pinion *g*, which, through the intermediate wheel *e*, drives the spur-wheel *k*; on the axis of this last wheel is fixed the bevel-wheel *m*, giving motion to the bevel-wheel *n*, and thereby to the shaft *o*, which crosses the end of the machine; each end of this shaft carries a bevel-wheel *p*, which drives a bevel-wheel *h*, fixed on the end of the shaft, on which the little spur-wheels that drive the spur-wheels of the bobbins are fixed. On this last shaft is also fixed a pinion, to work the traverse guide-bar; this it effects by giving motion to a small wheel, round which another pinion revolves, in the manner of the sun and planet-wheels, and, being connected by a short rod with the traverse-bar, the latter is consequently moved through a space equal to the added diameters of the wheels. In the usual mode of constructing this machine, there is a want of a mean of lessening the velocity of the drawing-bobbin, as its diameter increases by the accumulation of silk. In consequence of this want, the thread is very unequally twisted; for although at the commencement of the process the drawing or upper bobbin may, by appropriate toothed-wheels, be made to turn with the velocity requisite to allow of the thread receiving, say twelve twists in the inch, yet, after a very short time, the silk will have accumulated on it, and increased its diameter so much, that for every revolution which it now makes, it will take up and draw away a much greater length of thread from the revolving bobbin, whose speed remains constant, so that the number of twists are constantly on the decrease, and, at the end of the operation, may be no more than eight in the inch. A very ingenious mode of equalizing the draw of the bobbin has been put in practice In place of driving the drawing-bobbins by toothed-wheels, they are here driven by friction-rollers; the part of the bobbin on which the silk is wound rests on the roller, and receives motion from it; and, as the diameter of this part increases by the accumulation of silk, its velocity, of course, diminishes in precisely the same ratio; thus, the surface on which the silk is wound has a uniform rate of motion from the beginning to the end of the process, insuring, what has ever been a desideratum, perfect equality in the twist of the thread.

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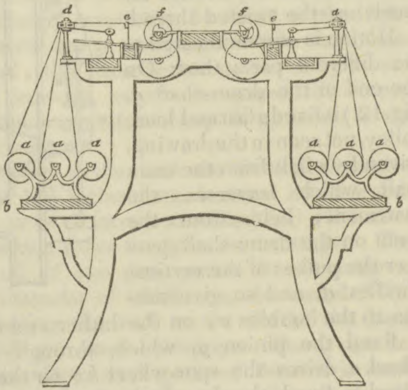
[1] The doffing board is an adoption from the cotton manufacture, and its use, as described above, is, we believe, peculiar to Scotland. Its chief advantage is, the check it affords against pilfering. When carried to the machine-room, the wires of the empty board are filled with empty bobbins, and, as the bobbins of the machine become charged with silk, they are exchanged for the empty ones of the board, which is again carried to the warehouse, that the bobbins may be assorted according to the quality of the silk. The filled bobbins are exchanged for empty ones, to be carried on the board to the winding machine room, and the same system is followed out in all the different stages of the operation.

Doubling.

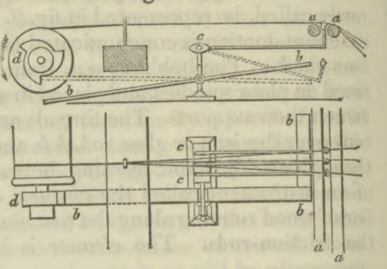
The next operation is doubling. Fig. 15 is an end view of the doubling-machine. In this machine the bobbins *a a a*, containing the spun silk, are arranged along the lower platform *b*, in little brackets capable of each containing three bobbins; from these the threads are carried over the guide-rods *d*, of which there are two on each side of the machine, and, after being passed through the eyes of an apparatus called the falling-wires, and the traverse-guides *e e*, are then attached to the bobbins *f f*, to which motion is given by friction-pullies, as in the first machines, and on them the threads are thus wound up in combination.

Fig. 15.



In all formerly described machines the breaking of the thread causes no injury, but, in the doubling process, were one of the three threads to break, and the upper bobbin to continue to revolve, the other two threads would be wound up separately, and so spoil the work; to prevent this is the use of the falling-wires described above, which, on the breaking of the thread, stop the bobbin until the damage is repaired. The subjoined sketch (figs. 16, 17), shews a side view and plan of this apparatus: *a a* are the two guide-rods, with the threads passing over them; between the rods are seen the eyelets of three bent wires, whose other extremities are hinged to a piece of brass at *c*. The threads are passed through these eyelets, and support the wires in the horizontal position shewn in the sketch. Hinged to the same supports as the wires is a brass lever, *bb*, bent at right angles horizontally under the wires; the straight end or tail of the lever is a little heavier than the bent end, and it consequently lies in the oblique position of our drawing. On the end of the bobbin is fixed a little ratchet-wheel, moving as indicated by the arrow. Now, when one of the threads sustaining the bent wires happens to break, the wire falls down on the bent part of the lever, which, by this additional weight, is depressed, and its opposite end consequently rises into the position shewn by the dotted line, and acts as a paul to the ratchet-wheel, effectually stopping the bobbin until the attendant has leisure to lift it out of its working-groove, repair the damaged thread, and again set it in motion.

Figs. 16, 17.



When the lighter kinds of silk have to be doubled, they would be injured by being made to drag round the heavy bobbins; therefore, for such kinds a modification of the apparatus is required. In place of the bobbins being placed horizontally in bearers, they are placed vertically on spindles, as shewn in figs. 12, 13, 14; the spindles project beyond the upper end of the bobbins, and carry a little wheel of hard wood, which is made to turn freely; this wheel has two flyers with eyelets at their extremities; the thread being put through these, and drawn by the upper bobbins, causes the light flyers to revolve round the vertical bobbin, and unwind the thread without straining it.

The next is the throwing machine. As this machine closely resembles the spinning-machine shewn in fig. 12, we here only sketch such a portion of it as will shew wherein they do not agree. Fig. 18 is an end view, and fig. 19 is a side view of one of the working parts: *a a* is a vertical bobbin with its loose flyer *b b*; the bobbin being driven by a band acting on the spindle pulley as in the spinning-machine; *c* is a traverse guide wire, through the eye of which the thread is passed; *d* a reel on which, in this case, the thread is wound into hanks as it is twisted by the revolution of the vertical bobbins. The traverse guide bars have, in this machine, a very short range of lateral motion, so as to confine each hank within a very narrow limit on the reel's surface. The motion of the reel can be so regulated in relation to that of the twisting bobbin, as in any way to modify the amount of twisting received by the thread.

Fig. 18.

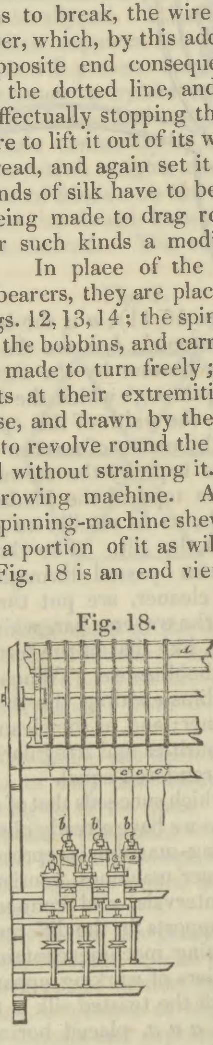
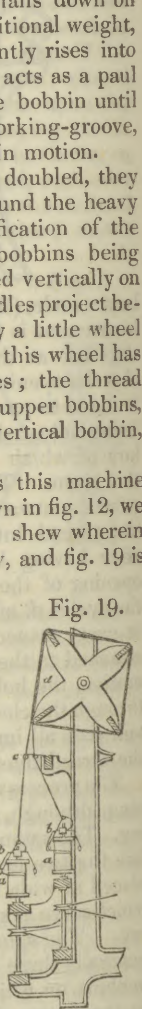


Fig. 19.



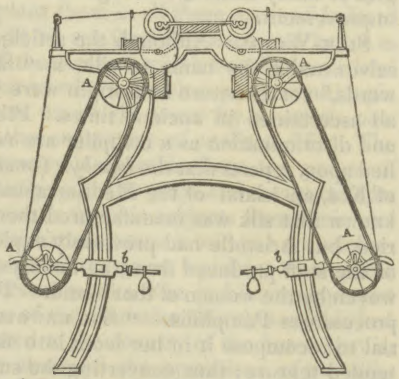
In the case of the heavier silk threads used for sewing, fringing, and the like, the doubling and throwing processes are both performed by one machine, called a throstle frame, which is similar to the machine of the same name used in the cotton and linen thread manufacture. The throstle, however, does not contain apparatus for reeling the silk, so, for this purpose, a subsidiary reel has to be used. This machine is automatic, in respect of stopping when a predetermined quantity of silk has been wound. One end of the axis of the reel is supported by a lever, whose fulcrum is at the centre of the machine; the other end of the axis has a fixed bearing. Motion is given to the reels by a pinion fixed on the end of its axis, being driven by a spur wheel on the main shaft; by raising the lever, which carries one end of the axis, the pinion would be withdrawn from the spur wheel, and the reel would necessarily cease to revolve. The machine is rendered automatic from the raising of the lever being effected by proper machinery at the very instant that the reel shall have wound up the length of silk predetermined, and by a detent locking it out of gear until the attendant shall have time to shift the apparatus which guides the silk to a new space on the reel.

We are sorry that we cannot present our readers with a more minute description of this machine, from the number of drawings which would be required to illustrate it.

Whether the hanks of silk have been reeled in the throwing-machine or on the automatic reel, they are afterwards treated in precisely the same manner. When the reels are filled with hanks, they are placed in a steam box, and subjected for a time to the action of the steam, to give the twisting of the thread a *set*, as it is termed; each skein or hank is then tied up separately in two places while yet on the reel, which is then carried to the proper apartment, and the hanks removed from it and bundled up.

The silk may be used without being deprived of its gum, and is termed *hard*, or it may be acted on by soap and water to deprive it of its gum, and reduce it to the *soft* state. In either of these states it may be put into the hands of the dyer, whose operations succeed those we have described. When the hanks come from the dyer they are again transferred to bobbins; the hard silk by a winding machine, similar to the one already described, the soft silk by the machine represented in fig. 20.[1] In this machine, in place of the swifts are substituted the small reels A A, the upper one fixed in position but turning freely on its axis, the lower one also turning freely on its axis, which is attached to a lever *b*, whose short end carries an adjustable weight, by means of which the hank of silk can be kept between the reels with the degree of tension suited to the strength of the thread. The operation of this machine will be understood from the winding machine already described, the only difference being, that the traverse guide has an equal and not an eccentric motion, so as to lay the silk regularly from end to end of the bobbin, and not heaped up in the centre as before. The transferring the silk to the bobbins finishes the operation of the silk throwster, from whose hands the silk passes into those of the warper, to prepare it for weaving.

Fig. 20.



The drawings of the machinery, by which we have illustrated our description of the throwing process, were, for the most part, made from machines constructed by Mr. Joseph Lomas of Glasgow, an engineer who has devoted much of his attention to the machinery used in this particular branch of manufacture.

Having thus traced the silk of the cocoons from its developement to the perfection of the filature, and its adaptation for the loom, we will briefly describe the means used for preparing the waste silk for the weaver, in so far as they are peculiar to the silk manufacture.

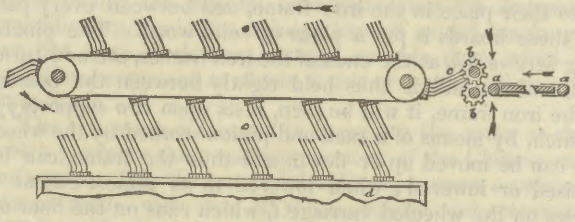
Silk Spinning.

Under this term are included those operations by which floss silk, and the refuse of the throwing process, are, under the name of waste, worked into yarns for coarser uses, such as the manufacture of shawls, Bandana handkerchiefs, and similar textures.

When received by the silk spinner, the waste is in the form of small balls of entangled filaments. These, as a preparatory step, he assorts in parcels according to their quality, and these different qualities are of course kept separate throughout the processes; after being assorted, the waste is hackled on a hand hackle, to disentangle the filaments, the instrument and manner of operating being the same as in flax-dressing. When, by the hackling process, the filaments of a quantity of the waste have, to a certain extent, been disentangled, they are ready for the *filling engine*, which is a kind of hackling machine, whose effect is, in a greater degree, to disentangle the filaments, and in some measure to lay them parallel.

The essential parts of this machine are sketched in fig. 21: *a a* is a feeding board, over the surface of which a travelling belt moves in the direction of the arrows, and carries forward to the feeding rollers *b b*, the hackled waste, which is laid on it. These rollers are fluted and move very slowly; between them the filaments from the feeding board enter, and are held fast, and at the same time drawn forward into the machine. As the ends of the filaments come to the other side of the rollers, they are acted upon by a series of iron teeth *c c*, fixed to an endless belt which revolves with a very quick motion in the direction of the arrows, and the teeth are consequently made to pass many times through the same portion of the filaments, clearing and disentangling them as they are slowly yielded by the feeding rollers; and as the ends of the successive portions of filaments cease to be held by the rollers, they are caught up by the teeth and carried round with them. Beneath the combs, as the travelling teeth are termed, a board *d* is fixed, having at intervals, along its surface, sets of teeth similar to the combs. When the filaments carried round by the travelling combs happen to fall off, they are caught on the fixed combs of the boards, and the regularity of their arrangement is not disturbed. When the combs, by repeated gleanings from the rollers, have become filled, the workman, with a pair of boards called *clutches*, removes from them, and from the teeth of the horizontal boards, their accumulation of filaments; these he carries to the next machine, called the *dressing frame*, which, like the filling engine, operates on the principle of combing. In this, however, the filaments are not gradually brought for-

Fig. 21.



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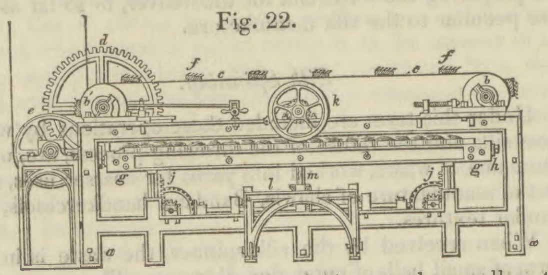
[1] In England, throwsters rarely if ever wind the soft silk, this duty devolving upon the manufacturer; but in Scotland, manufacturers being seldom provided with the requisite machinery, soft-silk winding is usually a part of the business of the throwster.

ward by rollers and yielded to the comb, but they are held firmly in their place by one end, while the combs travel over their surface, dragging away all impurities and all fibres which are shorter than the average length of the mass. Fig. 22 is a side view of the machine: *a a* is a fixed framing, at

Fig. 22.



each end of the frame is a roller *b b′*; over these rollers the endless web *c c* moves. Motion is communicated to the roller *b′* by the spur wheel *d*, on its axle being driven by a pinion on the axle of the pulley *e*, to which motion is given by a belt from a pulley of the main power shaft. The distance between the rollers *b b′* can be increased or diminished by a screw connected with *b*, so as to tighten or relax the endless web which travels round them. The endless web carries the combs *f f*, which, in this machine, are composed of a great number of short inclined teeth. Immediately below the top bar of the machine is seen the side of an iron frame *g g*, in which the silk to be operated on is fastened. Along the frame is seen the ends of a series of boards, whose lower edges are hinged together; between these boards, when opened like a book, the ends of the silk filaments from the filling engine are inserted, and the boards closed and put into their place in the iron frame, and between every pair of these boards is put a piece of solid wood. The pinching screws *h h*, at the ends of the iron frames, are now turned, and the silk is thus held tightly between the boards. The iron frame, it will be seen, rests upon two supports *j j*, which, by means of a rack and pinion worked by the wheel *k*, can be moved up or down, and thus the frame can be raised or lowered; when lowered to its utmost extent it rests on the wheeled carriage *l*, which runs on the floor on a railroad placed at right angles to the machine. The operation of the machine is as follows: The frame which contains the silk is lowered until it rests on the carriage, which is then drawn out at the side of the machine. The boards containing the silk are then put into their places and firmly compressed by the pinching screws; the carriage is now returned to its place under the combs, and by means of the wheel, the frame is adjusted so that the combs may act on the silk. The machine is then put in motion, and the combs, by repeatedly passing over the silk, disentangle and lay parallel the filaments and remove impurities. When the combing of one side of the filaments has been effected, the frame is again lowered, and the carriage withdrawn. The workman with a skewer turns over the silk so as to expose the uncombed side, wheels round the frame on its centre pivot *m*, and again runs the carriage into its place; again he raises the frame until within the scope of the combs, which constantly move in the same direction; and thus both sides of the material come to be thoroughly operated upon. The gleanings of the silk gathered by the combs, when accumulated, are screwed between the boards, and again subjected to the action of the machine; what is carried away by the combs in this operation is unfit for spinning, and is used, like the refuse of flax, for stuffing cushions and similar purposes.

When the filaments are by the dressing machine cleaned and laid parallel to each other, they are cut into lengths of about an inch and a quarter by the *cutting engine*, which operates upon the principle of chopping, and resembles the agricultural chaff machine. It is then operated upon by the scutcher, which is a modification of a similar machine used in the cotton manufacture. When it leaves the scutcher it resembles fine down, and is put into bags of a convenient size, and boiled for an hour and a half or so in soap and water, to deprive it of its gum; it is afterwards washed in pure soft water and again boiled, but not now for so long a period, this boiling being merely for the purpose of getting rid of impurities. It is then subjected to the action of a Bramah press, and when taken from the press, dried by means of a stove, after which it is cooled, and a second time passed through the scutching machine to fit it for carding. The carding is followed, as in the cotton manufacture, by the drawing and fly frames, to produce a rove, and these, by the spinning mill and the throstle, after which reeling and bundling complete the operations and fit the thread for the market.

Messrs. William Casey and Company, of Castle Mills, Edinburgh, have it in contemplation to introduce such alterations in the spinning of silk waste as will supersede the cutting, carding, and scutching processes. This improvement they mean to effect by adopting the principles of flax spinning, in place of treating the waste in the manner of cotton, the uncut filaments being in this case drawn into a sliver by a modification of the flax gill.

The art of silk waste spinning, we may observe, is still in its infancy, but is advancing rapidly to greater maturity. In 1814, the quantity of waste imported by Great Britain amounted to 28,996 lbs., and in 1836 it had reached to the amount of 1,509,334 lbs.

In closing this brief sketch of what is now an important branch of our manufacture, we beg to express our grateful acknowledgments to Messrs. Harvey, Brand, and Company, of Glasgow, whose beautiful silk-throwing factory of Blackhall, Paisley, was with the utmost liberality opened to our inspection; and it is our duty also to record our acknowledgments to Messrs. William Casey and Company, of Edinburgh, of whose contemplated improvements in silk waste spinning, we have before spoken; it is only through such liberality as these gentlemen have displayed, that knowledge of the arts can be disseminated, and the energies of many minds be brought to bear upon them to their improvement. (B. S.)

SILK-WORM. Although the article now known to ourselves under the name of silk, is "familiar as household words," yet its nature and origin were but obscurely, if at all ascertained in ancient times. Pliny, whose judgment and discrimination as a compiler are not greatly to be relied upon, reports that the *bombyx* (or silk worm) is a native of Kos, an island of the Mediterranean archipelago. It is known that silk was manufactured there at a very early period, but Aristotle had previously explained that *bombykia*, or the stuff produced from the bombyx, was respun and rewoven by the women of that island. The inventress of this process was Pamphilia. "She unwove the precious material to recompose it in her loom into fabrics of a more extended texture; thus converting the substantial silks of the Seres into thin transparent gauze, obtaining in measure what was lost in substance. Attempts have been made to rob the inventress of all the merit belonging to this process, by identifying the bombykia with the raw material, which it is said Pamphilia and her nymphs procured from Seres, and respun or wove into sericum or silk. But the fact of the reweaving rests upon too good authority to be doubted."[1]

Had Pliny been right in supposing that silk was a natural product of the island in question, it is by no means probable that so laborious a process as that of converting foreign wrought articles into threads for reweaving, would have been resorted to. Indeed, the Byzantine historians inform us, that prior to silk worms being imported into Constantinople in the sixth century, no one in that capital knew that silk was the produce of a caterpillar. Although Aristotle gives an account of the silk-worm, which he describes as a horned caterpillar, he does not indicate its native country. Assyria is named by Pliny as the original region of the bombyx, and he adds the extraordinary statement, that the stuff which the women of Rome unravelled and wove anew, was made from a *woollen* substance combed by the Seres from the leaves of trees, and that draperies formed from it were imported from the country of the Seres. These ancient people, we need scarcely remark, are generally believed to be the same with those we now name Chinese. Silk, in their language, is called *se* or *ser*, the latter term corresponding with that used by the Greeks, who, we cannot doubt, derived both the material itself, and the name by which it was designated, from the Chinese nation. According to Latreille, the city of Turfan, in Little Bucharia, was for a long time the rendezvous of the western caravans, and the chief entrepôt of the Chinese silks. It was the metropolis of the Seres of Upper Asia, or of the Serica of Ptolemy, situate, according to that author, between the Ganges and the Eastern Ocean. Hence the *Serica vestis* of the Romans, and the word *Sericum*, their name for silk.

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[1] Cabinet Cyclopædia, xxii. 5

This substance was but slightly known in Europe before the time of Augustus, and in the days of Aurelian was valued at its weight in gold. This was probably owing to the mode in which it was procured by the merchants of Alexandria, who had no direct intercourse with China, the chief, if not the only country in which the silk-worm was then reared. Though so highly lauded both by Greek and Roman writers, it was in frequent use for many centuries before any certain knowledge was obtained either of the country from which the material was derived, or of the means by which it was produced. By some it was supposed to be a fine down adhering to the leaves of trees and flowers; by others it was regarded as a delicate kind of wool or cotton,[1] and even those who had some idea of its insect origin, were incorrectly informed of the mode of its formation.[2] The court of the Greek emperors, which surpassed even that of the Asiatic sovereigns in splendour and magnificence, became profuse in its display of this lustrous ornament; but as the Persians, from the advantages which their local situation gave them over the merchants from the Arabian Gulph, were enabled to supplant them in all those marts of India to which silk was brought by sea from the East, and had it in their power to cut off the caravans which travelled over land to China through their northern provinces, Constantinople thus became dependent on a rival power for an article now deemed essential to the enjoyment of civilized life. The Persians, with the rapacity inseparable from the power of monopolists, exorbitantly raised its price, and many attempts were made by Justinian to free his subjects from their exactions. An accidental circumstance is said to have accomplished what the wisdom of the great legislator was unable to achieve. Two Persian monks, who had been employed as missionaries in one of the Christian churches established in India, had penetrated to the country of the Seres, that is, to China, where they observed the operations of the silk-worm, and acquired a knowledge of the art of man in working up its produce into so many rich and costly fabrics. The love of lucre, mingled, it is said, (though perhaps a single motive may suffice,) with a feeling of indignation that so valuable a branch of commerce should be enjoyed by unbelieving nations, induced them to repair to Constantinople, where they explained to the emperor the true origin of silk, and the various modes by which it was prepared and manufactured. Encouraged by the most liberal promises, they undertook to transport a sufficient supply of these extraordinary worms to Constantinople, which they effected by conveying the eggs of the parent moth in the interior of a hollow cane. They were hatched, it is alleged, by the heat of a dunghill, and the larvæ were fed with the leaves of wild mulberry. They worked, underwent their accustomed metamorphoses, and multiplied their kind according to use and wont, and in the course of time have become almost universally cultivated throughout the southern countries of Europe, thus effecting an important change in the commercial relations which had so long existed between our continent and the east.[3]

The cultivation of the silk-worm spread, at the period of the first crusades, from the Morea into Sicily, the kingdom of Naples, and several centuries afterwards, more especially under the administration of Sully, into France, to which kingdom it is well known to be now a source of great wealth. It is indeed curious to consider how the breeding of a few millions of small caterpillars should occasion such a disparity in the circumstances, or at least in the outward shew, of different tribes of the human race. When the wife and empress of Aurelian was refused a garment of silk on account of its extreme costliness, the most ordinary classes of the Chinese were, we doubt not, clad in that material from top to toe; and although, among ourselves, weekday and holiday are now alike profaned by uncouth forms, whose vast circumference is clothed in silk attire, yet our James the Sixth was forced to borrow a pair of silken hose from the Earl of Mar, that his state and bearing might be more effective in the presence of the ambassador of England, "for ye would not," said the uncouth pedant, "that your king should appear as a scrub before strangers." Queen Elizabeth, in the third year of her reign (1560), was highly gratified by receiving from her silk-woman, Mrs. Montague, a pair of knit black-silk stockings, with which she is said to have been so delighted, as never afterwards to have worn those of cloth. Even Henry the Eighth, notwithstanding his expensive magnificence, could not indulge himself as did his daughter, but wore cloth hose, except on gala days, when he sometimes contrived to obtain a pair or two of silken ones from Spain.

The silk-worm cultivated in Europe is the same as that which produces the greater proportion of the Chinese manufacture. It is the larva of the *Bombyx mori*, a pale coloured moth, with two or three obscure and transverse streaks, and a lunate spot on the superior wings. The caterpillar feeds on the leaves of the mulberry, and before assuming the chrysalis form, it spins a protecting covering in the shape of an oval cocoon, of a close tissue of the finest silk, usually of a yellow colour, but sometimes white. The filament does not form regular concentric circles round the interior surface of the cocoon, but is spun as it were in spots, going backwards and forwards with a wavy motion. This apparently irregular manner of proceeding is plainly perceptible when the silk is wound off the ball, which does not make more than one or two entire revolutions, while ten or twelve yards of silk are being transferred to the reel.[4] The caterpillar casts and renews its skin several times before it commences to spin, and when full grown, it measures from two and a half to three inches. The principal points to be attended to in its cultivation, are regular feeding three or four times a-day, good ventilation, and a rather high temperature, especially at the period of spinning, say 70° Fahrenheit. It lives and spins though fed only on lettuce leaves, but their true and natural food is the mulberry, especially the white kind, called by botanists *Morus alba*.

The important tree just named, is a native of China, from whence it is believed to have been transferred to India, Persia, and Asia Minor. It was introduced at Constantinople during the sixth century, in the reign of Justinian, in connection, no doubt, with the importation of the worms themselves. It was afterwards introduced into Greece, and the name *Morea*, by which the Peloponnesus is now distinguished, is ascribed by many authors to the vast quantity of mulberry trees there cultivated In 1130, Roger, king of Sicily, having conquered many portions of the Morea, transported the white mulberry into his own kingdom, along with a supply of silk worms, and of artizans who understood their cultivation, and the manufacture of their natural product. About the year 1493, in the reign of Charles the Eighth, some nobles who had accompanied that Prince into Italy, brought the mulberry from Naples, and planted it in the environs of Montélimart. Not many years have gone by since those parent trees, the source of so rich a branch of commercial industry to France, were exhibited with an almost religious veneration. The mulberry was cultivated not only in the south of France, but Henry the Fourth brought a great many to Paris, which he planted in the gardens of the Tuilleries, where an establishment was founded for the rearing of the worms, and the preparation of their silk. No vestige of this plantation now remains.

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[1] See Robertson's Historical Description concerning Ancient India.

[2] Edinburgh Cabinet Library, viii. 152.

[3] See Procopius De Bello Gothico; Gibbon's Decline and Fall (Reign of Justinian); Edin. Cab. Library, already cited; and this Encyc. Art. *Entomology*, ix. 247.

[4] Cabinet Cyclopædia, xxii. 112.

It was long supposed that the cultivation of the white mulberry required a high temperature, but the contrary is proved by the fact of its thriving well in so many northern provinces of Germany. Even in Russia it is reared with considerable success. In France, however, it is not raised in large quantities with a view to the feeding of silk-worms, except in the central and southern provinces, as far north as the environs of Lyons. Government does not seem to have held out any encouragement to its extension, otherwise we doubt not that both the tree and caterpillar might be more extensively and abundantly spread over the more northern departments. The white mulberry is by no means nice in regard to the constituent character of its soil, and it is known to flourish in a great variety of situations. At the same time, the nature both of soil and situation seems to exercise considerable influence over the produce of the caterpillars which feed upon its leaves; the silk being finer, ampler, and more resistant, in proportion as the plant is successfully cultivated in a dry and rather elevated position. In the south of France it is customary to cut off all the medium-sized branches every year, with a view to facilitate the production of a greater number of young shoots, these bearing the largest and most numerous leaves. The leaves of the black mulberry (*Morus nigra*), and in general those of all the other species of the genus, are adapted to the nourishment of the silk-worm. But not only are they apparently less grateful to their taste, but they actually produce a silk much inferior both in quantity and quality.

We have said that the silk-worm cultivated in Europe is the same as that which produces the greater proportion of the Chinese manufacture. But in Bengal and other parts of India, valuable silk is procured from the cocoons of other species of moth. The first of these is described by Dr. Roxburgh under the title of *Phalæna paphia*, and occurs in such abundance over many parts of Bengal, and the adjoining provinces, as to have afforded to the natives, from time immemorial, an abundant supply of a very durable, though coarse, and dark-coloured silk, called *Tusseh*, much used by the Brahmins, and other sects of Hindoos. This species, however, cannot be domesticated; so the hill people go into the jungles, and when they perceive the dung of the caterpillars under a tree, they immediately search for them among the branches, and carry off what they require. These they distribute on the Asseen trees (*Terminalia alata glabra* of Roxb.), and as long as they continue in the caterpillar state, the Pariahs guard them from birds by day, and from bats by night. The natural food of this species is the *Byer* tree of the Hindoos, called *Rhamnus jujuba* by botanists. The Jaroo cocoons are produced from a rare variety of the kind just mentioned. This tusseh silk-worm moth appears to be synonymous with *Bombyx mylitta* of Fabricius, and is figured by Drury.[1] The Arrindy silk-worms, however, belong to an entirely different species, *Phalæna cynthia* of the last named author.[2] It seems to be peculiar to two districts in the interior of Bengal, viz. Runpore and Dinagepore, where it is reared in a domestic state. The food of this kind of silk-worm consists entirely of the leaves of the common *Ricinus*, or Palma Christi, which the natives call *Arrindy*, and hence the name by which the insect is itself distinguished. The cocoons in general are about a couple of inches in length, three inches in circumference, and pointed at both ends. They are of a white or yellowish colour, and their texture is extremely soft and delicate. The filament, indeed, is so extremely fine, that the silk cannot be wound off, but must be spun like cotton. The yarn is wove into a kind of coarse white cloth, of a seemingly loose texture, but of such extreme durability, that the life of one person seldom suffices to wear out a garment of it; so that the same piece frequently descends from parent to child. It must always be washed in cold water.[3]

The only other species with which we are acquainted is that alluded to by Mr. Arthur Young, in an extract of a letter published in the *Annals of Agriculture*. It has been introduced into our Eastern possessions for a considerable number of years. "We have obtained," says the writer of the letter, "a monthly silk-worm from China, which I have reared with my own hands, and in twenty-five days have had the cocoons in my basins, and by the twenty-ninth or thirty-first day, a new progeny feeding in my trays. This makes it a mine to whoever would undertake the cultivation of it."

The practice of rearing silk worms in this country is usually followed rather as an amusing occupation than for purposes of gain. The female moth is induced to lay her eggs upon sheets of paper, to which they adhere by a natural viscosity. The period of hatching may be hastened or retarded by a higher or lower temperature, and the chief point for the breeder to bear in mind is, that the worms should not make their appearance till an abundance of natural food is near at hand. The eggs are at first of a very pale hue, but such as are to produce worms speedily become of a bluish grey colour; the unproductive ones continuing of a pale yellow. As there are tricks in all trades, the foreign dealers often favour their old useless eggs with a wash in dark-coloured muddy wine, which gives them for a time a deceptive healthy aspect. A stove-room, or other apartment, with a temperature of 64° will suffice for the hatching of eggs, and the heat may afterwards be raised with advantage a few degrees every other day, for about ten days, but not so as to exceed about 80°. They will, however, thrive well enough in summer in any comfortably kept apartment, though a continuous warmth by night as well as by day is of great advantage. Whatever broods are hatched at the same period, should be kept together, and those of different ages ought never to be fed in the same trays.

The best and simplest apparatus for keeping silk worms is that proposed by Mr. Swayne. It consists of an open quadrangular wooden frame, about four feet two inches high, provided with eight uncovered slides or drawers a few inches apart from each other, and which, moving in a groove or ledge, can easily be shifted out or in. The upper slide is made of paper, and is devoted to the reception of the newly hatched worms, which it is desirable to feed at first with young and delicate leaves, chopped into small pieces. The flooring of the second and third slides is made of catgut, the reticulations being about the tenth part of an inch asunder. In these the worms are placed during what may be called the second and third stages. The five remaining slides are made of wicker-work or netting, and in them the insects are distributed "fewer and far between," as they increase in size. Beneath every drawer except the uppermost, which is itself made of paper, additional paper slides should be placed to receive the dung, and the worms must not be kept any longer in the second and third drawers, so soon as the litter alluded to becomes so large as to stick in the catgut meshes, without falling through upon the paper slides beneath. By means of these additional slides, this litter may be removed any time the worms are fed, without the necessity of handling the latter. When the fresh food is placed in the drawers they will speedily creep upon it, and any remnants of old leaves can be picked up by a pair of small pincers.

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[1] Illustrations of Natural History, ii. tab. 5.

[2] Ibid. tab. 6.

[3] See Account of the Tusseh and Arrindy silk-worms of Bengal, by William Roxburgh, M.D. Linn. Trans. viii. 33; and British India (in Edin. Cab. Library), iii. 154.

Silk worms ought to be fed with regularity at least four times a-day; additional or intermediate meals being given when any extraordinary appetite is manifested. The duration of the lives of these animals depends, to a certain extent, upon temperature and locality; warmth, well kept quarters, and abundance of food, being found to hasten the spinning process. All these things should be very sedulously attended to by those who rear silk worms in large quantities with a view to profit, time being so important an element in all commercial undertakings.

When the silk worm makes its first appearance, it is of a dark colour, and measures only one or two lines in length; after the lapse of eight days, it is attacked by a lethargic sickness, which will cause the heart of the young or inexperienced breeder to despond, but he need fear no evil, for this is only an unavoidable symptom of the ordinary ongoings of nature. The creature is about to cast its skin, and for about three days it remains motionless, refusing food. On the termination of this period the old skin opens at the anterior end, the fore-legs are disengaged, and the new and delicately attired worm escapes forth, to enjoy itself once more on pastures green. It had previously exuded a peculiar fluid, and had also, by means of a few silken strings (how provident is benign nature!) fastened down its old and useless coat, that it might not be dragged after it when the hour of delivery has arrived. This coating is so complete, that even the skin which covers the eyes and teeth is thrown away. Immediately after this renewal, the body of the worm appears pale and somewhat wrinkled, the new coat being made full size to admit of future growth; but the latter attribute speedily disappears. It feeds freely for five additional days, during which it grows to about half an inch in length, and is then seized by its second sickness, and again casts its skin. Then succeed other five days of feasting, in the course of which it increases to three quarters of an inch, when it sickens a third time, and acquires in a similar manner a third suit of clothes. Again five days of feeding; again a removal of the outer garment, or a fourth casting of the skin. The caterpillar now measures from an inch and a half to two inches long, and for a continuous period of about ten days it eats voraciously, and increases greatly both in length and thickness. On the expiry of this last-mentioned period, it has attained the full stature of a silk-worm, being from two and a half to three inches long. Its desire for food abates, it nibbles and wastes its leaves, then ceases to eat, and becomes restless and uneasy, moving circularly from side to side, owing to some instinctive feeling of desire to secure a quiet haven in which to spin its silken shroud. Its colour is now of a palish green, with a mingling of a deeper hue. In the course of about twenty-four hours from the time of its having ceased to feed, the silky texture becomes abundantly supplied to its interior reservoirs; the green colour disappears, the body becomes glossy, and somewhat transparent towards the neck. Previous to spinning, the general dimensions rather decrease than otherwise, but greater firmness of substance is acquired.

When the desire to spin is thus unequivocally manifested, art must come in aid of nature. Our own method formerly was (we worked, however, in this department on a narrow scale,) to supply our caterpillars with small twisted paper bags, open at one end, such as any old woman may use on a Saturday night to carry from the grocer's her solitary ounce of tea. Into each of these would creep a single caterpillar, and weave his golden woof incessantly, till the loved work was done. But those who rear extensively, supply their completed caterpillars with small twigs or branches of broom, heath, or any other brushwood, which happens to unite tenderness and tenacity.

Great attention must now be paid in regard to keeping up a warm temperature. The observations of a writer in the fifth volume of the Society for the Encouragement of Arts, amply illustrate this important point. He had successfully reared thirty thousand silk-worms, when in the beginning of July, just as they were about to spin, there came a chilly north-east wind, and many assumed the chrysalis state, without making any attempt to form a protecting covering. On examining these individuals, it was apparent that their silken reservoirs had been congealed by cold, so that the insects were unable to draw out the filaments in their usual slender state, their own capacity of movement and exertion being no doubt at the same time chilled. Even when they have commenced to spin, or have made some progress in their labours, they will cease if exposed to cold, and if the surrounding web is still of sufficient transparency, they may be seen lying idle and inactive in the interior of their cocoons. But if the temperature is raised, they will immediately resume their work. A heat as high as 70° is thought advisable at this time.

These beautiful silken coverings, or cocoons as they are called, are generally completed in three or four days. They are commenced by the formation (among the twigs or in paper bags, as the case may be) of a loose decomposed structure of an oval form, made of what is denominated *floss* silk. Within this, in the course of the ensuing days, the firmer cocoons are completed. These are rounded somewhat oval balls, varying in tint, but usually more or less of a golden hue, though sometimes white. Those of a bright yellow hue yield the greater weight of reeled silk, but as the finer colouring substance is contained chiefly in the gum which is boiled out before weaving, less advantage is reaped by the grower. Raw silk, of a pale colour, is moreover preferred, on account of its better reception of certain dyes. The included worm, having finished its labour, casts its skin once more, but never appears again as a caterpillar, as it now assumes that rounded shapeless form termed *chrysalis*. The cocoons may be selected for reeling in about a week, and then comes the ungrateful and ungracious task of destroying the peaceful tenants of the tomb. This is variously accomplished, either by exposure (in sunny climates,) for some hours to unclouded solar light and heat; by steam; or by placing the cocoons in a temperature corresponding to that of an oven from which loaves have just been withdrawn after being baked.

If not killed, the chrysalis remains in its naturally dormant state for a longer or shorter time, in accordance with the clime in which it has had its birth. In eastern countries this is not more than eleven days; in the most southern parts of Europe from eighteen to twenty; in France about three weeks; in England, if unaided by artificial means, about a month. After these respective periods, according to climate, whether natural or acquired, the perfect moth emerges, and the reason for destroying the chrysalis is this, that in emerging *she* (the moth) destroys the silk, under the impression probably, that she may do what she likes with her own. A few, however, are of course spared for the sake of a future progeny, sound cocoons being selected, and in equal numbers as to sex, those containing the males being sharper or more pointed at the ends.

Such as have been killed for reeling are, before the commencement of that process, placed in warm water, so that their gummy nature may be partly softened, but not dissolved. The length of silken thread which may be unwound from a single cocoon, although it has been ridiculously exaggerated by Isnard and other writers, is in truth astonishing. Count Dandolo found it occasionally to exceed 600 yards; Miss Rhodes of Yorkshire mentions that one of her largest cocoons yielded 404 measured yards; and Pullein considers the average length to be about 300 yards. From data given by the first named author it was found, that to obtain one pound of reeled silk, twelve pounds of cocoons are required; that 2800 worms would be necessary to produce that amount of cocoons; and that to feed these caterpillars, 152 pounds of mulberry leaves must be collected.

As we write this brief notice rather for the amateur than the artizan, the mention of the above named tree reminds us of the propriety of stating, that as mulberry leaves cannot be easily obtained in Britain in required abundance, the best substitute is *lettuce*.

SILLA, a large town on the Niger, by which the travels of Mr. Park were bounded towards the east. He gives no particular description of the place, which his health and spirits permitted him not to survey, but assigns the reasons by which he was induced to proceed no farther. On his arrival, he was allowed to remain under a tree, till it was quite dark, surrounded by hundreds of people. But their language was extremely different from the other parts of Bambarra; and he was given to understand, that in his progress eastward, the Bambarra tongue was very little understood, and that, on his reaching Jenné, he would find the greater part of the inhabitants accustomed to speak a different language. He had now become the prey of sickness, exhausted with hunger and fatigue, half naked, and without any article of value to procure for himself provisions, clothes, or lodging, on which account he resolved to return, finding that to prosecute his journey further in that direction was wholly impracticable. Silla, acording to the latest map of Africa, is in 14. 48. N. lat. and 1. 24. W. long.

SILVERING, the covering of any thing with silver It is usual to silver metals, wood, paper, and the like, which is performed either with fire, oil, or size. Metal-gilders silver by the fire; painter gilders all the other ways.

To silver copper or brass. First cleanse the metal with aquafortis, by washing it lightly, and immediately throwing it into pure water; or by heating it red hot, and scouring it with salt and tartar, and some pure water, with a small wire brush. Secondly, Dissolve some silver in aquafortis, in a broad-bottomed glass vessel, or of glazed earth; then evaporate away the aquafortis over a chaffing dish of coals. Thirdly, Put five or six times its quantity of water, or as much as will be necessary to dissolve it perfectly, on the remaining dry calx; evaporate this water with the like heat; then put more fresh water, and evaporate again; and, if need be, the third time, making the fire towards the latter end so strong as to leave the calx perfectly dry, which, if your silver is good, will be of a pure white. Fourthly, Take of this calx, common salt, crystals of tartar, of each a like quantity or bulk, and mixing well the whole composition, put the metal into pure water, and take of the said powder with your wet fingers, and rub it well on, till you find every little cavity of the metal sufficiently silvered over. Fifthly, If you would have it richly done, you must rub on more of the powder; and, in the last place, wash the silvered metal in pure water, aud rub it hard with a dry cloth.

SIMEON *of* DURHAM, the contemporary of William of Malmsbury. He took great pains in collecting the muniments of our history, especially in the north of England, after they had been scattered by the Danes. From these he composed a history of the kings of England, from A. D. 616 to 1130, with some smaller historical pieces. Simeon both studied and taught the sciences, and particularly the mathematics, at Oxford; and he became precentor of the church at Durham, where he died, probably soon after the conclusion of his history, which was continued by John, prior of Hexham, to the year 1156.

SIMFEROPOL, called formerly Akhmetschet; a city of the province of Tauria in Russia, the capital of that province as well as of a circle of the same name. It stands on an elevated plain, surrounded on all sides by mountains, on the banks of the river Salair. It is divided into the new and the old city; the former is regularly laid out, and contains a public school, and a few offices of the government. The latter is surrounded with high walls, and has narrow and crooked streets without pavement, and is chiefly inhabited by the Tartars. The united towns contain about 1000 houses, and nearly 20,000 inhabitants, from a great variety of nations. It has a Russian, a Greek, and an Armenian church, and three Tartar mosques, with several baths. Lat. 44. 59. Long. 34. 1. 5. E. It is 1458 miles from St. Petersburg. It is considered to be unhealthy in summer, owing to a deficiency of good water, and the filthy habits of the Tartar population.

SIMILE, or SIMILITUDE, in *Rhetoric*, a comparison of two things, which, though different in other respects, yet agree in some one. The difference between a simile and comparison consists in this, that the simile properly belongs to whatever we call the quality of a thing, and the comparison to the quantity.

SIMILOR, a name given to an alloy of red copper and zinc, made in the best proportions, to imitate silver and gold.

SIMOGA, a fortified town of the south of India, in the province of Mysore, and district of Bednorr, situated on the Zunga or Zoom river. The fortifications are not strong, and are incapable of resisting a regular attack. It has a manufacture of cotton cloth in the neighbourhood. It contains the temple and convent of Kudali Sivami, the high priest of a sect of Mahratta Brahmins. In 1790, an action was fought near this place, between Purseram Bhow and Mahommed Reza, in which the Mahrattas were assisted by a detachment of British troops under Captain Little, who gained the battle. At this time Simoga contained 6000 houses, which were utterly destroyed by the Mahrattas. It was again destroyed in 1798, but has since considerably recovered its wealth and population. Long. 75. 35. E. Lat. 13. 51. N.

SIMON MACCABEUS, a celebrated leader, and high-priest of the Jews, who, after rendering the most important services to his country, was at last treacherously murdered by his son-in-law.

SIMON Magus, or the Sorcerer, was a native of Gitton, a village of Samaria. According to the usual practice of the Asiatics of that age, he visited Egypt, and there probably became aquainted with the sublime mysteries taught in the Alexandrian School, learning those theurgic or magical operations, by means of which it was believed that men might be delivered from the power of evil demons. Upon his return into his own country, the author of the *Clementine Recognitions* relates, that he imposed upon his countrymen by high pretensions to supernatural powers. St. Luke attests, that this artful fanatic had bewitched the people of Samaria, giving out that he was some great one; and that he obtained such general attention and reverence in Samaria, that the people all gave heed to him, from the least to the greatest, saying "This man is the great power of God."

By the preaching of Philip the Deacon, he was, with other Samaritans, converted to the Christian faith, and admitted into the infant church by the ordinance of baptism. His conversion, however, seems not to have been real; for, upon seeing the miraculous effects of the laying on of the apostles' hands, he offered them money, saying, "Give me also this power, that on whomsoever I lay hands he may receive the Holy Ghost." He probably thought Peter and John magicians like himself, but better skilled in the art of deceiving the multitude.

Being sharply reproved for this impiety, he seems by his answer to have been made sensible of his sin; but his repentance, if sincere, was of short duration. Returning to his former practices of imposture, he travelled through various provinces of the empire, opposing the progress of the gospel; and arriving at Rome, he led astray vast numbers of people by his pretended miracles. How long he lived in that metropolis of the world, or in what manner he died, we have no accounts that can be depended on. The Christian writers tell us, that being raised in the air by two demons, he was deprived of their support by the prayers of St. Peter and St. Paul, and falling, broke his legs. By some he is thought to have been the person mentioned by Suetonius, who having undertaken to fly in the presence of Nero, fell to the ground with such violence, that his blood spurted up to the gallery where the emperor was sitting.

The sum of this impostor's doctrine, divested of allegory, was, that from the Divine Being, as a fountain of light, flow various orders of æons, or eternal natures, subsisting within the plenitude of the divine essence; that beyond these, in the order of emanation, are different classes of intelligences, amongst the lowest of which are human souls; that matter is the most remote production of the emanative power, which, on account of its infinite distance from the Fountain of Light, possesses sluggish and malignant qualities, which oppose the divine operations, and are the cause of evil; that it is the great design of philosophy to deliver the soul from its imprisonment in matter, and restore it to that divine light from which it was derived, and that for this purpose God had sent him as one of the first æons amongst men. To his wife Helena he also ascribed a similar kind of divine nature, pretending that a female æon inhabited the body of this woman, to whom he gave the name of Εννοια, or *Wisdom;* whence some Christian fathers have said, that he called her the *Holy Spirit.* He also taught the transmigration of souls, and denied the resurrection of the body.

Simon, *Richard,* was born at Dieppe on the 15th May 1638. He began his studies amongst the priest of the Oratory in that city, but in a short time quitted their society. From Dieppe he went to Paris, where he made great progress in the study of the oriental languages. Some time afterwards he joined the society of the Oratory again, and became a priest of it in 1660. In 1670 he published some pieces of a smaller kind; and in 1678 his Critical History of the Old Testament appeared, but was immediately suppressed by the intrigues of the gentlemen of Port-Royal. It was reprinted the year after, and its excellence soon drew the attention of foreigners; an edition of it was accordingly published at Amsterdam in Latin, and in London in English. He died at Dieppe in 1712, at the age of seventy-four.

He certainly possessed a vast deal of learning. His criticism is exact, but not always moderate; and there reigns in his writings a spirit of novelty and singularity which raised him a great many adversaries. The most celebrated of these were Le Clerc, Vossius, Jurieu, Dupin, and Bossuet. Simon wrote an answer to most of the books that were published against him, and displays a pride and obstinacy in his controversial writings which do him little honour. He was the author of a great many books. The following are the principal, viz:—1. The Ceremonies of the Jews, translated from the Italian of Leo of Modena, with a supplement concerning the sects of the Caraites and Samaritans; 2. The Critical History of the Old Testament; 3. Critical History of the Text of the New Testament; 4. Critical History of the Versions of the New Testament; 5. Critical History of the principal Commentators on the New Testament; 6. Inspiration of the Sacred Books; 7. A translation of the New Testament, which was censured by Cardinal Noailles and by Bossuet; 8. The History of the Rise and Progress of Ecclesiastical Revenues, which is commended by Voltaire, as is his Critical History of the Old Testament; 9. A new select Library, pointing out the good books in various departments of literature, and the use to be made of them; 10. Critical History of the Belief and Customs of the nations on the Levant; and, 11. Critical Letters.

Simonides.

SIMONIDES, the name of several poets celebrated in antiquity. But by the Marbles it appears that the eldest and most illustrious of them was born in the fifty-fifth Olympiad, 538 years before Christ, and that he died in his ninetieth year, which nearly agrees with the chronology of Eusebius. He was a native of Ceos, one of the Cyclades, in the neighbourhood of Attica, and the preceptor of Pindar. Both Plato and Cicero give him the character of a good poet and musician, and speak of him as a person of great virtue and wisdom. Such longevity gave him an opportunity of knowing a great number of the first characters in antiquity with whom he was in some measure connected. It appears in Fabricius, that Simonides was contemporary with Pittacus of Mitylene, Hipparchus, tyrant of Athens, Pausanias, king of Sparta, Hiero, tyrant of Syracuse, as well as with Themistocles, and with Alevades, king of Thessaly. He is mentioned by Herodotus; and Xenophon, in his *Dialogue upon Tyranny,* makes him one of the interlocutors with Hiero king of Syracuse. Cicero alleges, what has often been quoted in proof of the modesty and wisdom of Simonides, that when Hiero asked him for a definition of God, the poet required a whole day to meditate on so important a question. At the end of that time, upon the prince putting the question to him, he asked two days' respite, and in this manner always doubled the delay each time he was required to answer it; till at length, to avoid offending his patron by more disappointments, he frankly confessed that he found the question so difficult, that the more he meditated upon it, the less was his hope of being able to solve it.

In his old age, perhaps from seeing the respect which money procured to such as had lost the charms of youth, and the power of attaching mankind by other means, he became somewhat mercenary and avaricious. He was frequently employed by the victors at the games to write panegyrics and odes in their praise, before his pupil Pindar had exercised his talents in their behalf. But Simonides refused to gratify their vanity in this particular, till he had first tied them down to a stipulated sum for his trouble; and upon being upbraided for his meanness, he said, that he had two coffers, in one of which he had for many years put his pecuniary rewards, whilst the other was for honours, verbal thanks, and promises, that the first was pretty well filled, but the last remained always empty; and he made no scruple to confess in his old age, that of all the enjoyments of life, the love of money was the only one of which time had not deprived him.

He was frequently reproached for this vice; but he always defended himself with good humour. Upon being asked by Hiero's queen, whether it was more desirable to be learned or rich, he answered, that it was far better to be rich; for the learned were always dependent on the rich, and waiting at their doors; whereas, he never saw rich men at the doors of the learned. When he was accused of being so sordid as to sell part of the provisions with which his table was furnished by Hiero, he said he had done it in order "to display to the world the magnificence of that prince and his own frugality." To others he said, that his reason for accumulating wealth was, that "he would rather leave money to his enemies after death, than be troublesome to his friends whilst living."

He obtained the prize in poetry at the public games when he was fourscore years of age. According to Suidas, he added four letters to the Greek alphabet, and Pliny assigns to him the eighth string of the Lyre; but these claims are disputed by the learned.

His poetry was so tender and plaintive, that he acquired the cognomen of ***Melicertes***, sweet as honey, and the tearful eye of his muse was proverbial. Dionysius places him amongst those polished writers who excel in a smooth volubility, and flow on like plenteous and perennial rivers, in a course of even and uninterrupted harmony.

There is a second great poet of the name of Simonides recorded on the Marbles, and supposed to have been his grandson, who gained, in 478 before Christ, the prize in the games at Athens.

SIMONY, is the corrupt presentation of any one to an ecclesiastical benefice for money, gift, or reward. It is so called from the resemblance it is said to bear to the sin of Simon Magus, though the purchasing of holy orders seems to approach nearer to his offence. It was by the canon law a very grievous crime; and is so much the more odious, because, as Sir Edward Coke observes, it is ever accompanied with perjury, the presentee being not to commit simony.

SIMOOM, a hot wind which blows occasionally in the deserts of Africa, and probably in other widely extended countries parched in the same manner by a vertical sun. Its effects on the human body are dreadful. If inhaled in any quantity, it produces instant suffocation, or at least leaves the unhappy sufferer oppressed with asthma and lowness of spirits. The approach of this awful scourge is indicated by a redness in the air, well understood by those who are accustomed to journey through the desert; and the only refuge which they have from it, is to fall down with their faces close to the ground, and to continue as long as possible without drawing in their breath. Mr. Bruce, who, in his journey though the desert, suffered from the simoom, gives the following graphical description of this visitation. "At eleven o'clock, while we contemplated with great pleasure the rugged top of Chiggre, to which we were fast approaching, and where we were to solace ourselves with plenty of good water, Idris our guide cried out, with a loud voice, fall upon your faces, for here is the simoom. I saw from the south-east a haze come, in colour like the purple part of the rainbow, but not so compressed or thick. It did not occupy twenty yards in breadth, and was about twelve feet high from the ground. It was a kind of blush upon the air, and it moved very rapidly; for I scarce could turn to fall upon the ground with my head to the northward, when I felt the heat of its current plainly upon my face. We all lay flat on the ground as if dead, till Idris told us it was blown over. The meteor or purple haze which I saw was indeed passed, but the light air that still blew was of heat to threaten suffocation. For my part, I found distinctly in my breast that I had imbibed a part of it, nor was I free of an asthmatic sensation till I had been some months in Italy, at the baths of Poretta, near two years afterwards." Though the severity of this blast seems to have passed over them almost instantaneously, it continued to blow so as to exhaust them till twenty minutes before five in the afternoon, lasting through all its stages very near six hours, and leaving them in a state of the utmost despondency.

SIMPLON, a village in Switzerland, in the canton of the Vallais, only to be noticed from giving its name to the most magnificent of the roads over the Alps. This road, which leads from Switzerland into Piedmont, was constructed by Bonaparte betwixt the years 1801 and 1806, and has been long considered as one of the noblest monuments of his genius and power. It is near seventy English miles in length, is in every part twenty-five feet in breadth, and with an ascent so gentle, only one inch and a half in six feet, that the heaviest carriage can pass down on both sides of the mountain without the necessity of applying the drag chain. It passes over several frightful precipices. It is carried through six solid rocks by means of arches called galleries, where by gunpowder a passage has been bored. Out of these the passenger steps into lovely valleys with the huts of the shepherds sprinkled on the sides, and looks through forests of pines, to behold the glaciers and the snow-toped mountains in lofty regions of the air. Some bold bridges lead over the deep fissures from one rock to another. The Italian side presents more picturesque scenery than the Swiss side, from the rocks being much more rugged. On that side, too, is the grand gallery, 690 feet in length, excavated through a granite rock, called, from a remarkable cascade near it, the gallery of Frissinone. The greatest height which the road attains, is at the gallery of the glaciers, where trees cease to grow, being somewhat more than 6000 feet above the level of the sea, while the mountain above it rises to the height of 11,000 feet. Owing to the expences of this magnificent road being to be provided for by the governments of Sardinia and of Switzerland, several repairs have been deferred or neglected, and it has in parts fallen into decay.

SIMPSON, Thomas, professor of mathematics at the Royal Academy at Woolwich, fellow of the Royal Society, and member of the Royal Academy at Stockholm, was born at Market Bosworth in Leicestershire in 1710. His father, a stuff-weaver, taught him only to read English, and brought him up to his own business; but meeting with a scientific pedlar, who likewise practised fortune-telling, young Simpson by his assistance and advice left off weaving, and professed astrology. As he improved in knowledge, however, he grew disgusted with this pretended art; and renouncing it, was driven to such difficulties for the subsistence of his family, that he came up to London, where he worked as a weaver, and taught mathematics at his spare hours. As his scholars increased, his abilities became better known, and he published his Treatise on Fluxions, by subscription, in 1737; in 1740, he published his Treatise on the Nature and Laws of Chance, and Essays in Speculative and Mixed Mathematics. After these, appeared his Doctrine of Annuities and Reversions; Mathematical Dissertations; Treatise on Algebra; Elements of Geometry; Trigonometry, Plane and Spherical; Select Exercises; and his Doctrine and Application of Fluxions, which he professes to be rather a new work, than a second edition of his former publication on Fluxions. In 1743, he obtained the mathematical professorship at Woolwich academy; and soon afterwards was chosen a member of the Royal Society, when the president and council, in consideration of his moderate circumstances, were pleased to excuse his admission-fees, and his giving bonds for the settled future payments. At the academy he exerted all his abilities in instructing the pupils who were the immediate objects of his duty, as well as others whom the superior officers of the ordnance permitted to be boarded and lodged in his house. In his manner of teaching he had a peculiar and happy address, a certain dignity and perspicuity, tempered with such a degree of mildness, as engaged the attention, esteem, and friendship of his scholars. He therefore acquired great applause from his superiors in the discharge of his duty. His application and close confinement, however, injured his health. Exercise and a proper regimen were prescribed to him, but to little purpose; for his spirits sunk gradually, till he became incapable of performing his duty, or even of reading the letters of his friends. The effects of this decay of nature were greatly increased by vexation of mind, owing to the haughty and insulting behaviour of his superior, the first professor of mathematics. This person, greatly his inferior in mathematical accomplishments, did what he could to make his situation uneasy, and even to depreciate him in the public opinion; but it was a vain endeavour, and only served to depress himself. At length his physicians advised his native air for his recovery, and he set out in February 1761; but was so fatigued by his journey, that upon his arrival at Bosworth, he betook himself to his chamber, and grew continually worse till the day of his death, which happened on the 14th of May, in the fifty-first year of his age.

Simpson's *Island*, in the south Pacific Ocean, discovered by Captain Carteret in 1767, four miles west from Carteret's Island. Long. 159. 20. E. Lat. 8. 26. S.

SIMSON, Dr. Robert, professor of mathematics in the university of Glasgow, was born in the year 1687, of a respectable family, which had held a small estate in the county of Lanark for some generations. He was, we think, the second son of the family. A younger brother was professor of medicine in the university of St. Andrews, and is known by some works of reputation, particularly a *Dissertation on the Nervous System*, occasioned by the dissection of a brain completely ossified.

Dr. Simson was educated in the university of Glasgow under the eye of some of his relations who were professors. Eager after knowledge, he made great progress in all his studies; and, as his mind did not, at the very first openings of science, strike into that path which afterwards so strongly attracted him, and in which he proceeded so far almost without a companion, he acquired in every walk of science a stock of information, which, though it had never been much augmented afterwards, would have done credit to a professional man in any of his studies. He became at a very early period, an adept in the philosophy and theology of the schools, was able to supply the place of a sick relation in the class of oriental languages, was noted for historical knowledge, and one of the most accomplished botanists of his time.

It was during his theological studies, as preparatory for his entering into orders, that mathematics took hold of his fancy. He used to tell in his convivial moments how he amused himself when preparing his exercises for the divinity hall. When tired with vague speculation, in which he did not meet with certainty to reward his labours, he turned up a book of oriental philology, in which he found something which he could discover to be true or to be false, without going out of the line of study which was to be of ultimate use to him. Sometimes even this could not relieve his fatigue. He then had recourse to mathematics, which never failed to satisfy and refresh him. For a long while he restricted himself to a very moderate use of the cordial, fearing that he would soon exhaust the small stock which so limited and abstract a science could yield; till at last he found, that the more he learned, a wider field opened to his view, and scenes that were inexhaustible. Becoming acquainted with subjects far beyond the elements of the science, and with numbers of names celebrated during that period of ardent research all over Europe, he found it to be a manly and important study, by which he was as likely to acquire reputation as by any other. About this time, too, a prospect began to open of making mathematics his profession for life. He then gave himself up to it without reserve.

His original incitement to this study as a treat, as something to please and refresh his mind in the midst of more severe tasks, gave a particular turn to his mathematical studies, from which he never could afterwards deviate. Perspicuity and elegance are more attainable, and more discernible, in pure geometry, than in any other parts of the science of measure. To this therefore he chiefly devoted himself. For the same reason he preferred the ancient mode of studying pure geometry, and even felt a dislike to the Cartesian method of substituting symbols for operations of the mind, and still more was he disgusted with the substitution of symbols for the very objects of discussion, for lines, surfaces, solids, and their affections. He was rather disposed, in the solution of an algebraical problem, where quantity alone was considered, to substitute figure and its affections for the algebraical symbols, and to convert the algebraic formula into an analogous geometrical theorem. And he came at last to consider algebraic analysis as little better than a kind of mechanical knack, in which we proceed without ideas of any kind, and obtain a result without meaning, and without being conscious of any process of reasoning, and therefore without any conviction of its truth. And there is no denying, that if genuine unsophisticated taste alone is to be consulted, Dr. Simson was in the right; for though it must also be acknowledged, that the reasoning in algebra is as strict as in the purest geometry of Euclid or Apollonius, the expert analyst has little perception of it as he goes on, and his final equation is not felt by himself as the result of ratiocination, any more than if he had obtained it by Pascal's arithmetical mill. This does not in the least diminish our admiration of the algebraic analysis; for its almost boundless grasp, its rapid and certain procedure, and the delicate metaphysics and great address which may be displayed in conducting it. Such, however, was the ground of the strong bias of Dr. Simson's mind to the analysis of the ancient geometers. It increased as he went forward; and his veneration for the ancient geometry was carried to a degree of idolatry. His chief labours were exerted in efforts to restore the works of the ancient geometers; and he has nowhere bestowed much pains in advancing the modern discoveries in mathematics. The noble inventions, for example, of fluxions and of logarithms, by which our progress in mathematical knowledge, and in the useful application of this knowledge, is so much promoted, attracted the notice of Dr. Simson; but he has contented himself with demonstrating their truth on the genuine principles of the ancient geometry. Yet was he thoroughly acquainted with all the modern discoveries; and there are to be seen amongst his papers, discussions and investigations in the Cartesian method, which show him thoroughly acquainted with all the principles, and even expert in the *tours de main*, of the most refined symbolical analysis.[1]

About the age of twenty-five, Dr. Simson was chosen professor of mathematics in the university of Glasgow. He went to London immediately after his appointment, and there formed an acquaintance with the most eminent men of that bright era of British science. Amongst these he always mentioned Captain Halley (the celebrated Dr. Edmund Halley) with particular respect; saying, that he had the most acute penetration, and the most just taste in that science, of any man he had ever known. And, indeed, Dr. Halley has strongly exemplified both of these in his divination of the work of Apollonius *de Sectione Spatii*, and the eighth book of his *Conics*, and in some of the most beautiful theorems in Sir Isaac Newton's *Principia*. Dr. Simson also admired the wide and masterly steps which Newton was accustomed to take in his investigations, and his manner of substituting geometrical figures for the quantities which are observed in the phenomena of nature. It was from Dr. Simson that the writer of this article had the remark which has been oftener than once repeated in the course of this work, "That the thirty-ninth proposition of the first book of the *Principia* was the most important proposition that had ever been exhibited to the physico-mathematical philosopher;" and he used always to illustrate to his more advanced scholars the superiority of the geometrical over the algebraic analysis, by comparing the solution given by Newton of the inverse problem of centripetal forces, in the forty-second proposition of that book, with the one given by John Bernoulli in the Memoirs of the Academy of Sciences at Paris for 1713. We have heard him say, that to his own knowledge Newton frequently investigated his propositions in the symbolical way, and that it was owing chiefly to Dr. Halley that they did not finally appear in that dress. But if Dr. Simson was well informed, we think it a great argument in favour of the symbolical analysis, when this most successful practical artist (for so we must call Newton when engaged in a task of discovery) found it conducive either to dispatch or perhaps to his very progress.

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[1] In 1752 the writer of this article, being then his scholar, requested him to examine an account which he gave him of what he thought a new curve (a conchoid having a circle for its base.) Dr. Simson returned it next day with a regular list of its leading properties, and the investigation of such as he thought his scholar would not so easily trace. In this hasty scrawl the lines related to the circle were familiarly considered as arithmetical fractions of the radius considered only as unity. This was before Euler published his Arithmetic of the Sines and Tangents, now in universal use.

Returning to his academical chair, Dr. Simson discharged the duties of a professor for more than fifty years, with great honour to the university and to himself.

It is almost needless to say, that in his prelections he followed strictly the Euclidian method in elementary geometry. He made use of Theodosius as an introduction to spherical trigonometry. In the higher geometry, he prelected from his own Conics, and he gave a small specimen of the linear problems of the ancients, by explaining the properties, sometimes of the conchoid, sometimes of the cissoid, with their application to the solution of such problems. In the more advanced class, he was accustomed to give Napier's mode of conceiving logarithms, that is, quantities as generated by motion, and Mr. Coats's view of them, as the sums of ratiunculæ; and to demonstrate Newton's lemmas concerning the limits of ratios, and then to give the elements of the fluxionary calculus; and to finish his course with a select set of propositions in optics, gnomonics, and central forces. His method of teaching was simple and perspicuous, his elocution clear, and his manner easy and impressive. He had the respect, and still more the affection, of his scholars.

With respect to his studies, we have already informed the reader that they got an early bias to pure geometry, and to the elegant but scrupulous methods of the ancients. We have heard Dr. Simson say, that it was in a great measure owing to Dr. Halley that he so early directed his efforts to the restoration of the ancient geometers. He had recommended this to him, as the most certain way for him, then a very young man, both to acquire reputation, and to improve his own knowledge and taste; and he presented him with a copy of Pappus's *Mathematical Collections*, enriched with some of his own notes. The perspicuity of the ancient geometrical analysis, and a certain elegance in the nature of the solutions which it affords, especially by means of the local theorems, soon took firm hold of his fancy, and made him, with the sanguine expectation of a young man, direct his very first efforts to the recovery of this *in toto;* and the restoration of Euclid's *Porisms* was the first task to which he set himself. The accomplished geometer knows what a desperate task this was, from the scanty and mutilated account which we have of this work in a single passage of Pappus. It was an ambition which nothing but success could justify in so young an adventurer. He succeeded; and as early as 1718, seemed to have been in complete possession of this method of investigation, which was considered by the eminent geometers of antiquity as their surest guide through the labyrinths of the higher geometry. Dr. Simson gave a specimen of his discovery in 1723, in the *Philosophical Transactions;* and after this time he ceased not from his endeavours to recover that choice collection of Porisms which Euclid had collected, as of the most general use in the solution of difficult questions. What some of these must have been, was pointed out to Dr. Simson by the very nature of the general proposition of Pappus, which he has restored. Others were pointed out by the lemmas which Pappus has given as helps to the young mathematician towards their demonstration. And, being thus in possession of a considerable number, their mutual relations pointed out a sort of system, of which these made a part, and the blanks of which now remained to be filled up.

Dr. Simson, having thus gained his favourite point, had leisure to turn his attention to the other works of the ancient geometers; and the porisms of Euclid now had only an occasional share. The *loci plani* of Apollonius was another task which he very early engaged in, and completed about the year 1738. But, after it was printed, he imagined that he had not given the *ipsissimæ propositiones* of Apollonius, and in the precise spirit and order of that author. The impression lay by him for some years; and it was with great reluctance that he yielded to the entreaties of his mathematical friends, and published the work, in 1746, with some emendations, where he thought he had deviated farthest from his author. He quickly repented of this scanty concession, and recalled what he could of the small number of copies which he had given to the booksellers, and the impression again lay by him for years. He afterwards recorrected the work, and still with some reluctance allowed it to come abroad as the *Restitution of Apollonius.* The public, however, had not been so fastidious as Dr. Simson, and the work had acquired great celebrity, and he was now considered as one of the first and the most elegant geometers of the age; for, in the meantime, he had published his *Conic Sections*, a work of uncommon merit, whether we consider it as equivalent to a complete restitution of the celebrated work of Apollonius Pergæus, or as an excellent system of this important part of mathematics. It is marked with the same features as the *loci plani*, the most anxious solicitude to exhibit the very text of Apollonius, even in the propositions belonging to the books which had been completely lost. These could be recovered in no other way but by a thorough knowledge of the precise plan proposed by the author, and by taking it for granted that the author had accurately accomplished this plan. In this manner did Viviani proceed in the first attempt which was made to restore the conics of Apollonius; and he has given us a detail of the process of his conjectures, by which we may form an opinion of its justness, and of the probability how far he has attained the desired object. Dr. Simson's view in his performance was something different, deviating a little in this one case from his general track. He was not altogether pleased with the work of Viviani, even as augmented by the eighth book added by Halley, and his wish was to restore the ancient original. But, in the meantime, an academical text-book for conic sections was much wanted. He was much dissatisfied with those in common use; and he was not insensible of the advantage resulting from the considerations of these sections, independent of the cone first introduced by Dr. Wallis. He therefore composed this excellent treatise as an elementary book, not to supersede, but to prepare for the study of Apollonius; and accordingly he accommodates it to this purpose, and gives several important propositions in their proper places, expressly as restitutions of Apollonius, whom he keeps constantly in view through the whole work.

Much about this time, Dr. Simson seriously began to prepare a perfect edition of Euclid's *Elements*. The intimate acquaintance which he had by this time acquired with all the original works of the ancient geometers, and their ancient commentators and critics, encouraged him to hope that he could restore to its original lustre this leader in mathematical science; and the errors which had crept into this celebrated work, and which still remained in it, appeared ot magnitude sufficient to merit the most careful efforts for their removal. The *data* also, which were in like manner the introduction to the whole art of geometrical investigation, seemed to call more loudly for his amending hand. For it appears that the Saracens, who have preserved to us the writings of the ancients, have contented themselves with admiring these celebrated works, and have availed themselves of the knowledge which they contain; but they have shewn no inclination to add to the stock, or to promote the sciences which they had received. They could not do any thing without the synthetical books of the geometers; but, not meaning to go beyond the discoveries which they had made, they neglected all the books which related to the analytic art alone, and the greatest part of them (about twenty-five out of thirty) have irrecoverably perished. The data of Euclid have fortunately been preserved, but the book was neglected, and the only ancient copies, which are but three or four, are miserably erroneous and mutilated. Fortunately, it is no very arduous matter to reinstate this work in its original perfection. The plan is precise, both in its extent and its method. It has been restored, therefore, with success by more than one author. But Dr. Simson's comprehensive view of the whole analytical system pointed out to him many occasions for amendment. He therefore made its restitution a joint task with that of the elements. All the lovers of true geometry will acknowledge their obligations to him for the edition of the *Elements* and *Data* which he published about 1758. The text is corrected with the most judicious and scrupulous care, and the notes are inestimable, both for their information, and for the tendency which they must have to form the mind of the student to a true judgment and taste in mathematical subjects. The more accomplished reader will perhaps be sometimes disposed to smile at the axiom which seems to pervade the notes, "that a work of Euclid must be supposed without error or defect." If this was not the case, Euclid has been obliged to his editor in more instances than one. Nor should his greatest admirers think it impossible, that in the progress of human improvement, a geometrical truth should occur to one of these latter days, which escaped the notice of even the lynx-eyed Euclid. Such merit, however, Dr. Simson nowhere claims, but lays every blame of error, omission, or obscurity, to the charge of Proclus, Theon, and other editors and commentators of the renowned Grecian.

There is another work of Apollonius on which Dr. Simson has bestowed great pains, and has restored, as we imagine, *omnibus numeris perfectum*, namely, the *Sectio Determinata*; one of those performances which are of indispensable use in the application of the ancient analysis. This also seems to have been an early task, though we do not know the date of his labours on it. It did not appear till after his death, being then published along with the great work, the *Porisms* of Euclid, at the expense of the Earl Stanhope, a nobleman intimately conversant with the ancient geometry, and zealous for its reception amongst the mathematicians of the present age. He had kept up a constant correspondence with Dr. Simson on mathematical subjects; and at his death in 1768, engaged Mr. Clow, professor of logic in the university of Glasgow, to whose care the Doctor had left all his valuable papers, to make a selection of such as would serve to support and increase his well-earned reputation as the restorer of ancient geometry.

We have been thus particular in our account of Dr. Simson's labours in these works, because his manner of execution, whilst it does honour to his inventive powers, and shews his just taste in mathematical composition, also confirms our former assertion, that he carried his respect for the ancient geometers to a degree of superstitious idolatry, and that his fancy, unchecked, viewed them as incapable of error or imperfection. This is distinctly to be seen in the emendations which he has given of the texts, particularly in his editions of Euclid. Not only every imperfection of the reading is ascribed to the ignorance of copyists, and every indistinctness in the conception, inconclusiveness in the reasoning, and defect in the method, is ascribed to the ignorance or mistake of the commentators; but it is all along assumed that the work was perfect in its kind, and that by exhibiting a perfect work, we restore the genuine original. This is surely gratuitous; and it is very possible that it has, in some instances, made Dr. Simson fail of his anxious purpose, and give us even a better than the original. It has undoubtedly made him fail in what should have been his great purpose, namely, to give the world a connected system of the ancient geometrical analysis, such as would, in the first place, exhibit it in its most engaging form, elegant, perspicuous, and comprehensive; and, in the next place, such as should engage the mathematicians of the present age to adopt it as the most certain and successful conductor in those laborious and difficult researches in which the demands of modern science continually engage them. And this might have been expected, in the province of speculative geometry at least, from a person of such extensive knowledge of the properties of figure, and who had so eminently succeeded in the many trials which he had made of its powers. We might have expected that he would at least have exhibited in one systematic point of view, what the ancients had done in several detached branches of the science, and how far they had proceeded in the solution of the several successive classes of problems; and we might have hoped, that he would have instructed us in what manner we should apply that method to the solution of problems of a more elevated kind, daily presented to us in the questions of physico-mathematical science. By this he would have acquired distinguished honour, and science would have received the most valuable improvement. But Dr. Simson has done little of all this; and we cannot say that great helps have been derived from his labours by the eminent mathematicians of this age, who are successfully occupied in advancing our knowledge of nature, or in improving the arts of life. He has indeed contributed greatly to the entertainment of the speculative mathematician, who is more delighted with the conscious exercise of his own reasoning powers, than with the final result of his researches. Yet we are not even certain that Dr. Simson has done this to the extent he wished and hoped. He has not engaged the liking of mathematicians to this analysis, by presenting it in the most agreeable form. His own extreme anxiety to tread in the very footsteps of the original authors, has, in a thousand instances, precluded him from using his own extensive knowledge, that he might not employ principles which were not of a class inferior to that of the question in hand. Thus, of necessity, did the method appear trammelled. We are deterred from employing a process which appears to restrain us in the application of the knowledge which we have already acquired; and, disgusted with the tedious, and perhaps indirect path, by which we must arrive at an object which we see clearly over the hedge, and which we could reach by a few steps, of the security of which we are otherwise perfectly assured. These prepossessions are indeed founded on mistake; but the mistake is such, that all fall into it, till experience has enlarged their views. This circumstance alone has hitherto prevented mathematicians from acquiring that knowledge of the ancient analysis which would enable them to proceed in their researches with certainty, dispatch, and delight. It is therefore deeply to be regretted, that this eminent genius has occupied, in this superstitious palæology, a long and busy life, which might have been employed in original works of infinite advantage to the world, and honour to himself.

Our readers will, it is hoped, consider these observations as of general scientific importance, and as intimately connected with the history of mathematics; and therefore as not improperly introduced in the biographical account of one of the most eminent writers on this science. Dr. Simson claimed our notice as a mathematician; and his affectionate admiration of the ancient analysis is the prominent feature of his literary character. By this he is known all over Europe; and his name is never mentioned by any foreign author without some very honourable allusion to his distinguished geometrical elegance and skill. Dr. James Moor, professor of Greek in the University of Glasgow, no less eminent for his knowledge in ancient geometry than for his professional talents, put the following apposite inscription below a portrait of Dr. Simson: "Geometriam, sub Tyranno barbaro sæva servitute diu squalentem, in libertatem et decus antiquum vindicavit unus."

Yet it must not be understood that Dr. Simson's predilection for the geometrical analysis of the ancients did so far mislead him as to make him neglect the symbolical analysis of the present times; on the contrary, he was completely master of it, as has been already observed, and frequently employed it. In his academical lectures to the students of his upper classes, he used to point out its proper province, which he by no means limited by a scanty boundary, and in what cases it might be applied with safety and advantage even to questions of pure geometry. He once honoured the writer of this article with the sight of a very short dissertation on this subject, perhaps the one referred to in the preface to his *Conic Sections*. In this piece he was perhaps more liberal than the most zealous partizans of the symbolical analysis could desire, admitting as a sufficient equation of the Conic Sections $L=\frac{p^2\ c}{x^2}$, where L is the *latus rectum*, x is the distance of any point of the curve from the focus, p is the perpendicular drawn from the focus to the tangent in the given point, and c is the chord of the equicurve circle drawn through the focus. Unfortunately this dissertation was not found amongst his papers. He spoke in high terms of the analytical works of Cotes, and of the two Bernoullis. He was consulted by Mr. Maclaurin during the progress of his inestimable *Treatise of Fluxions*, and contributed not a little to the reputation of that work. The spirit of that most ingenious algebraic demonstration of the fluxions of a rectangle, and the very process of the argument, is the same with Dr. Simson's in his dissertation on the limits of quantities. It was therefore from a thorough acquaintance with the subject, and by a just taste, that he was induced to prefer his favourite analysis, or, to speak more properly, to exhort mathematicians to employ it in his own sphere, and not to become ignorant of geometry, while he successively employed the symbolical analysis in cases which did not require it, and which suffered by its admission. It must be acknowledged, however, that in his later years, the disgust which he felt at the artificial and slovenly employment on subjects of pure geometry, sometimes hindered him from even looking at the most refined and ingenious improvements of the algebraic analysis which occur in the writings ef Euler, D'Alembert, and other eminent masters. But, when properly informed of them, he never failed to give them their due praise; and we remember him speaking, in terms of great satisfaction, of an improvement of the infinitesmal calculus, by D'Alembert and D'Lagrange, in their researches concerning the propagation of sound, and the vibration of musical cords.

And that Dr. Simson was not only master of this calculus and the symbolical calculus in general, but held them in proper esteem, appears from two valuable dissertations to be found in his posthumous works; the one on logarithms, and the other on the limits of ratios. The last, in particular, shews how completely he was satisfied with respect to the solid foundation of the method of fluxions; and it contains an elegant and strict demonstration of all the applications which have been made of the method by its illustrious author to the objects of pure geometry.

We hoped to have given a much more complete and instructive account of this eminent geometer and his works, by the aid of a person fully acquainted with both, and able to appreciate their value; but an accident has deprived us of this assistance, when it was too late to procure an equivalent. And we must request our readers to accept of this very imperfect account, since we cannot do justice to Dr. Simson's merit unless almost equally conversant in all the geometry of the ancient Greeks.

The life of a literary man rarely teems with anecdote; and a mathematician, devoted to his studies, is perhaps more abstracted than any other person from the ordinary occurrences of life, and even the ordinary topics of conversation. Dr. Simson was of this class; and, having never married, lived entirely a college life. Having no occasion for the commodious house to which his place in the university entitled him, he contented himself with chambers, good, indeed, and spacious enough for his sober accommodation, and for receiving his choice collection of mathematical writers, but without any decoration or commodious furniture. His official servant sufficed for valet, footman, and chambermaid. As this retirement was entirely devoted to study, he entertained no company in his chambers, but in a neighbouring house, where his apartment was sacred to him and his guests.

Having in early life devoted himself to the restoration of the works of the ancient geometers, he studied them with unremitting attention; and, retiring from the promiscuous intercourse of the world, he contented himself with a small society of intimate friends, with whom he could lay aside every restraint of ceremony or reserve, and indulge in all the innocent frivolities of life. Every Friday evening was spent in a party at whist, in which he excelled, and took delight in instructing others, till increasing years made him less patient with the dulness of a scholar. The card-party was followed by an hour or two dedicated solely to playful conversation. In like manner, every Saturday he had a less select party to dinner at a house about a mile from town. The Doctor's long life gave him occasion to see the *dramatis personæ* of this little theatre completely changed, whilst he continued to give it a personal identity; so that, without any design or wish of his own, it became, as it were, his own house and his own family, and went by his name.

Dr. Simson was of a good stature, with a fine countenance; and even in his old age he had a graceful carriage and manner, and always, except when in mourning, dressed in light coloured clothes. He was of a cheerful disposition; and though he did not make the first advances to acquaintance, had the most affable manner, and strangers were at perfect ease in his company. He enjoyed a long course of uninterrupted health; but toward the close of life suffered from an acute disease, and was obliged to employ an assistant in his professional labours for a few years preceding his death, which happened in 1768, at the age of eighty-one. He left to the university his valuable library, which is now arranged apart from the rest of the books, and the public use of it is limited by particular rules. It is considered as the most choice collection of mathematical books and manuscripts in the kingdom, and many of them are rendered doubly valuable by Dr. Simson's notes. (B.B.B.)

SINAI, a celebrated mountain of Arabia, near the head of the Red sea, the place whence the divine law was given by Moses. It is surrounded by a vast and gloomy desert, the few inhabited spots of which are occupied by the Arabs, who live by plunder, and attack all passengers unless they form part of a large and well defended caravan. Mount Sinai belongs to the range of mountains called by the Arabs Zibbel Musa, and consists of several lofty summits, separated by frightful gulfs between precipitous rocks. At the foot of the mountain is the Greek convent of St. Catherine, founded in 1331. It is 120 feet in length and almost as many in breadth, built entirely of hewn stone. In this convent, the monks remain imprisoned by the wild Arabs of the surrounding country; and they are supplied with provisions by a basket drawn up by a cord and pulley to the height of thirty feet. The predatory bands of Arabs often fire upon the convent from the rocks adjacent, and make prisoners of the monks who venture beyond the walls, for whose restoration they exact a considerable ransom. The convent has an excellent garden at a little distance, which is reached by a subterraneous passage secured with iron gates. It has a temperate climate, owing to the elevation, and snow sometimes falls. Fruits, plants, and vegetables, are produced in the utmost profusion. The convent is eighty feet long and fifty-three broad, paved with marble and adorned with a variety of figures. It has many lamps of gold and silver, and the grand altar is gilded and adorned with jewels. The ascent of the mountain is steep, and is by steps cut in the rock, or loose stones piled in succession. A Christian church and a Turkish mosque crowns the summit of Mount Sinai; the former now greatly dilapidated. It commands a most extensive view over the Red Sea and the opposite coast of Thebais; beneath is the port of Tor, by which the commodities of India were formerly conveyed to Egypt. The descent is even more rugged and steep than the ascent; and terminates at the monastery of the Forty Saints, which has been plundered often by the Arabs. On the other side is the still loftier mountain of St. Catherine, 150 miles east of Suez.

SINCLAIR'S ROCKS, four small rocks off the south coast of New Holland, included by Capt. Hindens in Nuyt's archipelago.

SINDANGAN BAY, on the north-west coast of Mindanao, extending from north to south about 100 miles. Long. 123. 52. Lat. 8. 15. N.

SINDE, an extensive kingdom of Hindustan, which extends from the district of Shikarpoor on the frontier of Cabul, and the island of Bukkor in the Indus, along the level plain, watered by that river to the sea; in length about two hundred and fifty miles by eighty miles in average breadth. The general boundaries are the British principality of Cutch and the Indian ocean to the south; the kingdom of Jessulmere and the Rejistah, or Sandy Desert, to the east, which extends from the territories of Cutch five hundred and fifty miles in length by a hundred and fifty in breadth; the mountains of Belochistan on the west; and the provinces of Seewistan and Bahawulpoor on the north. It is a flat alluvial country, situated between the 23d and 27th degrees of north latitude, and the 67th and 71st degrees of east longitude; and is crossed in a diagonal direction by the Indus and its branches, which form a delta, in length about a hundred miles along the coast. The lower part of this delta is intersected by numerous rivers and creeks, like the delta of the Ganges, but it has no trees on it, the dry parts being covered with brush-wood, and the remainder, by much the greater part, being noisome swamps, or muddy lakes. The streams which break off from the Indus, diverge in all directions into other streams, which interlock into each other, and chequer the whole country. To trace in detail those complicated branches into which the main stream is thus divided would be useless. All those various streams which overspread the country, greatly increase its fertility; but often prove pernicious to those who dwell on the banks, by the exhalations which arise under a tropical sun, from the annual inundations. "Few countries," says Major Rennel, "are more unwholesome to European constitutions, particularly the lower part of the delta."

Sinde.

Sinde may be termed a level country, intersected with rocky hills. Those tracts which are within the limits of the inundation, rival in fertility the borders of the Nile. Even those parts which are at a distance from the river, are capable of being cultivated, provided there is no failure in the periodical rains. This, however, frequently happens, as no country in the world is more subject to drought. During great part of the south-west monsoon, or at least in the months of July, August, and part of September, which is the season of the periodical rains in most parts of India, the atmosphere is generally clouded, but no rain falls, except very near the sea. At Tatta, when it was visited by Captain Hamilton, no rain had fallen for three years. Owing to this, and to the vicinity of the sandy deserts, which bound this country on the east, and on the north-west, the heats are so violent, and the winds from these quarters so unwholesome, that the houses are contrived so as to be ventilated by means of apertures on the top of them, resembling the funnels of small chimneys. During the prevalence of the hot winds, the windows are shut in order to exclude the lower and hottest current of the air, along with the clouds of dust which it sets in motion; and the cooler portion descends into the house through the funnels.[1] When Lieutenant now Colonel Pottinger was at Tatta with the mission that was sent to the court of Hydrabad in 1808, the rains were extremely violent; they descended so heavily that the streets frequently ran like rivulets; and in the coolest apartment, the thermometer usually ranged from 94 to 102; this was in June. Towards the middle of July it became much cooler, and strong northerly gales set in, which cooled the air; and at Hydrabad, during the summer season, the mission experienced the heaviest falls of rain, which caused the Futelee river to overflow its banks; and owing to the exhalations from a burning sun, the thermometer seldom falling below 102, and the atmosphere at night being particularly oppressive, beyond, Colonel Pottinger observes, what he had ever experienced in India, the followers of the mission were attacked by fevers and other complaints; and it was only by taking regular exercise, and using requisite precautions, that the gentlemen of the mission continued to maintain themselves in health.[2]

The country increases in barrenness as it recedes eastward from the Indus, and its tributaries; and in the vicinity of the Northern Runn, it is described by Dr. Burnes, who travelled through this country in 1825, as a dead unproductive flat, a perfect desert, in which not a tree, house, nor human being, was to be seen, and where it was even difficult to procure a little brackish water from the stagnant marshes that were occasionally seen. For about fifty miles eastward from Cutch, as far as the town of Ruree, and nearly the same distance from the Indus, the country presents the same aspect; namely, a sterile flat. The town of Ruree, though superior to most of the towns in this country, yet being removed beyond the freshes of the Indus, had suffered severely from drought, so that the inhabitants were reduced below 500.[3] The villages which are met with in this country, have also the same miserable appearance, being far inferior to those of Cutch, on the eastern side of the Runn. In place of the stone buildings, and tiled roofs, which give an air of neatness and comfort to those of the latter country, they are for the most part collections of low huts, composed of clay and thatch; and even the mosques are built of the same frail materials, of rather greater elevation indeed, and with a feeble attempt at ornament. Many of the inhabitants inhabit grass hovels in the fields, from which, by hard labour, they extort a miserable subsistence. When either food or forage fail, it is not unusual for the whole population of a village to migrate to another station, as choice or necessity prompts them. Westward, the country gradually improves, and on approaching the region of the inundation, it presents an appearance of extensive cultivation, and the richness of the soil is everywhere remarkable. It is intersected by numerous canals from the branches of the Indus, dug for the purposes of navigation, and over which small brick bridges have been thrown, on which water wheels are placed, by which a supply of moisture is distributed over the fields. The country in the vicinity of Hydrabad assumes a hilly appearance; and westward of the Indus it is bounded by a pile of barren mountains, that are quite as inhospitable, both as to soil and climate, as the sandy desert which is seen at a distance from the Indus and its waters. Near the sea at Kurachee, in latitude 24. 52. north, longitude 67. 17. east, west of the river, the country is, for eight or ten miles, a dead flat; and as, when it was visited by Pottinger, there had been a want of rain for several seasons, the earth was quite burned, without the slightest trace of vegetation, except some small stunted bushes scattered over the plain. But the inhabitants assured him that in forty-eight hours after a plentiful fall of rain, the ground would be a perfect grass plat, moisture being here, as in other hot regions, the great agent of fertility.

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[1] Rennel's Memoir of a Map of Hindostan, p. 290.

[2] Pottinger's Narrative, chap. 10, p. 368.

[3] See Narrative of a Visit to the Court of Sinde, by James Burnes, p. 36.

Climate.

The climate is hot; the thermometer varying, in the months of June and July, from 90 to 100; and the country is within the range of the monsoons, and the periodical rains. It is mentioned, however, by Dr. Burnes, that in January 1828, the rain fell in torrents at Hydrabad, which was attended with more piercing cold than he had ever experienced in Europe. In the northern parts of Sinde the air is pure, and refreshed by the cooling breezes from the westward, so that the heat is far from being intolerable. On the western bank of the river, from the latitude of Sehwan in 26. 6., there is a variety of feature in the face of the country, some districts being mountainous, some flat, some intersected by ranges of low mountains down to the sea.[1]

The banks of the Indus near Hydrabad, and generally throughout its lower course, are well cultivated, except where the Ameers, the rulers of the country, have converted the most fruitful fields and districts into gloomy and impervious forests for the preservation of game; those princes being unfortunately passionately fond of hunting, and like all despotic princes, gratifying their inclinations at whatever expense of misery to their subjects. It is mentioned that one of the princes, Meer Futteh Ali, depopulated one of the most fertile spots in the neighbourhood of Hydrabad, which yielded two to three lacs of rupees annually, because frequented by a peculiar species of antelope, which he found great pleasure in hunting. And the youngest brother, Mourad Ali, banished the inhabitants of an ancient village and razed it to the ground, because the crowing of cocks, and the grazing of cattle, disturbed the game in the neighbouring lands, which were contiguous. The game laws of Europe are sufficiently tyrannical; but they are fortunately corrected by the milder influence of manners. During the swelling of the river, grain and other seeds are reared; the remainder of the year is employed in the production of indigo, sugar-cane, and all kinds of grain. They have also extensive pastures; and the country would rapidly advance in wealth, but for the oppressive rapacity of the government. It is the heavy taxes which ruin industry in this, as in most other eastern countries. Every beegah of land watered by a canal or wheel, pays a revenue of from $1\frac{1}{2}$ to $3\frac{1}{2}$ rupees to the government. A duty of one rupee is also charged on each kunwar, or 120 pounds of grain reaped by the farmers. Garden land producing fruit trees, pays $2\frac{1}{2}$ rupees per beegah; and the spring crop of tobacco is rated at $4\frac{1}{2}$ rupees per beegah. The tax on sugar is collected in kind, and is $4\frac{1}{2}$ rupees per beegah. But these are not the only exactions with which agriculture is burdened. Its produce has to pay other dues in the market before it is allowed to be sold. Boats that arrive at Tatta are all taxed in proportion to their value; and these exactions generally exceed the original cost of the articles on which they are imposed. The revenues that are derived from Kurachee, situated west of the Indus, at the south-western extremity of Sinde, of which it has become of late years the principal sea-port, are farmed, agreeable to the wretched policy that obtains throughout this country; and in 1809, according to the information of the able and enterprising traveller, Lieutenant Pottinger, there was paid on this account, into the public treasury, 99,000 rupees, or L.12,375; and the vender was supposed to clear 12,000 rupees. The revenues have since increased to one lack 23,000 rupees, equal to L.15,375. This increase of revenue is ascribed solely to the local advantages of the port, being a central point between India and the dominions of Cabul, as also Khorassan, Balk, Bokhara, &c. The disorderly state of the country, from the decreasing authority of the Khan of Kelat, diverted the trade into this route through Sinde, the merchants finding the heavy exactions imposed on them more tolerable than the risk of violence to which they were exposed in other parts.

It has been remarked that despotic power, wielded by wisdom and goodness, would constitute the best government. But unfortunately, in Sinde it is wielded neither by wisdom nor goodness, but is a fearful instrument of rapacity and oppression, in the hands of the tyrants who rule the country, who, having no conception that it is for their own interest that the people should thrive, despoil them of their wealth, thus crushing the seeds of future accumulation, and for ever preventing any improvement of the national revenues. Under this short-sighted policy, the imposts and taxation in Sinde, according to Dr. Burnes, whose work affords valuable information on this subject, are enormous, and paralyze the whole trade and industry of the country. With the characteristic recklessness of an arbitrary government, the revenues are farmed to the highest bidders, who, as they are responsible to their task-masters for the produce, and can never expect indulgence on any pretence, are obliged to satisfy their rapacity, and to extort a revenue by whatever means from the impoverished people. Were it not for the great natural advantages with which the country is blessed, in the never-failing supply of moisture from the inundation of the Indus, which renders the cultivator independent of the tropical rains, her industry must have sunk under the manifold evils of ignorance and misrule. This is a source of fertility, of which no tyranny can despoil this highly favoured land; and thus the bounty of Providence is here more effectual to renovate, than the wickedness of man to destroy. The cultivator looks with certainty to an abundant harvest, and is enabled to export of his abundance to other countries. "Hence," says the judicious traveller already referred to, "there is an appearance of plenty and contentment throughout this misgoverned land, which would surprise any traveller who did not take every circumstance into consideration." Certain checks, however imperfect, no doubt exist to the excesses of despotic power. The farmers of the revenues are generally Hindus, who have no influence with the Ameers, by whom they are despised for their religion, and envied on account of their wealth; and on this account, they are the more ready to listen to any complaints against their oppressions from the Ryots, and to grant them redress. This, however, is but a feeble safeguard against oppression; and it too often happens that the interests of the two parties lead them to unite in the spoliation of the helpless villager.

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[1] Pottinger's Narrative of a Journey through Belochistan, chap. 9. p. 361.

The principal articles of domestic produce, which are exported chiefly from Kurachee, are rice, ghee, hides, shark fins, potash, saltpetre, assafœtida, bdellium, madder, frankincense, Tatta-cloths, indigo, oleaginous and other seeds. From Mooltan, and the countries to the northward, are imported for re-exportation, alum, musk, horses, Kashmeer shawls, dried fruit, diamonds, lapis lazuli, turquoise, and other precious stones and gums. Other imports are tin, iron, lead, steel, ivory, European manufactures, sandal and other scented woods, from the south of India; swords and carpets from Khorasan and Candahar, silk and other articles from the Persian Gulf. The merchants who are settled here from Mooltan are the principal traders, and the wealthiest part of the community. The exports from Sinde to Bombay consist of sharks' fins and flesh, bdellium, ghee, potash, saltpetre, hides, oil of sesame, wheat, assafœtida, oil, raisins, almonds, colouring plants, pistachio flowers and nuts, shawls, cloths, mustard, wild saffron, black cummin seed from Kerman, white cummin seed, chintzes both from Sinde and Khorasan. In return are received from Bombay, sugar, sugar-candy, steel, iron, tin, tutenaque, lead, cochineal, betel-nut, black pepper, dried cocoa nuts, vermillion, red lead, quicksilver, Bengal and China silks and cloths, cinnamon, cardamoms, cloves, nutmegs, sandal-wood, grapes, china ware, pearls, aloes, and amuttas. A considerable trade is carried on with Muscat, Cutch, and with Mooltan and Cabul. To Muscat the exports are dressed leather, rice, wheat, sirshif oil, ghee, bdellium, chintzes, and other cloths; for which the returns are dates, limes, roses, silk from the Persian province of Ghilan, elephants' teeth, pearls, almonds, preserved fruit, cowries, slaves, arsenic, senna from Mecca, quince seeds, and gum. From Cutch it derives a supply of cotton, snuff, unwrought iron found in Cutch, and the small Arabian aloe. The Indus affords an easy means of intercourse with this province and the countries to the northward, being navigable for small vessels to a great distance from the sea. With Mooltan and Cabul the trade is carried on chiefly by caravans, and also by merchants and travellers. It is proper to add, that the trade in the Indus had greatly decayed, and had become merely nominal, the ignorant and tyrannical policy of the Ameers having nearly crushed it in that province, and the unsettled state of the countries to the northward rendering it precarious in that quarter. In 1808 it was carried on by a few boats passing up and down with grain, saltpetre, salt, and firewood; though, with the increasing ascendancy of the British in this quarter, and the restoration of order and peace in these former regions of anarchy, the former intercourse has revived, and will now be carried on with greater security than ever. A factory, established at Tatta in 1756 by the East India Company, which carried on a considerable trade with the province of Sinde, and was withdrawn, probably from the demoralised state and poverty of the country; though so late as the beginning of the present century, Mr. Crow was a commercial resident at Tatta. An unsuccessful attempt was since made in 1808 to renew the intercourse; but the haughty and jealous chieftains who ruled in this province rejected all advances on the part of the British. Ever since the occupation of Cutch by the British troops in 1819, they viewed the extension of their dominions with distrust, and maintained a cold and unfriendly attitude. No European officer was allowed to cross the frontier from Cutch; and even a special envoy, who had proceeded from Bombay in 1820, on the invitation of their own minister, was coldly received, and it was only in 1825 that a most friendly letter was received, with an invitation to Dr. Burnes to proceed without delay to Hydrabad, on account of the alleged sickness of one of the principal chiefs. The invitation was accepted, and he was received with every mark of confidence. A treaty has been since ratified in 1838 by the Ameers of Sinde, providing for the reception of a British resident; to which office Colonel Pottinger has been appointed.

Government.

The government of Sinde is a military despotism. After a long era of civil commotion, Futteh Ali Khan was called to exercise the supreme power, who generously admitted his three brothers, Ghoolam Ali, Kurm Ali, and Mourad Ali, to a participation in his high destiny. He died in 1801, and Ghoolam Ali in 1811. The supreme power in Sinde is now vested in the two youngest and surviving brothers, Meers Kurm and Mourad Ali, who are known as the chief Ameers, and whose seals are affixed to all public documents issued in the name of the government. But there are others of the family who are scarcely inferior in rank to these princes, on whom has devolved the executive government. The two deceased brothers, Futteh and Ghoolam Ali, left sons, to whom they bequeathed their shares in the administration, and who, though they have been kept back by their youth, and the grasping spirit of their uncles, had, when Dr. Burnes was at Hydrabad in 1827, acquired ascendancy in the state; and since his departure, one of them had risen in successful rebellion, and had raised himself to a political equality with his relatives. The two sons of Mourad Ali, Noor Mahommed and Nusseer Khan, are also among the heads of the government. All these chiefs are in possession of respective portions of the revenues of Sinde. After the death of Futteh Ali, the province was partitioned into four shares, of which the largest belongs to Mourad Ali, who, on the plea of his having descendants, continued to despoil his brother and Meer Mahommed of much of their possessions. There are other nobles who are related to the royal family, and who are allowed to assume the title of meer, or lord, but are not permitted to interfere in the affairs of state, deriving their importance solely from their alliance with the reigning princes. The real power centres in Meer Mourad Ali, who is represented as a gloomy tyrant, a slave to avarice, and a plunderer of his people. At the court of the Ameers, every thing is conducted on a scale of magnificence scarcely equalled at any other court in Hindustan. The parade that was exhibited when Colonel Pottinger and Dr. Burnes were severally received at court, is described by these travellers; and they both agree in celebrating the surpassing richness and splendour of the scene. The princes, says the former writer, wore a vast number of jewels, beside those that were set in the hilts and scabbards of their swords and daggers; and their waist-belts displayed some extraordinary emeralds and rubies. They were seated on a thin felt, that extended all round the circle, and over which was laid a silk mattrass, about an inch thick, spread with a muslin cloth, embroidered in a most exquisite manner with gold and silver flowers. They reclined on three large pillows, covered with similar embroidery, which, with the display of jewels, gave the whole an inconceivably rich effect. "Many of the officers of government," he continues, "appeared in very good style; and the general splendour and richness of the scene far surpassed any thing we had expected to see at the court of Hydrabad."[1] The dress of the princes, which was not ornamental, consisted in fine muslin tunics, with costly sashes tied round their waists, and their turbans of thin transparent gauze were of the largest dimensions, about 2½ feet in diameter, and yet so neatly folded up, as to give them a very becoming appearance. Dr. Burnes observes, that when he was first introduced at court, the *coup d'œil* was splendid, and that the spectacle approached nearer than any thing he had seen to the fancies formed in childhood of eastern grandeur. The two principal Ameers were seated amid a group of elegantly attired figures, at the end of a lofty hall, spread with Persian carpetting, on their musnud, a slightly elevated cushion of French white satin, beautifully worked with flowers of silk and gold, the corners of which were raised by four massive and highly chased golden ornaments, resembling pine-apples, and, together with a long velvet pillow behind, covered with rich embroidery, presented a very grand appearance. There was no tinsel or gaudy display of scarlet; none of the incongruities seen at the Hindoo courts, of gorgeousness and dirt; but a simple and becoming elegance, far surpassing any thing he had seen in India. The Ameers and their attendants were habited nearly alike, in tunics of fine white muslin, neatly prepared and plaited, so as to resemble dimity, with sashes of silk and gold, wide Turkish trousers of silk tied at the ankle, chiefly dark blue, and Sindian caps made of gold brocade or embroidered velvet. "A pair of Cashmere shawls," adds Dr. Burnes, "of great beauty, generally white, thrown negligently over the arm, and a Persian dagger at the girdle, richly ornamented with diamonds or precious stones, completed the dress and decorations of each of the princes. All the officers in attendance, judging from their dress and manners, seemed to be of inferior rank. There was no crowding for places; the rabble had been shut entirely out of doors; and there was a degree of stillness and solemnity throughout the whole, and an order and decorum in the demeanour of each individual, which impressed one with a feeling of awe and respect. I could not have anticipated the brilliant collection of jewels and armour that is in possession of these princes, and is of all things calculated most to surprise a European stranger." Colonel Pottinger mentions with admiration the profusion of pearls which they displayed; the size of one which the prince carried in his hand, he declares was such as before he should have regarded as perfectly incredible; and a perfect emerald, suspended from the hilt of a dagger which one of the younger princes wore in his sash, was considerably larger than a pigeon's egg. They had still this emerald in their possession when Dr. Burnes visited the court; and the immense treasure which they have accumulated from the spoil of the country which they govern, consists in rubies, diamonds, pearls, and emeralds, with which their daggers, swords, and matchlocks are adorned, or they are worn as rings and clasps, on different parts of their dresses. Many of these precious stones were purchased at reduced prices from the unfortunate princes of the Cabul monarchy and the nobility, when they were reduced to ruin by the revolutions which took place in that kingdom; and merchants are encouraged to visit Sinde from all parts, in consequence of the avidity of the princes to buy up the precious articles in which they deal. One or two Persian goldsmiths are employed at court, who continue to display to the best advantage the jewellery of their masters; and the art of inlaying letters of gold on steel has been brought to the greatest perfection by these artizans. The Ameers of Sinde are also remarkably curious in the qualities of swords and gun-barrels; and they possess a more valuable collection of these articles than is to be met with in any other part of the world. The value of a sword is estimated by the age and fineness of the steel, or by the temper and watering. One which was shewn by Kurm Ali to Dr. Burnes, dated 1122, (A. D. 1708,) was valued at 2000 rupees, or about L.125. They have in their armoury swords that have been worn by almost every prince renowned in Asiatic story; by Shah Abbas the Great, Nadir Shah, Ahmed Shah Doranee, besides other equally illustrious personages. Their blades are generally embellished with inscriptions in gold, of verses from the Koran, or short prayers for aid and protection. They manage their swords with great skill; and though they are not heavier than common English sabres, Dr. Burnes mentions that he has seen one of them cut a large sheep, with one stroke, in two pieces, a feat that depends on a certain mode of striking that requires great practice and dexterity.

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[1] Travels in Belochistan and in Sinde, chap. x. p. 367.

The Ameers are passionately fond of hunting; and for this purpose large tracts of fertile land are enclosed to prevent the egress of the quadrupeds, and are converted into jungle; and once or twice a-month they visit their different game preserves to enjoy the pleasures of the chace, though the manner of killing the game in this country does not bear the appellation. Their mode of hunting does not at all partake of the animation which belongs to that amusement in Europe. Their plan is to close up all the wells, except the one in front of their tents, to which, when the animals resort, being compelled by dire necessity, they are then shot by the Ameers, amid the acclamations of their followers. They never hunt on horseback; but sometimes, though rarely, go a deer shooting on camels, and none, except themselves, are permitted to fire at any game. There is rarely a sporting excursion which does not cost the lives of two or three of their subjects, a matter of extremely little consequence in this tyrannical country, either from their false aiming, or from the fury of the boars driven desperate. The mode in which those hunting excursions are conducted, marks the jealous policy of the tyrannical government. They are attended by large retinues; and they never previously announce in which direction they mean to travel; nor will any of the princes leave the other behind. They are afraid of leaving them this short interval for intrigue, and, perhaps, rebellion; and it was by being left for two or three hours behind, that one of the princes succeeded in his late rebellion. Though related, they place no confidence in each other. They sleep in apartments peculiarly contrived for safety, with loaded arms laid beside their uneasy pillows; though these precautions are now somewhat relaxed, in consequence of the long era of nearly forty years' tranquillity which the country has enjoyed under the existing regime. There is nothing like the spirit of independence among the courtiers or nobility of Sinde. They only retain their places by the most implicit obedience and the most fawning adulation to their superiors; and their habitual propensity to flatter a European who is in favour at court, or even each other, is ludicrous; scarcely two persons meet without indulging in the most fulsome strain of oriental flattery; social life is burdened with this ceremonious formality, which is the mark of inferior civilization, and is common in Persia, Cabul, and generally among the semi-barbarous tribes of Asia.

The whole family of the Ameers are extremely strict, and mere bigots in their intolerant religion. With one or two exceptions, they have become Sheahs, or followers of Ali; who hate the sect of the Soonees even more bitterly than Brahmins or Christians. They are remarkable for the intolerance with which they persecute the Hindus, forming a considerable proportion of their subjects, who are subjected to the most exasperating indignities, and often to the greatest cruelties; they are forced to adopt the Mahometan dress, and to allow their beards to grow. It is only lately that they have been allowed to ride on horseback, and it is only the few who are in the immediate service of government that are allowed the privilege and honour, as it is esteemed, of a saddle. Merchants of wealth and respectability may be seen mounted on asses and mules, considered unclean animals, such as none but the vilest outcasts in other Asiatic countries can touch with impunity; and they are obliged to descend and stand aside when any Musselman passes by. They are denied the free exercise of their religion; the tom-tom can only be beat when special permission is granted; and though images are placed in most of the temples at Hydrabad, the sound of music never echoes from their walls; they are subjected to other shocking and degrading cruelties revolting to humanity; any two of the true believers, by declaring that they have heard a Hindoo repeat a verse in the Koran, or the words "Mahomed the prophet," may procure his immediate circumcision, which this degraded and persecuted class consider the most cruel calamity that can befal them, in which, as it is resorted to on the slightest provocation, and performed with the deriding pretence that it is for their eternal happiness, the torture of the mind is added to that of the body. On the other hand, the most bigotted veneration is expressed for the Seynds, or descendants of the prophet. The meanest wretch who can boast a connection, however remote, with this holy stock, enjoys a station in society such as no temporal man can bestow. If any one, under whatever provocation, would dare to retaliate, by abusing or striking any one of this favoured class, he would be torn to pieces by the enraged populace; and, in consequence of this high favour which they enjoy, an idle herd of these wretches flock into Sinde from the neighbouring countries, where, besides being useless members of the community, and withal insolent and lazy, they debase the minds and drain the purses of the deluded inhabitants.

The Ameers commence business about two hours before day-break, each holding a levee to hear compliments, and to adjust the affairs belonging to his department. About sun-rise they repair to their apartments to dress, and appear shortly afterwards in durbar, where the whole family regularly assemble for transacting public business; all letters are then laid before them, which, being read and considered, and some time passed in conversation, they withdraw to their morning repast about ten or eleven o'clock. They again appear abroad about two o'clock and remain together until dark, when they repair for the night to their respective apartments. At the residences of the younger princes every thing forms a contrast to the stately ceremonial of the elder Ameers; all restraint is thrown aside, and every species of amusement, such as boar-baiting, fencing, ball practice, and wrestling, are pursued with avidity. At the public audiences in the durbar the Ameers, though courteous, are for the most part haughty and reserved in their manners; nothing approaching to familiarity being allowed between them and their most favoured servants. Under such a government as has been described, justice is very imperfectly administered. The Koran is the foundation of law as it is of religion; and between man and man disputes are generally settled fairly enough by the cadi, except where bribery is employed, when the best security for justice is a weighty purse. The Hindus generally settle all disputes among themselves by punchayets or juries, as is practised in many parts of Hindustan, as they have no encouragement to come before the ruling authorities. The native inhabitants, the Beloches, according to their military notions, generally take the law into their own hands, and act on the simple principle of retaliation; nor do the authorities interfere, except where the dispute extends to whole tribes, and seriously endangers the peace of the country. In this case they interfere to settle matters by force or by conciliation. A serious quarrel of this nature occurred when Dr. Burnes was at Hydrabad, when the contending parties were sent for by the princes, who, with much flattery and address, obtained a promise from them to desist.

Mili y force

The military force of Sinde is very inefficient; their armed retainers are few in number and contemptible in appearance. Several of the chiefs of the tribes reside at court, and they can collect in a few days their followers, who are generally employed in agriculture and other occupations. In this manner it is estimated that 40,000 men may be collected. But though the iron rod of oppression has repressed the daring spirit of the military classes, yet the anarchy which has prevailed in this, as in other parts of Hindustan, has nurtured, among the great body of the people, a spirit of disorder and a love of plunder which is ready to break out on all occasions. The country is, in short, filled with licentious banditti, and would have been, in the evil days that are passed, a fit nursery of recruits for the Pindarie bands. "Like hungry vultures," says Dr. Burnes, "they would almost seem to scent the battle from afar, for the train of dissension is no sooner lighted than war becomes their universal cry, and it is incredible in how short time they flock to the rendezvous." The late insurrection of the princes was settled in a few days; yet, in that short time, about 20,000 or 30,000 volunteers had joined the different standards, and they were hourly crowding in when the adjustment took place. In military qualities, the Sindian soldier ranks very low; he has no discipline nor steadiness in the field, though he is brave and hardy; and his vanity and gasconading are proverbial. The army presents, when assembled, a motley and ill-accoutred assemblage of mercenaries from all quarters, chiefly composed of ferocious adventurers from the mountains of Belochistan, to one of whose rude tribes the reigning house traces its origin. The Ameers are well aware of the inefficient state of their military force, and of the utter hopelessness of any conflict with the British arms. And this furnishes the explanation of their distance and reserve, justly fearing that any close intercourse would only expose the nakedness of the land. It is not easy to obtain any exact estimate of the revenue of Sinde. Colonel Pottinger states its total amount, including those of all the collateral branches of the reigning family, at sixty-one lacs of rupees yearly, equal to L.767,500 sterling, which shews an increase, since 1809, several years previous to his estimate, of L.232,750, the amount being, at that time, forty-two lacs and 78,000, or L.534,000 sterling.

The men of Sinde are dark in colour but are an exceedingly handsome race; above the medium height of Asiatics, with good features and well-formed limbs. The beauty of the women is proverbial, and it is remarked by Pottinger in his instructive and excellent work, that though he had only casual opportunities of seeing any of the higher class of females, yet among the dancing girls who came to exhibit before them, there was not one who was not distinguished by loveliness of face or the symmetry of her figure, and in most instances both these requisites of beauty were strikingly combined. The dress of the men consists of a loose shirt, a pair of trousers, puckered at the ancles, and a quilted cotton or cloth cap, ornamented with flowers of silk or gold sewed round the bottom: that of the women, with the exception of the cap, is much the same; they wear beside, underneath their shifts, a silk jacket made to fit the form, that laces behind; and when abroad, a cloth shirt wraps round the body, having one end brought round the crown of the head, and serving as a veil to cover the face from strangers. This traveller does not, however, commend, in the same degree, the character of the people, in which the bad qualities, according to his estimate, greatly predominate. They are, he observes, avaricious, full of deceit, cruel, ungrateful, and strangers to veracity; and all the extenuation which he offers for these vices is, that the present generation has grown up under a government whose extortion, ignorance, and tyranny, is unequalled in the world. The Sindians, however, he does not rate lower in the scale of morality than the population and society of the other nations of Asia. Their good qualities consist in personal bravery, abstinence, and obedience to their superiors; for which they are reckoned the best mercenary soldiers in Hindustan. In manners they are generally forward and unpolished; in intellect dark and inapt, and in hospitality and fidelity signally regardless and deficient.

History.

The ancient history of Sinde is involved in obscurity. When Alexander of Macedon invaded the country, it was

Sinde.

governed by Hindu Rajahs; and from that time little is known of its history till the rise and progress of the Mahomedan power. It was conquered by a general dispatched for this purpose by a lieutenant of the Ommade Caliph Walid in Sejestim and Candahar; and flourished under the vicegerents of the prophet till its conquest by the Sultan of Ghizni. It afterwards came under the jurisdiction of the Soomrai, a native tribe, and was again reduced by Mahommed Ghori, and annexed as a fief to the crown of Delhi, to which it remained attached for two centuries. In the various conquests and revolutions which subsequently took place in India, this country was the prize of the victor. It was finally subdued by the armies of Acbar about the year 1580, since which period its rulers have never ventured openly to avow their independence, though they have sometimes evaded the payment of the tribute fixed, and have even frequently appeared in arms against the lord paramount. Under the succeeding emperors the province of Sinde was kept under strict subjection, though the unsettled aspect of Hindustan sometimes encouraged the rulers of Sinde to withhold the tribute. In the mean time the introduction of vast tribes of Beloches as mercenaries, had changed the character of the population, and the rule of the family of Toor Khan had given place to the tribe of Caloras, sprung, it is supposed, from adventurers that followed the Persian army. The invasion of India by Nadir Shah in 1739, extended the rule of Persia over Sinde and all the provinces west of the Indus; but his assassination paved the way for the rise of the Dooranee empire under Ahmed Khan Seedozy, who declared himself king of Cabul, to whom Sinde after a time submitted, and has ever since been considered subordinate, though frequently rebelling and refusing to pay tribute. The country was long a scene of civil dissension, different competitors contending for the throne, the Talpoories, a tribe of Beloche origin, rebelling against the house of Calora. Their contentions were carried on with various success, and with ruin and misery to the country, which was wasted in these wars. Ahmed Shah, the conquerer of the Mahrattas in the battle of Panipart in 1761, exacted the tribute with all its arrears. In 1786, Meer Futteh Allee, the eldest of four brothers, was confirmed as ruler of the country. He admitted to a participation in his high destiny his three younger brothers, Ghoulam Ali, Kurm Ali, and Mourad Ali; and they agreed to reign together as the ameers or the lords of Sinde. Futteh Allee died in 1801, and Ghoulam Ali in 1811; and the country, as has been already mentioned, is now partitioned between the surviving brothers, and their respective sons.

It is scarcely possible that this outlying country of Sinde can remain long independent of British control. The late great and successful expedition, for the purpose of restoring Dost Mahommed to the throne of Cabul, however questionable its policy, has extended the power of the British in India into countries where their name was scarcely known before. All the intervening states through whose territories the army passed in its progress to the scene of action, viewed the mighty movement with a mixed feeling of jealousy and awe. Having seen the various states of India, its princes and chiefs, with their dependent tributaries, successively swallowed up in the wide extending sway of this European empire, they would willingly have joined in repelling its further advances into the interior of Asia; but they were overawed; and the late brilliant operations of the British will tend to confirm and extend their political influence, and will in the end bring all such petty states as Sinde, alternately the prey of despotism and anarchy, under the control or the direct supremacy of that great power, whose mighty empire in the east, reared up by a continued train of brilliant success for more than half a century, seems only a step in her farther progress to the dominion of Asia.

Sinde *River*, in Hindustan, has its rise in the high table land of the Malwah province to the west of Seronge; and after a winding course, falls into the Jumna six miles to the north of Calpee.

Sinde Sagor, a district of Hindustan in the province of Lahore, situated principally between the 31st and 32d degrees of north latitude. It is bounded on three sides by the Indus, the Ravey, and the Jhylum, and on the north by the mountains of Joud. Zinda Singh is the term by which the inhabitants of the districts under the Seiks bordering on the Indus are known; and the Nakai Singh is the name given to the Seiks who reside in the province of Mooltan.

SINDOORG, a town of Hindustan, in the territories of the Nagpoor Rajah, in the province of Gundwana, eleven miles S. by E. from Ruttanpoor. Long. 82. 40. E. Lat. 22. 7. N.

SINDKERA, a town of the Mahratta territories, in the province of Khandesh, 107 miles west from Boorhampoor. Long. 74. 40. E. Lat. 21. 11. N.

SINE, or *Right Sine of an Arch*, in *Trigonometry*, is a right line drawn from one end of that arch, perpendicular to the radius drawn to the other end of the arch; being always equal to half the cord of twice the arch.

SINGAN, a city of China of the first rank, in the frontier province of Shan-si. It formed at one time the imperial residence, and is still a very large and fine city. It is the rendezvous of the troops appointed to defend the empire on the north-western side. Long. 108. 29. E. Lat. 35. 14. N.

SINGAPORE. The island of Singapore is situated at the extremity of the peninsula, in the straits of Singapore, through which lies the route of vessels to and from the China seas. The town stands in lat. 1. 17. 22. N., long. 103. 51. 45. E., on a point of land near the western part of a bay, and is easily distinguished by a pleasant hill behind it, mostly cleared of trees, which abound on the island. This was the situation chosen by Sir Stamford Raffles for establishing a settlement under the protection of Britain, which might, in some degree, command the free navigation of the Straits of Malacca. He accordingly sailed from Calcutta for this purpose in the latter end of the year 1818, and in 1819 he hoisted the British flag, with a population of not more than 200 souls. In three months, according to the official letter of Sir Stamford Raffles, the number had increased to 3000; and at the date of the letter, April 1820, to 10,000, principally Chinese. Not less than 173 sail of vessels, of different descriptions, principally native, arrived and sailed in the course of the first two months, and in a short time it had grown up into an important commercial port. The rapid rise of this important station, is, perhaps, unequalled in the history of any other country, and marks the sagacity with which so central a situation was chosen, with respect to India and China, from the latter of which it is distant only five days' sail; in regard also to Java, the great islands of Borneo and Sumatra, and the Eastern Archipelago. Its natural advantages are great. It is placed on a rich soil, with fertile tracts of land in the neighbourhood, which give ample scope to agricultural improvement; and this, combined with the freedom from imposts, and the security for life and property, under a mild and enlightened government, are the circumstances which have attracted these industrious settlers, who, descrying from afar the ensign of freedom and justice, fly to it for protection from the tyranny and extortion of their own native rulers. The island of Singapore, which has been surveyed since the British settlement was established, is about twenty-seven miles in its greatest length, and fifteen in its greatest breadth. It is estimated to contain an area of 270 square miles; is diversified with hill and dale, and is adapted to the growth of numerous and valuable commodities. Plantations of gambier, pepper, and spices, have been already begun; cultivation has also extended to the neighbouring islands, which formerly afforded a harbour for pirates. The water that is found in the island is excellent; the soil is rich and fruitful; the temperature is comparatively cool, the thermometer ranging between 71 and 89; and the climate, on the whole, is salubrious. On the south side of the island, an inlet penetrates into the interior, which is about 300 feet wide towards its mouth, has regular tides, and is capable of admitting lighters for about a quarter of a mile from the sea. On this inlet the town is built. Between this and a parallel inlet, at the distance of a quarter of a mile, is a square plain, faced with a high sandy beach free from surf, and terminated on the inner side by a steep hill, of a sufficient elevation to possess a beautiful and commanding view of the surrounding country and the straits. On the frontier side of the inlet, is, on one hand, a regularly built Chinese town; and, on the other, beyond the rivulet, an extensive plain, in front of which the sandy beach stretches into an inner bay, and whence another inlet encompasses it behind. Singapore harbour, or rather roadstead, situated four miles to the N.N.E. of St. John's island in Singapore straits, affords a safe anchorage to ships in all seasons; and, being clear of sudden danger, the approach to it is rendered easy by day or by night. Its position is also favourable for connecting the navigation of the straits, the track which the ships pursue being distant about five miles. The ships are well sheltered at the anchorage from E.N.E. round to north and west, as far as S. by W.

The population of Singapore consists of Chinese, Malays, -Buggis. The principal merchants are Englishmen, of whom there are also a few shopkeepers, auctioneers, &c. Some of the respectable merchants are Chinese, as are also the cultivators and other labourers. The Malays are chiefly employed as fishermen, in cutting timber, and in bringing supplies into the town from the surrounding neighbourhood; and the boatmen are chiefly natives of the Coromandel coast.

Singapore trades to a great extent with all the countries and islands in the Eastern seas. One of the most valuable branches of trade is with Siam, which is carried on in the Siamese junks, which frequent the port of Singapore to the number of eighteen or twenty, and which are from 100 to 350 tons burden, the greater number being from 150 to 200. They import chiefly sugar, rice, cocoa nut oil, saffron wood, garro root, dried fish, and a small quantity of gamboge, sticklac, elephants' teeth, raw silk, and onions; and are said to be of the value of from 3000 to 15,000 Spanish dollars each. Many of these vessels belong entirely to their commanders, and the others to parties residing in Siam. Sugar is the most valuable part of their cargoes, which is nearly all taken by the European merchants, and is shipped for Europe, whither, also, are sent the elephants' teeth and gamboge. Of the numerous tribes who visit this settlement, the Siamese carry off the greatest quantity of manufactured goods. Their return cargoes consist of Bengal muslins, sannahs, and gurrahs, (pieces of dress,) chintzes, European long cloths, cambrics, long ells, camblets, woollens, bees' wax, camphor, gold dust, and a few rattans; cotton twist is now also sought after. This trade is entirely confined to the Chinese, who are chiefly natives of the country, descendants of Chinese settlers. The trade with Cochin-China is not nearly so extensive or valuable as that with Siam. It is also carried on by means of junks, verging from 100 to 200 tons burden, which come to the number annually of between thirty and forty, from various ports along the whole coast of that immense country, and the gulf of Tonquin. The imports consist chiefly of rice and salt; but they bring also in small quantities sticklac, gamboge, saffron wood, tortoise shell, coarse sugar, cocoa nut oil, cocoa nuts, pigs and goats, salted vegetables, and other provisions. The return cargoes consist chiefly of opium, also of European long cloths, long ells, cambrics, Madras cloths, Indian piece goods, woollens, camlets, and a small quantity of gambier and rattans. A considerable trade is carried on with Campar, an ancient Malayan state on the east coast of Sumatra. This trade is entirely in the hands of the Malays, there being no Chinese settlers in that country, and is carried on in small proas, which visit Singapore monthly, in small fleets of ten or twelve, well armed, to guard them against the attacks of pirates, who infest the numerous straits that are formed amongst the Asiatic islands. They carry from fifteen to thirty men, and are armed with two long brass guns, spears, swords, &c. Their cargoes consist principally of coffee; but they also bring gambier, bees' wax, twine, and cassia of an inferior quality, elephants' teeth, rhinoceros' horns, and a few rattans. These articles they readily dispose of on their arrival, to Chinese merchants, and receive in return white and unbleached Madras cloths, raw silk and cotton, European shirtings, cambrics, and chintzes, handkerchiefs, camblets, lead, iron, steel, gold thread, Java tobacco, sticklac, &c. Singapore also trades with the west coast of the island of Borneo, situated between Tanjong Dattoo and the northern extremity of the island, and with the Dutch settlements of Sambos, Mampawa and Pontianak. The whole of this trade is conducted by the Malays and Buggis, in proas belonging to the different ports whence they come. The proas from Borneo Proper are chiefly of the burden of from 800 to 1200 piculs, carrying from forty to sixty men each, and, like most native vessels, are well armed with long brass guns, as well as with spears, swords, and small arms. About fifteen or twenty of these vessels trade with Singapore; and they make generally two voyages in the course of a year. Their imports principally consist of pepper, camphor, bees' wax, birds' nests, tortoise shell, mother-of-pearl shells, and pearls; the cargoes being valued at from 2000 to 8000 Spanish dollars each. They are very readily disposed of to the richest Chinese merchants, in barter for blue and white Madras cloths, Bengal chintzes and white goods, European chintzes and long cloths, iron, steel, cotton twist in blue, red, and white, blue and yellow nankeens, Chinese gold thread, and various other minor articles. The annual value of this trade is estimated at from 60,000 to 70,000 Spanish dollars. With the Dutch settlements the trade is still more considerable. From Sambas about fifteen to twenty proas arrive at Singapore every six months, each bringing cargoes of gold dust, according to the means of the trader, and scarcely any other commodity, on account of the heavy duties imposed on exports to a British port. From Mampawa and Pontianak about thirty or forty proas come twice a-year with gold dust, diamonds, tin, and rattans. The different cargoes are said to vary from 2000 to 20,000 dollars; the value of the whole trade is estimated at 250,000 Spanish dollars. In return they take chiefly Bengal and Madras piece goods and iron. They take no British manufactured goods, in consequence of the heavy protecting duties imposed on them by the Dutch, for the encouragement of the trade of the mother country; and no opium, because it is monopolized by the government, of which, however, only a few chests are disposed of; the chief supply being brought by the contraband traders. About ten or twelve Chinese junks commonly arrive from Amoy and Canton. Their imports are earthenware, tiles, granite, slates, paper umbrellas, vermicelli, dried fruits, sticks, paper, tobacco, and a few nankeens, raw silk, &c. The cargoes from Canton are said generally to consist of the same articles, with the addition of silk, camlets, satins, camphor, sugar candy, and tea, and a much greater proportion of nankeens and raw silk. Those cargoes, of which the value of each is from 30,000 to 60,000 dollars, generally belong to the owners of the junks, who remain in China. These junks are generally of about from

350 to 400 tons burdens; they carry from eighty to a hundred seamen; and such is their ignorance of navigation, that great numbers, notwithstanding their being so fully manned, perish in the stormy seas that wash the Chinese shores. They bring annually about 2000 Chinese; and for several days after their arrival, the Sampan proas which trade to Rhio, Malacca, Penang, &c., are literally crowded with emigrants proceeding to the various neighbouring ports, with a view of getting employment in the pepper, coffee, and gambier plantations, and in the tin mines. Great numbers go to Java to the sugar and coffee plantations, and many to Borneo to collect gold dust. Those various imports, however, are not consumed in Singapore, which is rather a mercantile depôt of goods, from which they are dispersed all over the Eastern seas. The goods which are adapted for a European remittance, such as raw silk, nankeens, and camphor, are chiefly purchased by the Europeans from the Chinese merchants, through whose hands the trade chiefly passes. The other articles are taken by the proas which frequent the harbour, and are by these spread over the whole Archipelago. The exports of the Chinese from Singapore, are birds' nests, camphor, beche de-mer, sandal wood, ebony, tortoise shell, rattans, flint stones, buffaloes' hides, sharks' fins, tripang, European camlets, woollens, and long ells, and a few pieces of chintzes, long cloths, Bengal piece goods, tin, pepper, gambier, and from eight to ten chests of opium, a contraband article, the importation of which into Canton is now effectually proscribed. The exports of Singapore to Calcutta, Madras, and Bombay, amount in value to about 2,600,000, and the imports to 2,748,026 sicca rupees.

	Exports.	Imports.
1831–2..	7,825,786 dollars.	8,904,774 dollars.
1836–7...	7,806,965 „	8,243,629 „
1837–8...	8.024,123 „	8,881,195 „

No export or import duties are levied at this port, nor any anchorage, harbour, or lighthouse dues, or any fees; but a register is kept of all exports and imports. A newspaper is published once a-week, the *Singapore Chronicle.* The population of Singapore, as already stated, rapidly increased after the settlement was established. Population in 1823, 10,683. In 1828, the inhabitants, consisting of Europeans, Malays, Chinese, natives of Bengal, of Coromandel, Arabs, Buggis, and others, amounted to 17,664; in 1833, to 20,978. In 1838 a handsome new church was opened for worship. (*Asiatic Journal*, new series; *Singapore Chronicle;* Macculloch's *Commercial Dictionary.*)

SINGBOOM, a district and town in the province of Orissa. The province is situated between the 22d and 23d degrees of north latitude, and bounded on three sides by the districts of Chuta, Nagpoor, Michnapoor, and Mohurbunge; and on the south by that of Kunjeur. The town is possessed by Zemindars. Long. 85. 55. E. Lat. 22. 37. N.

SINGHEA, or SINGEE, a town of Hindustan, province of Bahar, situated on the river Gunduck. Long. 85. 15. E. Lat. 25. 52. N.

SINGHERICONDA, a town of the Northern Carnatic, twenty miles south from Ongole. Lat. 80. 2. E. Lat. 15. 14. N.

SINGING, in a general sense, means the production of appreciable and varied sounds by the voice. In a more limited sense, it means different inflexions of the voice through intervals admitted in music, and consistent with the rules of melodic modulation. It is well known that these inflexions differ from those of the voice in speaking. In singing, harshness of vocal *timbre*, (see MUSIC,) and falseness of intonation are much more frequently met with than the opposite qualities, especially among persons not trained to sing. Musical training, when applied to a person possessed of a naturally good quality of voice, and a good ear, produces effects that can hardly be imagined by those who have not watched them attentively. Upon the subject of vocal-training, the reader may consult any of the best treatises on singing. For some remarks on the mechanism of the human voice in singing, and the compasses of voices, see MUSIC.

SINGING of Birds. Birds may more correctly be said to *whistle* than to *sing*. This is shown by the structure of their vocal organs, as well as by the mechanism of the automaton singing-bird of Maillardet. The power of *singing* is confined to the human race. In the notes of but few birds can distinct melodic intervals be perceived. The notes of the quail, the cuckoo, &c. as well as many of the notes of the blackbird, &c. constitute distinct melodic intervals, and are therefore susceptible of musical notation. Captive singing-birds may be taught tunes, as in the case of piping-bullfinches, &c. These last have even been taught to perform in concert. We have observed, among a number of piping-bullfinches, marked differences of musical ear. Some piped well in tune; others more or less out of tune.

SINGROWLA, a district of Hindustan, in the province of Gundwana, situated about the 24th degree of north latitude, and bounded on the east by the district of Palamow in Bahar. The country is in general very desolate.

SINGUMNERE, a district of Hindustan, belonging to the Mahratta Peshwa, in the province of Aurungabad, situated about the 20th degree of north latitude. It is a hilly, but a fertile district. The chief towns are Singumnere, Battowal, and Bejapoor. The capital is of the same name. Long. 74. 40. E. Lat. 19. 46. N.

SINKEL, a town situated near the mouth of the Sinkel river, on the west coast of Sumatra. Long. 98. 26. E. Lat. 2. 15. N. Camphor, benzoin, wax, and gold, are exported from this place. Vessels that frequent this port are exposed to great danger from piratical attacks. The river Sinkel is the longest on the western coast, which rises in the mountains of Dalholi, and after a long course, empties itself into the sea by a mouth three quarters of a mile wide.

SINISTER, something on or towards the left hand. Hence some derive the word *sinister a sinendo*, because the gods, by such auguries, permit us to proceed in our designs.

SINISTER, is ordinarily used amongst us for unlucky; though, in the sacred rights of divination, the Romans used it in an opposite sense. Thus *avis sinistra*, or a bird on the left hand, was esteemed a happy omen; and hence in the law of the twelve tables, *Ava sinistra populi magister esto.*

SINISTER, in *Heraldry.* The sinister side of an escutcheon is the left-hand side; the sinister chief, the left angle of the chief; the sinister base, the left-hand part of the base.

SINISTER Aspect, amongst astrologers, is an appearance of two planets happening according to the succession of the signs, as Saturn in Aries, and Mars in the same degree of Gemini.

SINISTRI, a set of ancient heretics, so called because they held the left hand in abhorrence, and made it a point of religion not to receive any thing therewith.

SINKING FUND, a provision made by parliament, consisting of the surplusage of other funds, intended to be appropriated to the payment of the national debt; on the credit of which very large sums have been borrowed for public uses. See FUNDING SYSTEM.

SINOPLE, in *Heraldry*, denotes vert, or green colour in armories. Sinople is used to signify love, youth, beauty, rejoicing, and liberty; and hence it is that letters of grace, ambition, and legitimation, are always sealed with green wax.

SINTCHEI, one of the remote Kurile islands in the Eastern ocean. Long. 155. 14. E. Lat. 50. 15. N.

SINUOSITY, a series of bends and turns in arches or other irregular figures, sometimes jutting out and sometimes falling in.

SINUS, in *Anatomy*, denotes a cavity in certain bones and other parts, the entrance of which is very narrow, and the bottom wider and more spacious.

Sinus, in *Surgery*, a little cavity or sacculus, frequently formed by a wound or ulcer, in which pus is collected.

SION, a small town and port in the island of Bombay, situated about nine miles from the presidency, at the opposite extremity of the island, on the top of a small conical hill, where it commands the passage from Bombay to the neighbouring island of Salsette. A causeway was built by Mr. Duncan across a small arm of the sea, which separated the two islands. It has a draw-bridge in the centre.

SIPHANTO, an island in the Ægeian sea subject to Turkey, south-west from Paros, and north-east from Komili. It is forty-five square miles in extent, and generally mountainous. Its inhabitants are about 5000, chiefly Greek by religion, and wholly so by origin, who grow corn, capers, figs, oil, cotton, and vines. They have some small manufactures of silk, linen, sail-cloth, and straw hats. This island had in ancient times mines of gold and silver, but no traces of them now exist. There is one town and five villages. The town has the same name as the island. Lat. 37. 1. Long. 24. 33. E.

SI-PORAH, or Good Fortune Island, a woody island in the Eastern seas, inhabited by the same race of people as the Poggy or Napan islands, from which it lies north-west.

SIR, the title of a knight or baronet, which, for distinction's sake, as it is now given indiscriminately to all men, is always prefixed to the knight's Christian name, either in speaking or in writing to him.

Sir Charles Hardy's island, in the Southern Pacific Ocean, discovered by Captain Carteret in the year 1767. Long. 154. 6. E. Lat. 4. 38. S.

Sir Charles Hardy's Islands, a cluster of small islands in the South Pacific Ocean, discovered by Captain Cook in 1770. Long. 217. W. Lat. 11. 55. S.

Sir Charles Saunders' Island, or *Tapooamanhoo*, in the Southern Pacific Ocean, discovered by Captain Wallis in 1765. It is about six miles in length. Long. 150. 40. W. Lat. 17. 28. S.

Sir Henry Martin's Island, in the Pacific Ocean, discovered by Lieutenant Hergest in 1792, and the most fertile and considerable of the group to which it belongs. Long. 220. 19. E. Lat. 80. 51. S.

Sir Isaac Point, a cape on the south coast of New Holland. Long. 135. 10. E. Lat. 34. 27. S.

Sir Joseph Banks' Group, a cluster of small islands in Spencer's Gulf, on the south coast of New Holland.

Sir Roger Curtis' Isles, an island, with two smaller ones near it, on the south coast of New Holland, twenty-two miles south-east of Wilson's promontory.

SIRAF, a small sea-port of Persia, in Laristan, chiefly inhabited by Arabians. Thirty-eight miles south-west of Lar.

SIRCAR, or Circar, any office under the government in Hindustan. It is sometimes used for the state of government itself; likewise a province, or any number of pergunnahs placed under one head in the government books, for convenience in keeping accounts. In common usage, the under banyans of European gentlemen are, in Bengal, called *sircars*.

SIRE, a title of honour formerly given to the king of France as a mark of sovereignty.

Sire, was also anciently used in the same sense with *sieur* and *seigneur*, and applied to barons, gentlemen, and citizens.

SIRENS, in fabulous history, certain celebrated songstresses who were ranked amongst the demigods of antiquity. Hyginus places their birth amongst the consequences of the rape of Prosperine. Others make them daughters of the river Acheleüs and one of the muses. The number of the Sirens was three, and their names were Parthenope, Lygea, and Leucosia. Some make them half women and half fish; others half women and half birds; there are antique representations of them still subsisting under both these forms. Pausanias tells us, that the Sirens, by the persuasion of Juno, challenged the Muses to a trial of skill in singing; and these having vanquished them, plucked the golden feathers from the wings of the Sirens, and formed them into crowns, with which they adorned their own heads. The Argonauts are said to have been diverted from the enchantment of their songs by the superior strains of Orpheus, Ulysses, however, had great difficulty in securing himself from seduction.

Pope, in his notes to the twelfth book of the Odyssey, observes, that the critics have greatly laboured to explain what was the foundation of this fiction of the Sirens. We are told by some, that the Sirens were queens of certain small islands named *Sirenusæ*, that lie near Capræa in Italy, and chiefly inhabited the promontory of Minerva, upon the top of which that goddess had a temple built by Ulysses.

Mr. Bryant says, however, that the Sirens were Cuthite and Canaanitish priests, who had founded temples in Sicily, which were rendered infamous on account of the women who officiated. They were much addicted to cruel rites, so that the shores upon which they resided are described as covered with the bones of men destroyed by their artifice.

All ancient authors agree in telling us, that Sirens inhabited the coast of Sicily. The name, according to Bochart, who derives it from the Phœnician language, implies a songstress. Hence it is probable, says Dr. Burney, that in ancient times there may have been excellent singers, but of corrupt morals, on the coast of Sicily, who, by seducing voyagers, gave rise to this fable. And if this conjecture be well founded, he observes, the Muses are not the only pagan divinities who preserved their influence over mankind in modern times; for every age has its Sirens, and every Siren her votaries. When beauty and talents, both powerful in themselves, are united, they become still more attractive.

SIRGOOJAH, a town and district of Hindustan, in the province of Gundwana, the latter situated about the 23d degree of north latitude. The town is situated about twelve miles from the northern frontier of Palamow. Long. 83. 50. E. Lat. 23. 5. N.

SIRHIND, a town and district in the province of Delhi, of which the latter occupies the north-western quarter, being situated between the 30th and 31st degrees of north latitude. It is not fertile, being barren and sandy, and in many places destitute of water. Its vicinity to the capital was, however, in its favour, as the Afghan emperor, Feroze III. caused several canals to be cut from the rivers Jumna and Suttubje, in order to fertilize it. The country is at present possessed by the Seiks. Its principal towns are Paticola, which is large and flourishing, and Tahnesir. The town was built or repaired by Sultan Feroze about the year 1351. It is now a scene of desolation, and has never recovered the dreadful ravages to which it was exposed by the Seiks in 1707. It is 155 miles north north-west from Delhi. Long. 75. 55. E. Lat. 30. 40. N.

SIRINAGAR, a town of Hindustan, in the province of Allahabad, district of Bundelama, twelve miles north north-east from Chatterpoor. Long. 79. 55. E. Lat. 25. 6. N.

SIROCCO, a periodical wind which generally blows in Italy and Dalmatia every year about Easter. It blows from the south-east by south. It is attended with heat, but not rain. Its ordinary period is twenty days, and it usually ceases at sunset.

SIRSEY, a small town of Hindustan, in the province of Bahar, twenty-five miles east south-east from Patna. Long. 85. 35. E. Long. 25. 22. N.

SIRVATON, a rock in the Eastern seas, near the north coast of Java. Long. 110. 49. E. Lat. 6. 36. S.

SISTRUM, or Cistrum, a kind of ancient musical instrument used by the priests of Isis and Osiris. It is described by Spon as of an oval form; in manner of a racket, with three sticks traversing it breadthwise, which playing freely by the agitation of the whole instrument, yielded a kind of sound which to them seemed melodious. Mr. Malcom takes the sistrum to be no better than a kind of rattle. Oiselius observes, that the sistrum is found represented on several medals, and on talismans.

Sistrum, or *Cistrum*, an ancient Egyptian musical instrument of percussion. A similar instrument, consisting of moveable metal rods passing through holes in a metal plate, is used in modern military bands.

SISTERS, two small islands in the great southern ocean, lying in the strait between Van Dieman's Land and the south-west coast of New Holland.

SISTERON, an arrondisement of the department of the Lower Alps in France, 341⅓ square miles in extent. It is divided into five cantons, which are subdivided into fifty communes, containing in 1836, 26,643 inhabitants. The capital is the city of the same name. It stands on the river Durance, where the Baech falls into that stream, at the foot of a rock on which is an ancient castle commanding a fine prospect. It is well built, and has a cathedral with a fine altar-piece. In 1836, it contained about 4546 inhabitants, who deal largely in wool, and cultivate almonds very extensively. Lat. 44. 11. 51. Long. 5. 51. 13. E.

SISYPHUS, in fabulous history, one of the descendants of Eolus, married Merope, one of the Pleiades, who bore him Glaucus. He resided at Epyra in Peloponnesus, and was a very crafty man. Others say, that he was a Trojan secretary, who was punished for discovering secrets of state; and others, that he was a notorious robber, who was killed by Theseus. All the poets, however, agree that he was punished in Tartarus for his crimes, by rolling a great stone to the top of a hill, which constantly recoiled, and rolling down incessantly, renewed his labour.

SITANG, a large river of the Birman empire, province of Pegu, which rises in a range of mountains about the 20th degree of north latitude, and passing the ancient city of Pegu, falls into the gulf of Murtaban.

SITAR, an Indian musical instrument resembling the European guitar. Some writers maintain that the guitar, the lute, the violin, &c., are all of oriental origin. The Indian *saringee* is similar to the European violin.

SITOPHYLAX, Σιτοφυλαξ, formed from σιτος, corn, and φυλαξ, keeper in antiquity, an Athenian magistrate, who had the superintendence of the corn, and was to take care that nobody bought more than was necessary for the provision of his family. By the Attic laws, particular persons were prohibited from buying more than fifty measures of wheat a man; and that such persons might not purchase more, the sitophylax was appointed to see the laws properly executed. It was a capital crime to prevaricate in it. There were fifteen of these *sitopylaces*, ten for the city, and five for the Piræus.

SITTINGBOURNE, a town in the hundred of Milton, in the lathe of Scray, in the county of Kent, forty miles from London. It depends chiefly on the trade arising from its being on the great road from London to Dover. The inhabitants were in 1801, 1347; in 1811, 1362; in 1821, 1537; and in 1831, 2182.

SITTIVACCA, a small town in the island of Ceylon. It is separated from the king of Candy's country by a large branch of the Malivaddy river. Long. 80. 13. E. Lat. 7. 2. N.

SITUS, in *Algebra* and *Geometry*, denotes the situation of lines, surfaces, and the like. Worfius delivers some things in geometry, which are not deduced from common analysis, particularly matters depending on the *situs* of lines and figures. Leibnitz has even founded a particular kind of analysis upon it, called *calculus situs*.

SIUT, or Siout, a large town of Upper Egypt, situated on the western bank of the Nile, about half a mile from the river, with which it communicates by a canal, crossed by a bridge of three arches. The inhabitants are chiefly Copts, who are extensively employed in the manufacture of blue cloth, with which they carry on a considerable trade, and likewise in earthenware, natoon, and opium. The surrounding country is very fertile, producing abundance of fruits; great quantities of wheat, barley, dhourra, and hemp, are likewise raised. Siut is the rendezvous of the caravans which proceed from Egypt southwards into the interior of Africa, to Sennaar and Darfur, from which countries they bring slaves and gold. This town is supposed to be the ancient Lycopolis; but the only remarkable antiquity which it presents, consists in the excavations made in the neighbouring mountains. These are numerous, consisting of chambers, many of which are thirty feet in height, covered with hieroglyphics, and exhibiting symbolical figures. They were most probably formed for sepulchral purposes. The town is large and populous, and the extensive district attached is likewise thickly inhabited. The united population amounts to 200,000. The taxes are reckoned at L.40,000. Lat. 27. 13. 14. N. Long. 31. 13. 32. E.

SIVA, a name given by the Hindus to the Supreme Being, when considered as the avenger or destroyer. Sir William Jones has shown that in several respects the character of Jupiter and Siva are the same. As Jupiter overthrew the Titans and giants, so did Siva overthrow the Daityas, or children of Ditti, who frequently rebelled against heaven; and as during the contest the god of Olympus was furnished with lightning and thunderbolts by an eagle, so Brahma, who is sometimes represented riding on the Garuda, or eagle, presented the god of destruction with fiery shafts. Siva also corresponds with the Stygian Jove, or Pluto; for, if we can rely on the Persian translation of the Bhágavat, the sovereign of Pátála, or the infernal regions, is the king of serpents, named Seshanaga, who is exhibited in painting and sculpture, with a diadem and sceptre, in the same manner as Pluto. There is yet another attribute of Siva, or Mahádéva, by which he is visibly distinguished in the drawings and temples of Bengal. To destroy, according to the Vedantis of India, the Sufis of Persia, and many philosophers of our European schools, is only to generate and reproduce in another form. Hence the god of destruction is holden in this country to preside over generation, as a symbol of which he rides on a white bull. Can we doubt that the loves and feats of Jupiter Genitor, not forgetting the white bull of Europa, and his extraordinary title of Lapis, for which no satisfactory reason is commonly given, have a connection with the Indian philosophy and mythology?

SIVANA Samudra, an island formed by the river Caveny, in the province of north Coimbetoor, about nine miles in length, by one in breadth. It is remarkable for an uncommon grand cataract near it; and it communicates with the continent by a bridge formerly magnificent, and three hundred yards in length, but is now in ruins.

SIWAH, a considerable oasis of the Lybian desert, on the route from Egypt to Fezzan, and the most interesting island of the waste, as being the supposed site of the temple of Jupiter Ammon. It is situated in latitude 29° 12′ north, and longitude 26° 5′ east. Horneman represents it as fifty miles in circumference; but subsequent travellers have reduced its dimensions to about one half of that. The nearest distance from the river does not exceed 120 miles. Date trees cover a large portion of the soil, which is extremely fertile; but the palm, pomegranate, olive, vine, fig, apricot, plum, and even apple, flourish in the gardens. Tepid saline springs are numerous throughout the district; and shocks of earthquakes are here frequently felt. The town of Siwah is built upon a steep conical rock, and both in external aspect and internal arrangement, presents a striking and singular appearance. The streets are narrow, crooked, and so dark, that artificial light is required at noon-day. Each house has several floors, the upper communicating with the lower by galleries and chambers which cover the streets. The houses and walls are for the most part built of natron or mineral soda, and rock salt mixed with sand, coated with a gypseous earth, which preserves the salt from melting. The total population of the town is from 2000 to 2500; that of the whole oasis is supposed to amount to 8000 souls.

The great object of interest connected with this place, is, as we have said, the ruins of what is conjectured to have been the famous temple of Ammon. They are situated a league and a half east of the town, and are called by the natives Om Beydeh. The edifice has been built in the Egyptian style of architecture. The vestiges of a triple enclosure, enormous stones lying on the ground, and masses still standing, prove it to have been a monument of the first order. The part which is in tolerable preservation is thirty feet in length, and consists of part of a gateway and two great walls, which are covered with three immense stones, measuring thirty-four feet by twenty-seven. The only apartment which has been distinctly made out is 112 feet in length; the whole area of ruins being a rectangular space about 360 feet by 300. The decorations are observed to bear the closest resemblance to those of the Egyptian monuments; the figures, scenes, and arrangements being entirely the same. Here are seen the identical style, cast of countenance, costumes and sacrifices, as in the monuments of Thebaid. Here is the god with the ram's head, priests in long procession, multitudes of hieroglyphic tables, and at the entrance is sculptured in full relief the figure of Typhon, or the evil genius, about five feet in height. Nearly a mile from these ruins is situated the fountain of the sun, dedicated of old to the Ammonian deity. It is a small marsh rather than a well, extending about ninety feet in length by sixty in breadth, but is at the same time perfectly transparent. The diurnal change of temperature recorded by the father of history is quite perceptible. A temple stands near this spring, and there are other temples and lakes extending in succession towards the west. Major Rennel has employed much learning to prove that Siwah is the site of the famous temple of Ammon, and with considerable success. See his work, *The Geographical System of Herodotus Examined and Explained*, &c. vol. ii. p. 230.

SIX ISLANDS, small islands in the eastern seas, near the north coast of Java. Long. 110. 49. E. Lat. 6. 36. S.

SIXTH, *in Music.* (See INTERVAL and MUSIC.)

SIXTUS V., POPE, was born on the 13th of December 1521, in La Marca, a village in the seigniory of Montalto. His father, Francis Peretti, was a gardener, and his mother a servant maid. He was their eldest child, and was called Felix. At the age of nine he was hired out to an inhabitant of the village to keep sheep; but disobliging his master, he was soon afterwards degraded to be keeper of the hogs. He was engaged in this employment when father Michael Angelo Selleri, a Franciscan friar, asked the road to Ascoli, where he was going to preach. Young Felix conducted him thither, and struck the father so much with his conversation and eagerness for knowledge, that he recommended him to the fraternity to which he had come. Accordingly he was received amongst them, invested with the habit of a lay brother, and placed under the sacristan, to assist in sweeping the church, lighting the candles, and other offices of that nature, for which he was to be taught the responses, and the rudiments of grammar. His progress in learning was so surprising, that at the age of fourteen he was thought qualified to begin his noviciate, and was admitted the year following to make his profession.

He pursued his studies with such unwearied assiduity, that he was soon reckoned equal to the best disputants. He was ordained priest in 1545, when he assumed the name of father Montalto; soon afterwards he took his doctor's degree, and was appointed professor of theology at Sienna. It was then that he so effectually recommended himself to Cardinal Carpi, and his secretary Bossius, that they ever remained his steady friends. Meanwhile the severity and obstinacy of his temper incessantly engaged him in disputes with his monastic brethren. His reputation for eloquence, which was now spread about this time over Italy, gained him some new friends. Amongst these were the Colonna family, and father Ghisilieri, by whose recommendation he was appointed inquisitor-general at Venice; but he exercised that office with so much severity, that he was obliged to flee precipitately from that city. Upon this he went to Rome, where he was made procurator-general of his order, and soon afterwards accompanied Cardinal Buon Compagnon into Spain, as a chaplain and consultor to the inquisition. There he was treated with great respect, and liberal offers were made to induce him to continue in Spain, which, however, he could not be prevailed on to accept.

In the meantime news were brought to Madrid that Pius IV. was dead, and that father Ghisilieri, who had been made Cardinal Alexandrino by Paul IV. had succeeded him under the name of Pius V. These tidings filled Montalto with joy, and not without reason, for he was immediately invested by the pontiff with new dignities. He was made general of his order, bishop of St. Agatha, soon afterwards raised to the dignity of cardinal, and received a pension. About this time he was employed by the pope to draw up the bill of excommunication against queen Elizabeth.

He began now to cast his eyes upon the papacy; and, in order to obtain it, formed and executed a plan of hypocrisy with unparalleled constancy and success. He became humble, patient, and affable. He changed his dress, his air, his words, and his actions, so completely, that his most intimate friends declared him a new man. Never was there such an absolute victory gained over the passions; never was a fictitious character so long maintained, nor the foibles of human nature so artfully concealed. He courted the ambassadors of every foreign power, but attached himself to the interests of none; nor did he accept a single favour that would have laid him under any peculiar obligation. He had formerly treated his relations with the greatest tenderness, but he now changed his behaviour altogether. When his brother Anthony came to visit him, he lodged him in an inn, and sent him home next day, charging him to inform his family that he was now dead to his relations and the world.

When Pius V. died in 1572, he entered the conclave with the other cardinals, but seemed altogether indifferent about the election, and never left his apartments except to his devotion. When solicited to join any party, he declined it, declaring that he was of no consequence, and that he would leave the choice of a pope entirely to persons of greater knowledge and experience. When Cardinal Buon Compagnon, who assumed the name of Gregory XIII. was elected, Montalto assured him that he never wished for any thing so much in his life, and that he would always remember his goodness, and the favours he had conferred on him in Spain. But the new pope treated him with the greatest contempt, and deprived him of his pension. The cardinals also, deceived by his artifices, paid him no greater respect, and used to call him, by way of ridicule, the Roman beast, the ass of La Marca.

He now assumed all the infirmities of old age; his head hung down upon his shoulders; he tottered as he walked, and supported himself on a staff. His voice became feeble, and was often interrupted by a cough so exceedingly severe, that it seemed every moment to threaten his dissolution. He interfered in no public transactions, but spent his whole time in acts of devotion and benevolence. Mean time he constantly employed the ablest spies, who brought him intelligence of every particular.

When Gregory XIII. died in 1585, he entered the con-

Sixtus V.

clave with the greatest reluctance, and immediately shut himself up in his chamber, and was no more thought of than if he had not existed. When he went to mass, for which purpose alone he left his apartment, he appeared perfectly indifferent about the event of the election. He joined no party, yet flattered all.

He knew early that there would be great divisions in the conclave, and he was aware that when the leaders of the different parties were disappointed in their own views, they all frequently agreed in the election of some old and infirm cardinal, the length of whose life would merely enable them to prepare themselves sufficiently for the next vacancy. These views directed his conduct, nor was he mistaken in his hopes of success.

Three cardinals, the leaders of opposite factions, being unable to procure the election which each of them wished, unanimously agreed to make choice of Montalto. When they came to acquaint him with their intention, he fell into such a violent fit of coughing, that every person thought he would expire on the spot. He told them that his reign would last but a few days; that, besides a continual difficulty in breathing, he wanted strength to support such a weight, and that his small experience rendered him very unfit for so important a charge. He conjured them all three not to abandon him, but to take the whole weight of affairs upon their own shoulders; and declared that he would never accept the mitre upon any other terms. "If you are resolved," added he, "to make me pope, it will only be placing yourselves on the throne. For my part, I shall be satisfied with the bare title. Let the world call me pope, and I make you heartily welcome to the power and authority." The cardinals swallowed the bait, and exerted themselves so effectually that Montalto was elected. He now pulled off the mask which he had worn for fourteen years. No sooner was his election secured, than he started from his seat, flung down his staff in the middle of the hall, and appeared almost a foot taller than he had done for several years.

After his accession to the pontificate he sent for his family to Rome, with express orders that they should appear in a decent and modest manner. Accordingly his sister Camilla came thither, accompanied by her daughter and two grandchildren. Some cardinals, in order to pay court to the pope, went out to meet her, and introduced her in a very magnificent dress. Sixtus pretended not to know her, and asked two or three times who she was. Upon this one of the cardinals said, "It is your sister, holy father." "I have but one sister," replied Sixtus with a frown, "and she is a poor woman at Le Grotte; if you have introduced her in this disguise, I declare I do not know her; yet I think I would know her again, if I saw her in the clothes she used to wear."

Her conductors at last found it necessary to carry her to an inn, and strip her of her finery. When Camilla was introduced a second time, Sixtus embraced her tenderly, and said, "Now we know indeed that it is our sister; nobody shall make a princess of you but ourselves." He stipulated with his sister, that she should neither ask any favour in matters of government, nor intercede for criminals, nor interfere in the administration of justice; declaring that every request of that kind would meet with a certain refusal. These terms being agreed to, and punctually observed, he made the most ample provision, not only for Camilla, but for his whole relations.

This great man was also an encourager of learning. He caused an Italian translation of the Bible to be published, which raised a good deal of discontent amongst the Catholics. When some cardinals reproached him for his conduct in this respect, he replied, "It was published for the benefit of you cardinals who cannot read Latin."

Sixtus died in 1590, after having reigned little more than five years. His death was ascribed to poison, said to have been administered by the Spaniards; but the story seems rather improbable. It was to the indulgence of a disposition naturally formed for severity, that all the defects of this wonderful man are to be ascribed. Clemency was a stranger to his bosom; his punishments were often too cruel, and seemed sometimes to border on revenge. But though the conduct of Sixtus seldom excites love, it generally commands our esteem, and sometimes our admiration. He strenuously defended the cause of the poor, the widow, and the orphan; he never refused audience to the injured, however wretched or forlorn their appearance was. He never forgave those magistrates who were capable of partiality or corruption; nor suffered crimes to pass unpunished, whether committed by the rich or the poor. He was frugal, temperate, sober, and never neglected to reward the smallest favour which had been conferred on him before his exaltation. When he mounted the throne, the treasury was not only exhausted, but in debt; at his death it contained five millions of gold. Rome was indebted to him for several of her greatest embellishments, particularly the Vatican library; it was by him, too, that trade was first introduced into the ecclesiastical state.

SIZAR, or Sizer, in Latin *Sizator*, an appellation by which the lowest order of students in some universities are distinguished, is derived from the word *size*, which has a peculiar meaning. To *size*, in the language of the university, is to get any sort of victuals from the kitchens, which the students may want in their own rooms, or in addition to their commons in the hall, and for which they pay the cooks or butchers at the end of each quarter. A size of any thing is the smallest quantity of that thing which can be thus bought; two sizes, or a part of beef, being nearly equal to what a young person will eat of that dish to his dinner, and a size of ale or beer being equal to half an English pint. In Oxford, the order similar to that of sizar is denominated servitor, a name evidently derived from the menial duties which they perform. The sizars are not upon the foundation, and therefore whilst they continue sizars, are not capable of being elected fellows; but they may at any time, if they choose, become pensioners, and they generally sit for scholarships immediately before they take their first degrees. If successful, they are then on the foundation, and are entitled to become candidates for fellowships when they have got their degree. In the mean time, whilst they continue sizars, besides free commons they enjoy many benefactions, which have been made at different times, under the name of *sizar's prætor*, *exhibitions*, and the like, and the rate of tuition, the rent of rooms, and other things of that sort within their respective colleges, is less than to the other orders. But though their education is thus obtained at a less expence, they are not now considered as a menial order; for sizars, pensioner-scholars, and even sometimes fellow-commoners, mix together with the utmost cordiality.

SIZE, the name of an instrument used for finding the bigness of fine round pearls. It consists of thin pieces or leaves, about two inches in length, and half an inch in breadth, fastened together at one end by a rivet. In each of these are round holes drilled of different diameters. Those in the first leaf serve for measuring pearls from half a grain to seven grains; those of the second for pearls from eight grains or two carats to five carats; and those of the third, for pearls from six carats and a half to eight carats and a half.

Size, is also a sort of paint, varnish, or glue, used by painters and others. The shreds and parings of leather, parchment, or vellum, being boiled in water and strained, make size. This substance is much used in many trades. The manner of using size is to melt some of it over a gentle fire, and scraping as much whiting into it as will just colour it, let them be well incorporated together. After it dries, melt the size again, and put more whiting and whiten the frames seven or eight times, letting it dry between each time; but before it be quite dry, between each washing with size, you must smooth and wet it over with a clean brush-pencil in fair water.

SKATING, an exercise on ice, both graceful and healthy. Although the ancients were remarkable for their dexterity in most of the athletic sports, yet skating seems to have been unknown to them. It may therefore be considered as a modern invention; and probably it derived its origin in Holland, where it was practised not only as a graceful and elegant amusement, but as an expeditious mode of travelling when the lakes and canals were frozen up during winter. In Holland long journeys are made upon skates, with ease and expedition; but in general less attention is there paid to graceful and elegant movements, than to the expedition and celerity of what is called journey skating. It is only in those countries where it is considered as an amusement, that its graceful attitudes and movements can be studied; and there is no exercise whatever better calculated to set off the human figure to advantage. The acquirement of most exercises may be attained at an advanced period of life; but to become an expert skater, it is necessary to begin the practice of the art at a very early age. It is difficult to reduce the art of skating to a system. It is principally by the imitation of a good skater that a young practitioner can form his own practice. The English, though often remarkable for feats of agility upon skates, are very deficient in gracefulness, which is partly owing to the construction of the skates. They are too much curved in the surface which embraces the ice; consequently they involuntarily bring the users of them round on the outside upon a quick and small circle; whereas the skater, by using skates of a different construction, viz. less curved, has the command of his stroke, and can enlarge or diminish the circle according to his own wish and desire. The metropolis of Scotland has produced more instances of elegant skaters than perhaps any other country whatever; and the institution of a skating club has contributed not a little to the improvement of this elegant amusement.

SKELETON, in *Anatomy*, the dried bones of any animal joined together by wires, or by the natural ligament dried, in such a manner as to show their position when the creature was alive.

In the *Philosophical Transactions* we have an account of a human skeleton, all the bones of which were so united as to make but one articulation from the back to the os sacrum, and downwards a little way. On sawing some of them where they were unnaturally joined, they were found not to cohere throughout their whole substance, but only about a sixth of an inch deep all round. The figure of the trunk was crooked, the spinæ making the convex, and the inside of the vertebræ the concave part of the segment. The whole had been found in a charnel-house, and was of the size of a full-grown person.

SKENE, Sir John, a Scotish lawyer, was the second son of James Skene of Ramore, and of Janet the second daughter of Alexander Burnet of Leys. He thus derived his lineage from the ancient family of Skene of Skene. We may place his birth about the year 1540. He is said to have been partly educated at King's College, Aberdeen; but he is known to have been incorporated at St. Andrews in the year 1556; and in this university he took the degree of A.M. In 1564 and 1565 he taught as one of the regents of St. Mary's College. According to Dempster, he spent a great part of his youth in Norway, Denmark, and Poland, and had thus an opportunity of acquiring a familiar acquaintance with modern languages, as well as of extending his knowledge of men and manners.[1] Skene has incidentally mentioned that he was in Switzerland in 1568, and that he was at Cracow in Poland during the following year.[2] He has likewise stated that he returned home after a peregrination of seven years, and that he returned from the famous university of Wittemberg, honoured with an annual pension from the elector of Saxony, and imbued with some knowledge of the civil law. He appears to have begun his travels in 1567, and to have returned in 1574.[3] On revisiting his native country, he finally made choice of the legal profession, and was admitted as an advocate on the 19th of March 1575. He speedily acquired some degree of distinction as a lawyer.

The earl of Morton, then regent of the kingdom, had formed a plan for reducing the laws into a more easy form and method. The execution of the plan was committed to Skene and to Sir James Balfour, president of the court of session. Among other ostensible coadjutors, we find Lord Glammis, chancellor, Lord Ruthven, and William Baillie of Provand, who likewise attained to the dignity of president. The only result of this commission is supposed to have been the compilation of a book which passes under the title of Sir James Balfour's Practicks. "If I might be allowed to indulge in conjecture," says Mr. Thomson, "I should be inclined to suppose, that the conception or project of this digest of the laws may have originated with Balfour; that his own exile afterwards precluded him from continuing to take any part in its execution; that the active drudgery of the proposed investigation was devolved upon younger men; and that the unfinished result of their labours is perhaps no other than the volume of Practicks to which the name of Sir James Balfour has been traditionally annexed."[4] It is at least evident that the work must have been interpolated; for, as Lord Hailes has remarked, it mentions certain acts of parliament, and the names of certain peers, that did not exist till after the death of Balfour. Of this compilation, which was not printed till 1754, the value has never been highly estimated. The labours of Skene, whatever may have been their nature or extent, were, on the 10th of June 1577, rewarded by the grant of an annual pension of "ten chalders of meal," payable out of the revenues of the abbey of Aberbrothock.

In the year 1589 he was employed in another capacity. Sir James Melville was selected by the king as his ambassador to the court of Denmark, for the purpose of negociating a marriage with a Danish princess; and he required the advice and assistance of a lawyer, with a special reference to the Danish claims on Orkney. "When I schew his maieste," says Melville, "that I wald tak with me, for man of law, Mester Jhon Skein, his maieste thocht then that ther wer many better lawers. I said that he was best acquanted with the conditions of the Germanes, and culd mak them lang harangues in Latin, and was a gud trew stout man, lyk a Dutche man. Then his maieste was content that he suld ga ther with me."[5] Melville was however supplanted, and the Earl Marischal having been placed at the head of the embassy, Skene accompanied him to Denmark. Dr. Craig, physician to the king, addressed a letter to Tycho Brahe, recommending to his friendly attentions Skene, Swinton, Nicolson, and Fowler, who were all attached to this mission,

In the course of the same year, Skene was conjoined with David Makgill for executing the office of his majesty's advocate; and in 1590 he was associated with Colonel Stewart in an embassy to some of the princes of Germany.[1] During the same year he was employed on an embassy to the States-General.[2] In 1592 an act of parliament authorized the chancellor, assisted by other commissioners, of whom Skene was one, to institute a general examination of the municipal laws, to consider what laws and acts should be known to the king's subjects, and to take the necessary steps for printing them.[3] The most laborious part of this undertaking devolved upon Skene; and after an interval of five years, he published "The Lawes and Actes of Parliament maid be King Iames the First and his Svccessovrs, Kinges of Scotland: visied, collected, and extracted furth of the Register." Edinb. 15 Martii A.D. 1597, fol. According to our present mode of reckoning, the book was published in the year 1598. With a separate title, it includes a treatise "De Verborum Significatione. The Exposition of the Termes and difficill Wordes, conteined in the fovre bvikes of Regiam Majestatem, and vthers, in the Actes of Parliament, Infeftments, and vsed in practicque of this Realme, with diuerse rules and common places, or principalles of the Lawes: collected and exponed be M. Iohn Skene, Clerke of our Soveraine Lordis Register, Councell, and Rolles."

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[1] Dempsteri Historia Ecclesiastica Gentis Scotorum, p. 600.

[2] Skene de Verborum Significatione, vv. *Menetum* and *Pede-pulverosus.*

[3] In the dedication prefixed to Regiam Majestatem, Skene expresses himself thus: "Annus jam agitur tricesimus quintus, cum Dei beneficio, post septem annorum peregrinationem, ex inclyta Academia Witebergensi (quae est in Germania, sedes et domicilium bonarum literarum) Augusti Ducis et Electoris Saxoniæ annua pensione honoratus, et qualicunque juris civilis cognitione imbutus, domum redii." This dedication was printed in the year 1609.

[4] Fourth Annual Report of the Deputy Clerk Register, p. 21.

[5] Melville's Memoirs, p. 366. Edinb. 1827, 4to.

In September 1594 he had been appointed to the office of Clerk Register, in the room of Alexander Hay of Easter Kennet, whom he also succeeded as one of the Judges of the Court of Session. He was admitted on the 30th of November. For his preferment he is said to have been indebted to the influence of Walter Stewart, prior of Blantyre, who had married a sister of Skene's wife, Helen the daughter of Sir James Somerville of Cambusnethan. In 1596 he was nominated one of the commissioners of the exchequer, commonly described as the Octavians; but being viewed by the people as a dangerous junto, they relinquished their office in the course of the following year. In 1604 he was associated with other commissioners for discussing the terms of a union between the two kingdoms.

About the beginning of the year 1607 he had prepared another work for the press; and "the meanness of his estaite and fortune not answerand to his witt, ingyne, and literature," the privy council, after having examined it, addressed a letter to the king, requesting him to provide the means for its publication.[4] His manuscript was afterwards presented to parliament, and having been highly approved, was ordered to be printed. With the view of defraying the expense, and procuring some remuneration to the editor, a sum of money was ordered to be paid by the sheriffs, bailies, stewards, and other judges, and likewise by the prelates, earls, lords, and boroughs of the kingdom. A commission was appointed for the purpose of fixing the rate of the different contributions. James Carmichael, minister of Haddington, was selected as the fittest person for correcting the press; and on the 13th of October 1608, the privy council requested the presbytery to grant him leave of absence for the period of about two months.[5] This period must however have been too short for correcting one half of the work. It was at length published, under the title of "Regiam Majestatem. Scotiæ veteres Leges et Constitutiones, ex Archivis publicis et antiquis libris manuscriptis collectæ, recognitæ, et notis juris civilis, canonici, Nortmannici auctoritate confirmatis illustratæ," &c. Edinb. 1609, fol. A Scotish translation speedily followed: "Regiam Majestatem. The avld Lawes and Constitvtions of Scotland, &c., translated out of Latine in Scottish language, to the vse and knawledge of all the subjects within this Realme, with ane large table of the contents therof, be S^{r} John Skene of Curriehill, Clerk of our Soveraigne Lordis Register, Counsell, and Rollis. Qvherevnto are adjoined twa Treatises, the ane anent the Order of Proces observed before the Lords of Counsell and Session; the other of Crimes, and Judges in Criminal Causes." Edinb. 1609, fol.

The labours of Sir John Skene were highly valued by his contemporaries, who must have found them useful at a period when so little had been effected for illustrating either the principles or the history of our law. It is not however to be concealed that his publications are deficient in critical accuracy, and even in editorial fidelity. It is well known that the treatise "De Legibus et Consuetudinibus Regni Angliæ," commonly ascribed to Glanville, was at an early period adopted in Scotland, with a few changes and modifications; and that, under this new form, it bears the title of *Regiam Majestatem*, from the initial words of the prologue. Ranulph Glanville was chief justice of England during the reign of Henry the Second, and he still retained his office when Richard succeeded to the throne.[6] Sir Mathew Hale has remarked that although it perhaps was not written by him, yet it seems to have been wholly written at that time.[7] According to the title of the book, it was composed in the time of Henry the Second, "justiciæ gubernacula tenente illustri viro Ranulpho de Glanvilla;" an inscription which by no means describes the chief justice as the author. From these words, says Lord Lyttelton, I infer that the book was not written by Glanville himself, "but by some clergyman, under his direction and care; I say clergyman, because it is written in Latin, which could hardly be done but by a clergyman of that age."[8] Sir Thomas Craig easily discerned that the original work was not Scotish but English.[9] Skene was however anxious to exhibit *Regiam Majestatem* as the original, and to represent it as having been composed and divulged by the authority of David the First, who closed his reign in the year 1153. From what manuscripts he derived his text, he has not thought proper to specify; but several are to be found which contain a reference to Glanville by name. Henry, under whom he acted as chief justice, did not begin his reign till the year 1154. Lord Cromarty's MS. contains references to the gloss on the Decretals of Gregory IX. and to the Decretals of Boniface VIII.[10] The pontificate of Gregory extended from 1227 to 1241; that of Boniface from 1294 to 1303. It is sufficiently evident that a writer in the reign of David could not quote such authorities. Of this circumstance Skene was sufficiently aware; and the passages which refer to Glanville and the canon law are silently excluded from his edition. This is not merely a defect in literary accuracy; it is a want of that ordinary fidelity which every editor is bound to exercise. If he had excluded such passages from the text, and stated in the notes his reasons for rejecting them as spurious, his conduct would not have been liable to censure.

Having reached an advanced age, he became anxious to secure for his eldest son James the office of Clerk Re-

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[1] Moysie's Memoirs of the Affairs of Scotland, p. 84. Edinb. 1830, 4to.

[2] Maidment's Analecta Scotica, vol. i. p. 51.

[3] Acts of the Parliaments of Scotland, vol. iii. p. 564.

[4] Brunton and Haig's Historical Account of the Senators of the College of Justice, p. 232.

[5] M'Crie's Life of Melville, vol. ii. p. 318.

[6] See Sir Francis Palgrave's Introduction to the Rotuli Curiæ Regis, p xxxix.

[7] Hale's History of the Common Law of England, p. 138.

[8] Lyttelton's Hist. of Henry II. vol. ii. p. 267.

[9] Cragii Jus Feudale, p. 51.

[10] See Lord Hailes's Examination of some of the Arguments for the high Antiquity of Regiam Majestatem, p. 7. Edinb. 1769, 4to.

gister; but his attempt was defeated by the dexterity of Sir Thomas Hamilton, afterwards successively earl of Melrose and of Haddington. "Thinking to get his son provided to his office," says Spotswood, he "had sent him to court with a dimission of the place, but with a charge not to use it, unless he found the king willing to admit him: yet he, abused by some politick wits, made a resignation of the office, accepting an ordinary place among the Lords of Session. The office upon his resignation was presently disponed to the advocate; which grieved the father beyond all measure. And the case indeed was pitiful, and much regrated by all honest men; for he had been a man much employed, and honoured with divers legations, which he discharged with good credit, and now in age to be circumvented in this sort by the simplicity or folly of his son, 'twas held lamentable. The king being informed of the abuse by the old mans complaint, was very careful to satisfie him, and to have the son reconciled to his father, which after some travel was brought to pass: yet so exceeding was the old man's discontent, as within a few days he deceased."[1] Grief however is seldom so rapidly fatal. Skene resigned his office in the year 1612, and he survived till the 16th of March 1617.

At that period the legal profession not unfrequently opened the road to emoluments and wealth comparatively great. He acquired the demesnes of Curriehill and Redhall in the county of Edinburgh, and Edinganoch in the county of Aberdeen. His title on the bench was Lord Curriehill. His son Sir James Skene succeeded him on the 12th of June 1612, and became president of the Court of Session on the 14th of February 1626. On the 15th of October 1633, he died in his own house near the grammar school. The second son, named John, was appointed one of the principal clerks of Session in 1614. He purchased the estate of Hallyards. About twenty years ago, his last descendant, Elizabeth Skene, bequeathed to the Advocates Library a collection of family papers, together with a very curious collection of ancient music, which appears to have belonged to this ancestor. The *Skene Papers* have been carefully bound in a folio volume; and the music has very recently been published by Mr. Dauney, who has added a copious and elaborate introduction, together with notes and illustrations.[2] Alexander, the third son of Sir John Skene, was clerk of the registration of hornings. Beside these three sons, he had four daughters. The eldest daughter became the wife of Alexander Hay of Fosterseat, a judge and privy councillor. The second daughter was married to Sir William Scott of Ardross; the third to Robert Lermont, advocate, brother to Lermont of Balcomy; and the fourth to Sir Robert Richardson of Pencaitland.[3]

The clerk register had a brother named Alexander, who was likewise an advocate and an author. For some time at least, he must have adhered to the popish church; for we find that in 1561 he was committed to prison by the magistrates of Edinburgh for attending mass, but was released at the intercession of William Skene.[4] This was apparently his brother, who was commissary of St. Andrews, and professor of law in that university. Of his method of teaching, we find an account in the very curious Diary of a pupil, who relinquished the study of law for that of divinity. "In the thrid and fourt yeirs of my course, at the direction of my father. I hard the comissar, Mr. Wilyeam Skein, teatche Cicero de Legibus, and diuerss partes of the Institutiones of Justinian. I was burdet in the houss of a man of law, a verie guid honest man, Andro Greine be nam, wha louit me exceiding weill, whase wyff also was an of my mothers [freinds]: I am sure sche haid nocht sone nor bern sche loued better. This lawier tuk me to the consistorie with him, whar the comissar wald tak pleasour to schaw ws the practise in judgment of that quhilk he teatched in the scholles. He was a man of skill and guid conscience in his calling, lernit and diligent in his profession, and tuk delyt in na thing mair nor to repeat ower and ower again to anie schollar that wald ask him the things he haid bein teatching."[5] (x.)

Skew Bridge.

General observations.

SKEW BRIDGE. Square arches, or those which stand at right angles to their abutments, and exert their thrust in that direction, have been already treated at considerable length under the article BRIDGE. Till lately, any other form of arch was rarely to be met with. But there are cases of frequent occurrence, in which various sorts of passages and courses necessarily cross each other obliquely, as well as on different levels;[6] and where, on account of the difficulty or impossibility of constructing a square bridge, which should both have sufficient strength, and, at the same time, leave the lower passage quite clear, a different form of arch, placed obliquely to the abutments, and yet exerting its thrust in the direction of the upper passage, is almost the only practicable alternative. Such a structure is called a *skew* bridge, and is very frequently required since the more general introduction of railways, in which it is of great consequence to preserve as direct or straight a line as possible. Nay, it is not uncommon for a railway to have to traverse districts in which it may neither be allowable nor practicable to use any means of avoiding the obliquity with which it may have to cross canals, roads, &c.; its course being so much controlled by conflicting interests, and by the natural features of the country.

If a common square bridge were to be employed in the circumstances just supposed, namely, in which the passages mutually intersecting obliquely, cannot be so diverted as to cross at right angles, then the arch must either be built stretching in the direction of the upper passage, and of sufficient span to allow the lower passage, with its course unaltered, to pass uninterruptedly under it; or, it must be built stretching at right angles to the lower passage, and having its embankments and abutments so much extended, that the whole structure may both stand securely, and furnish sufficient area above for the upper passage to continue its oblique course over it unaltered. An arch partaking of both these forms might, it is true, be employed; but to such expedients, a proper skew bridge is in general greatly preferable, and is indeed sometimes the only allowable form of construction that will serve the purpose required. As for any alteration in the old courses, they would often be incompatible with the particular or vested rights of proprietors, and especially with the provisions which are generally inserted in the acts of Parliament expressly prohibiting any alteration to be made in the original courses of canals, &c.; and even were there no such restrictions, the diversion of the courses might be attended with great expense, and might occasion much inconvenience to the traffic. The wide or broad arch again, is a most unscientific mode of overcoming the difficulty. Room for it, with the requisite embankments, could not always be had, and it would, besides, greatly increase the expense, owing to the necessity of constructing a bridge of much larger dimensions than would be required were a proper oblique arch introduced, which, from its exerting its thrust in the most advantageous direction, is stronger than any other of the same magnitude. For, besides endeavouring to preserve a certain degree of equilibrium amongst the several parts of an arch,[1] it is considered still more necessary to the insuring the greatest strength, especially where the span is considerable, and the upper passage narrow, that the beds of the courses of the stones should be everywhere at right angles, both to the soffit or under surface of the arch, and also to every vertical plane running in the direction of the road or other passage carried over the bridge. There is no difficulty in fulfilling or combining these conditions in a square bridge, but it is very different with the oblique sort.

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[1] Spotswood's Hist. of the Church of Scotland, p. 517.

[2] Ancient Scotish Melodies, from a manuscript of the reign of King James VI., with an introductory Enquiry illustrative of the History of the Music of Scotland, by William Dauney, Esq., F.S.A. Scot. Edinb. 1838, 4to.

[3] Cowper's Account of Sir John Skene, Lord Curriehill, Clerk Register, his Predecessors and Successors, MS. The author of this account, Robert the brother of Sir John Cowper of Gogar, died at Balberton near Edinburgh in 1726, in the ninetieth year of his age.

[4] M'Crie's Life of Andrew Melville, vol. i. p. 113.

[5] Diary of James Melville, p. 23. Edinb. 1829, 4to.

[6] Indeed to avoid interruptions and accidents, it is always desirable that any crossings with a railway should take place on different levels. The like may be said of canals, which besides, cannot, without some kind of moveable bridges, be crossed closely above by any sort of road, and in fact can only be crossed quite on the same level by some water course; not to say any thing of fording or wading through them.

The screw thread arch

Writers on the theory of bridges for the most part say nothing of the oblique arch; and the few who do mention it, generally content themselves with slurring it over in such brief, vague, or general terms, as to be nearly unintelligible. Those again who have professedly drawn up, what they reckon practical rules for workmen, have, for the most part, tacitly assumed it as perfectly ascertained and indisputable, that the conditions above mentioned may, with only a little more labour, be equally well attained in the case of the oblique, as in that of the square bridge, by merely making the courses of the stones to form portions of the thread of a square threaded screw, or rather, perhaps, of a thread somewhat of the dovetailed form; the highest part of each thread, or that on the crown of the arch, being at right angles to the direction of the road. Such, in particular, is the doctrine laid down by Mr. Nicholson, and also by Mr. Fox; and it is not a little amusing, that the honour of inventing this supposed valuable theory has been warmly disputed between these gentlemen, or at least their friends.[2] When the soffit is to be a cylindrical surface, the side of the screw-thread may, it is true, be readily formed so as to be everywhere at right angles to the soffit; and, as all the beds of the courses of the stones would have the same curvature, the stones might be conveniently prepared beforehand, which is a great recommendation to the scheme. But unfortunately, the other, and by far the more important condition of the two, namely, to have the beds of the courses everywhere at right angles to the direction of the upper passage, can by no means be accurately fulfilled by the figure of the screw; for no two parallel planes can both of them cut the same thread of the screw at right angles, if they intercept a less portion of it than a revolution, so that a thread which has the proper position or direction at the crown of the arch, can have it at no other point; its direction on the one side of the crown being too much inclined to the course of the under passage, whilst, on the other side, it is too little inclined.

Its defects.

However, although it thus appears that the principle of the screw thread cannot well serve the purpose of the skew bridge, especially when the obliquity is great; yet there can be no question that the beds of the courses of the stones might always be formed with such a curvature as would make them very nearly fulfil both the conditions above specified; but as the several parts of this curved surface, if different from that of a screw, would necessarily be far from being uniform, the stones, owing to their requiring to be of so many different shapes, could not, without immense labour of measurements, drawings, and innumerable patterns, be prepared beforehand; and, therefore, most probably, the easiest way of putting such a scheme in practice, would be to prepare the stones no faster than they are required in building, and then it would be easy to form each stone in such a manner, that two of its opposite sides, or at least the middle parts of these sides, should be as nearly as possible at right angles, both to the soffit, and also to the direction of the passage over the bridge. In this way of working, the soffit need not be restricted to the cylindrical form, because it may suit equally well though of a very different figure. We are aware, that something similar to the method just mentioned has been already acted on, and has also been heartily ridiculed as unscientific and unsystematic; but it will be quite in time to condemn it when once a better shall have been substituted in its stead: for, most assuredly, if closely followed up, it should form an incomparably more perfect structure than that with the screw thread. The like remarks are equally applicable when the material is brick.

Some bridges may be said to consist generally of a platform supported by a set of curved iron ribs, which either abut like a stone arch against the piers, or, if the curvature be small, and especially if there be nothing to abut against, each rib has its extremities connected and kept from spreading, by a straight rod crossing the span underneath. Ribs of this last construction are often used as beams for supporting floors in large buildings; for, being in effect beams of great depth, they only rest or press downwards upon the piers or walls supporting them, and so have no horizontal thrust. Curved iron ribs, whether with or without the rods, are equally applicable to the oblique as to the square arch, since each rib may always be placed in a plane, which is both vertical, and runs in the direction of the upper passage. The horizontal rods, though generally of unnecessarily great strength throughout the most part of their length, are commonly rendered very weak near their extremities, owing to their either being very needlessly pierced with large holes near the ends, or by being very much reduced there, for the purpose of being formed into a screw. Common sense, one would think, could not fail to hint to even the most inexperienced, that to resist a longitudinal pull, there is no use in having one part of the rod stronger than another; because one weak part will render it as likely to fail, as if the whole were equally weak. Neither is it necessary that such rods should be stronger at the middle to sustain their own weight, since they are commonly suspended there by a vertical strap.

It is evident that the opposite horizontal thrusts of an arch, formed of any other materials as well as iron, might, in a similar manner, be made to annihilate or counteract each other by means of horizontal rods beneath, so that a common square arch, having the thrusts obviated in this way, could be used instead of a skew bridge, wherever there is sufficient head-room for the horizontal rods, and likewise space for carrying out a mere wall as far as will square the faces of the arch, and support its weight at the two projecting corners; no additional embankment being required where there is no thrust.

Mr. nel's arch

An elegant mode of constructing arches of brick, without requiring the aid of anything like ordinary centring on the great scale, has been introduced by Mr. Brunel, and is equally applicable to the oblique as to the square bridge. The principle of this, as originally adopted, and its sufficiency tested in constructing the shaft of the Thames Tunnel, depends on the cohesive power of Roman cement, coupled with a system of ties, the most eligible material for which Mr. Brunel found to be hoop iron. After the piers have been constructed in the usual manner, a mould, curved according to the figure of the arch, is fixed to, and stretched between these piers, and upon this a narrow arch or rib of brick is carried over and keyed, using cement, with the occasional insertion of ties. The adhesion of the cement to the brick being greater than the cohesion of the brick itself, enables the rib to be carried to any extent of which the strength of the material will admit. When once a sufficient number of such ribs have been successively constructed, side by side, like so many beams stretched between the piers, they will be in a state to receive and support all the other materials necessary to complete the structure.

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[1] The mode of attaining an equilibrium in an oblique arch, is a subject on which no one, so far as we know, has entered. It seems generally to be taken for granted, that the obliquity makes no difference; but though in this we cannot acquiesce, our limits will not admit of attempting to discuss the question

[2] See Philosophical Magazine for April 1836, January and March 1837, and Reports of British Association for 1838.

The bridge of the Santissima Trinita at Florence, though of ruble construction, affords a magnificent example of the strength of cementitious architecture, and of the durability of the materials; the arches being composed of a mass of irregular stones so strongly united by mortar, as to have the consistence of a single stone. It is evidently a matter of perfect indifference whether such arches were square or oblique. A very ancient bridge, said to have been built by the Romans, over the Danube at Ratisbon, has wonderfully resisted the ravages of time. It consists of gray freestone and thin bricks, firmly united by pozzolano cement.

On several lines of railway, an ingenious mode of constructing arches of laminated ribs of wood or iron has been introduced by Mr. Green, and is alike applicable to the oblique as to the square arch. At the Ouseburn, close to the east side of the town of Newcastle, is one of the great viaducts constructed in this manner by Mr. Green, on the Shields railway. The piers and abutments are of stone, with large projecting buttresses on each side, whilst the arches, which are circular, are of Memel timber. Each arch is one hundred and sixteen feet in span, and consists of three separate and parallel curved ribs, and each rib, which is four feet in depth by twenty-two inches in thickness, is composed of sixteen layers of three-inch planks laminating over each other, and these again, whilst being bent over a curved frame or centre into the form of the required arch, were firmly fixed together by means of oaken pins and iron straps. The three ribs of each arch are connected by diagonal braces, and their ends rest in large iron sockets fixed on the stone piers or abutments. From the upper sides of the ribs a series of very strong struts, braces, and framing, bound with iron straps and bolts, is carried up, filling the spandrils, to support the platform or roadway, which is formed of longitudinal beams; these again are covered with three-inch planks to carry the rails. Hitherto almost all wooden bridges had been constructed of straight timbers, upon the same principles as are used in roofing; and on account of the shrinkage from the frequent joggles and the weight of the structure, the roadway and framing generally became bent or crippled. But the ribs constructed by Mr. Green make a very close approach to solid pieces of timber. Their strength is very little impaired by the joining of the planks, which are from twenty to forty-five feet in length by eleven inches in breadth; particularly since great care has been taken that no two junctions of their ends might occur at the same place. In forming a rib, the first layer of planks consists of two whole deals in breadth, and the next of one whole and two half deals, and so on alternately, until the rib is completed. This construction is supposed to be better able to resist the load which it may have to bear at a given point, than can be done by the same quantity of materials in a different form. The struts which discharge the weight from the spandril beams upon the ribs, stand at right angles to the latter, and divide them into equal parts. The strength, durability, and beauty, can only be exceeded by arches of stone. The whole of the timber was subjected to Kyan's process, and between every two deals was introduced a layer of brown paper dipped in tar, to exclude moisture. The bridge across the Ouseburn has five wooden arches of one hundred and sixteen feet span, and four of stone of forty-three feet span. Each of the wooden arches required three centres, which were made so light as to admit of being shifted from one arch to another without being taken to pieces. The total length of this bridge is nine hundred and fifty feet, and greatest height one hundred and eight feet. At Willington, four miles farther east, on the same railway, is a still longer bridge of the same construction.

Mr. Green has applied the same principle to the construction of iron bridges with laminated ribs of that metal. Wrought iron bars from 1·5 to 4 inches square, according to the span of the arch, and from fifteen to twenty-five feet in length, grooved on the under, and tongued on the upper side, are laid one over another, and bent over a centre until the rib is formed. The bars are bound together with iron straps at intervals of from four to six feet apart. A considerable saving of expense, and great lightness, as compared with stone or ordinary iron bridges, may thus be attained.

Skinner.

SKINNER, John, a poet and theologian, was born at Balfour in the parish of Birse and county of Aberdeen, on the third day of October 1721. His father, who bore the same name, was master of the parochial school, and had married Jane the widow of Donald Farquharson, Esq. of Balfour, grandfather to the late Dr. Farquharson of Edinburgh. The mother, whose maiden name was Gillanders, died about two years after the birth of this their only son; and Mr. Skinner afterwards removed to the parish of Echt, at the distance of about twelve miles from Aberdeen. Here he continued for fifty years to discharge the duties of a schoolmaster, "to the entire satisfaction of many persons of distinction, whose sons were entrusted to his care and tuition; and so great was his diligence in the line of his profession, that he fitted out more young men for the university, than most country schoolmasters of his day." After having continued a widower for several years, he contracted a second marriage, and had a numerous family. His youngest son, Mr. James Skinner, a solicitor of Edinburgh, still survives, and has reached a very advanced age.

For the rudiments of learning, John was indebted to his father's school, where he made rapid progress in the acquisition of the Latin language. At the early age of thirteen, he was emboldened to present himself at the annual competition in Marischal College; and there he gained a considerable *bursary*, or exhibition, which served to defray a great proportion of his expenses during the four years of his academical course. After the completion of this period, he was for a few months employed as a teacher in Kemnay school; from which he transferred his services to the adjoining parish of Monymusk, as an assistant to the schoolmaster. Lady Grant, admiring some of his poetical effusions in the Scottish dialect, "was pleased to encourage his rustic muse, by affording him in the house of Monymusk every accommodation for prosecuting his studies, and improving his mind in the attainment of useful learning. Here it was, that enjoying the conversation, and the benefit of reading under the direction of a worthy episcopal clergyman in that neighbourhood, he became a convert to the principles of episcopacy, and united himself to the venerable remains of the old established church of Scotland." This *venerable* church was, at that period, chiefly distinguished by a narrow bigotry in politics, as well as religion. In the month of June 1740, he became tutor to the only son of Mr. Sinclair of Scalloway, a gentleman of considerable property in Zetland. Here he only resided for about twelve months, the death of his pupil's father having occasioned another arrangement. He honoured his memory by an English elegy and a Latin epitaph, both of which were printed by Ruddiman. Here he became intimately acquainted with Mr. Hunter, the only episcopal clergyman in those islands, who not only assisted him in his theological studies, but likewise bestowed upon him the hand of his eldest daughter; "and with her the best of all earthly blessings, a sweetly soothing affectionate wife, who was his dear companion, and ministered tenderly to all his wants, for the uncommon space of fifty-eight years." This marriage must have taken place when he had scarcely attained the twentieth year of his age.

Having now returned to Aberdeenshire, and made some further preparation, he received ordination from Bishop Dunbar, who resided at Peterhead. In November 1742 he fixed his residence at Linshart in the parish of Longside, as minister of a congregation which his biographer describes as large and respectable.[1] It is not however to be supposed that his stipend was very ample. The rebellion, which ensued in 1745, exposed him to no small annoyance. The episcopal clergy were very generally disaffected to the existing government, and many of them were subjected to useless severities. On returning home one evening, Mr. Skinner "found his house in the possession of a military party; some of them guarding the door with fixed bayonets, and others searching the several apartments, even the bedchamber where Mrs. Skinner was lying-in of her fifth child, and little able to bear such a rude unseasonable visit. No lenity was to be looked for from such unfeeling visitors, who pillaged the house of every thing they could carry with them, hardly leaving a change of linen to father, mother, or child in the family. The chapel with all its furniture was destroyed; and for several years the congregation could find no place to meet in for public worship but the clergyman's house, which not being sufficiently large, many of them were obliged to stand in the open air, during divine service." Of this miserable species of persecution, it is not easy to devise any plausible justification. The episcopalians of Longside, even if we suppose all of them to have been the most decided Jacobites, certainly could not convert their chapel to any political or military purpose; nor is it very obvious how this mode of treatment could have any tendency to increase their attachment to the reigning family. With the view of preventing his flock from being scattered from the true fold, he now prepared a small tract, entitled "A Preservative against Presbytery," which was printed in the year 1746.

In the course of the same year, an act of parliament enjoined the episcopal clergy to register their letters of orders before the first day of September; after which date, it was provided that none should be admitted for registration, except such as had been obtained from a bishop of the church of England or of Ireland. And another act, passed two years afterwards, declared that no letters of orders, unless such as were granted by bishops of those churches, should after the 29th of September be sufficient to qualify any minister of an episcopalian meeting. From such vexatious and unavailing regulations as these, many hardships must have resulted, and Skinner seems to have experienced his full share. In 1753 he was apprehended under the authority of a warrant from the sheriff-substitute of the county; nor did he hesitate to make a voluntary confession that he had violated the recent act, by officiating as a clergyman to more than four persons, beside the members of his own family. For this offence he was sentenced to six months imprisonment. His wife, with her six children, were in the mean time kindly treated by the good people of Longside. The solitude of his prison was enlivened by the visits of some faithful friends, to whom he was likewise indebted for a liberal supply of books. His literary ardour did not suffer any abatement; and he frequently declared that no six months of his life had ever passed with so little interruption to his studies and improvement. In the exercise of his poetical talents he found a pleasing recreation, but his attention was chiefly directed to more serious pursuits.

For several years he had devoted much of his leisure to the study of the Hebrew language; and during his prison hours he formed the design of his Dissertation on the Shechinah, which appeared amongst his posthumous works. In the year 1757 he published at London "A Dissertation on Jacob's Prophecy, Genesis xix. 10." According to his interpretation, this prophecy denotes "that the *tribeship* should not depart from Judah, nor a *typifer* from between his feet, or from among his descendants, till Shiloh (the Messiah) should come, and till the gathering of the people should be to him." This explanation, we are informed, was highly approved by Bishop Sherlock, and by other biblical critics of acknowledged eminence. His next work was of a different denomination. Mr. Sievwright, an episcopal minister of Brechin, published a somewhat curious volume, exposing the principles and practices of his nonjuring brethren.[2] It appeared in 1767, and Mr. Skinner soon afterwards published, but without his name, "A Letter to Norman Sievwright, M.A., in Vindication of the Episcopal Clergy of Scotland from his Charge of Innovations in Politics and Religion." Of his next publication, neither the date nor the precise title is mentioned by his biographer. It however assumed the form of an answer to an Enquiry into the Powers of Ecclesiastics, on the Principles of Scripture and Reason, written by the Rev. Thomas Gordon, minister of Speymouth.

This was followed by a more elaborate work, "An Ecclesiastical History of Scotland, from the first appearance of Christianity in that kingdom, to the present time: with remarks on the most important occurrences. In a Series of Letters to a Friend." Lond. 1788, 2 vols. 8vo. Prefixed is a dedication, in Latin verse, to his son the bishop. The value of this work is far from being considerable. It is written in a spirit too sectarian, and in a style too provincial. Many facts are very inaccurately stated. Thus he asserts that with the exception of Dr. Featley, no episcopalian divine ever sat in the Westminster assembly. According to this ecclesiastical historian, the praise of Archbishop Laud "is and ever will be in the English church." A man who could thus bestow commendation on a merciless bigot, is not to be admired for his wisdom or moderation. Nothing is so apt as bigotry to blind a man's understanding, and to suppress the best feelings of his heart. In the nefarious sentence of death pronounced on the earl of Argyle for adding an explanation when he took the test-oath, Mr. Skinner finds nothing to condemn. According to the same authority, King James's attachment to popery was acknowledged by his greatest enemies to be the only blemish of his character. The sufferings of the episcopal clergy after the Revolution are commemorated in terms sufficiently tragical; but the bloody persecution of the presbyterians during the reign of Charles the Second is represented as a very trivial matter; and it seems to have been the author's deliberate opinion, that they were treated neither better nor worse than they deserved. A very different opinion was entertained by a more impartial, as well as a more able writer. "Scotland," says Jonathan Edwards, "has also been the scene, for many years together, of cruelties and blood by the hands of high-churchmen, such as came very little short of the popish persecution in Queen Mary's days, and in many things much exceeded it."[1] Mr. Skinner is lively where he is not edifying or instructive; and if he is here entitled to any other praise, it is that of supplying an account of his own sect from the era of the Revolution. A supplementary volume, under the title of "Annals of Scottish Episcopacy," was published at Edinburgh in 1818 by the author's grandson the Rev. John Skinner of Forfar.

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[1] During the following year, he wrote a Latin elegy on the death of Bishop Rattray, which appeared in a small publication entitled "A Letter to a Friend: with two Poems sacred to the memory of the late R. R. Dr. Thomas Rattray of Craighall, Bishop of Edinburgh." Edinb. 1743, 4to. The letter was also written by Skinner. This elegy is followed by an English poem, written by a different person.

[2] Principles, Political and Religious: or, a Preservative against Innovations in Politics and Religion. By Norman Sievwright, M.A. a Presbyter of the Communion of the Church of England as by Law established, and Minister to the authorised Episcopal Congregation in Brechin. Edinb. 1767 12mo.

Towards the close of the century, he published "a Letter to the Congregation of the Chapel of Old Deer;" and "Some plain Remarks on a plain Account of Conversion, now in circulation through the Parish and Neighbourhood of Old Deer." This last tract, printed in 1799, is directed against William Ward, A.M., a clergyman of the church of England. He continued to augment his stores of theological learning, and undertook some more laborious works, which were not however published till after the death of the author. His name was favourably known to many distinguished individuals in England, as well as Scotland. As a poet, he corresponded with Burns; as a man of erudition, with Doig. The master of Stirling school and the minister of Longside chapel were both remarkable men in their generation; and to those who complain of the want of leisure, opportunities, and encouragement in the pursuit of learning, their history supplies a most edifying example. During the summer of 1795, Dr. Doig and Mr. Ramsay of Ochtertyre paid him a visit; and he spent a delightful week with them at Peterhead, which was then a watering place of fashionable resort.

Of the activity, as well as the benevolence of his disposition, he exhibited a signal proof by devoting a portion of his time to the study of physic, not for his own benefit, but for that of his poor neighbours, whether episcopalians or presbyterians. "Nor was it only to those," says his biographer, "who were placed more immediately under his pastoral care, that his benevolence was extended. Though he always considered them as entitled to his first and principal concern, yet did he never feel himself more happily employed, than when administering relief to the distresses, whether bodily or mental, of all that were within his reach, and would listen to his advice, whatever might be their religious profession. As no medical practitioner resided within four or five miles of Longside, soon after his settlement there, Mr. Skinner's sympathy was often excited by perceiving his neighbours suffering under a want, of which the state of the country afforded no prospect of a regular supply. He resolved therefore to devote part of his own time to the study of physic; and with the aid of an eminent physician in Aberdeen [Dr. Thomas Livingston], who approved of his design, and felt the force of the motives from which it sprung, he soon acquired such a knowledge of the healing art, as enabled him to afford to the poor, labouring under disease, that relief which they could not otherwise have easily obtained, and the want of which might sometimes have proved fatal. It is proper to add, that for his medical prescriptions he accepted no fees."

During the autumn of 1799 he had the heavy misfortune to lose his wife. This was a loss which could not be repaired; and at length, when the weight of age pressed more heavily upon him, his only surviving son Bishop Skinner invited him to spend the remainder of his days under his roof. He accordingly removed to Aberdeen on the 4th of June 1807, and for about eight days he apparently enjoyed his usual health and spirits. Some feverish symptoms, with a difficulty of respiration, afterwards supervened: but during the last day of his life, he moved into the garden, when finding his strength to be totally impaired, and having with much difficulty been supported into the house, he was placed in a chair, and calmly closing his eyes, expired without a groan or a struggle. He thus departed on the 16th of June, in the eighty-sixth year of his age. In compliance with his own request, his remains were interred in the church-yard of Longside, in the same grave with those of his wife. A marble tablet was there erected by the members of his congregation, by whom his memory was much revered.

Skinner appears to have been a man of a cheerful and friendly disposition; and in the discharge of his pastoral duties, he is represented as very exemplary. During the greater part of his professional life, it was not his practice to commit his discourses to writing, but he nevertheless preached with much ease and fluency. His opinions were deeply tinctured with the Hutchinsonian philosophy. To a lively fancy he added no despicable share of learning. He had cultivated not only a knowledge of the Latin and Greek, but likewise of the Hebrew language. In the composition of Latin verse he had attained to great facility, and to considerable skill. The longest of his poems is a Latin version of the Batrachomyomachia ascribed to Homer. He likewise translated Christis Kirk of the Grene, a Scotish poem remarkable for its genuine humour. The measure which he has here adopted, hexameter and pentameter verse, is not peculiarly suited to so familiar and ludicrous a subject: iambics would certainly have been more appropriate. Some of his Scotish poems are written in a pleasant strain, and three of his songs, Tullochgorum, John o' Badenyon, and the Ewie wi' the crookit Horn, have obtained a great share of popularity.

Not long after his death appeared "Theological Works of the late Rev. John Skinner, Episcopal Clergyman in Longside, Aberdeenshire. To which is prefixed a biographical memoir of the author." Aberdeen, 1809, 2 vols. 8vo. This publication was accompanied or immediately followed by "A miscellaneous Collection of Fugitive Pieces of Poetry, &c. Vol. III. of his Posthumous Works." Edinburgh, 1809. A separate edition of his poems was published under the title of "Amusements of Leisure Hours: or, Poetical Pieces, chiefly in the Scottish dialect." Edinburgh, 1809, 12mo. A copious life of the author, evidently written by his son, is prefixed to the theological works. The first volume likewise includes a series of "Letters addressed to Candidates for Holy Orders in the *Episcopal Church of Scotland*." The second contains "A Dissertation on the Shechinah, or Divine Presence with the Church or People of God," "An Essay towards a literal or true radical Exposition of the Song of Songs, which is Solomon's," and "Psalms viii., xxiii., and xlv. translated into Latin verse." In his Essay he strenuously maintains the opinion of those who regard the Song of Solomon as an inspired book. Of the value of his Dissertation, some notion may perhaps be formed from a single specimen. The divine presence, says this learned theologian, "is not now to be looked for, but in the way of God's own divine appointment, and under the sacred symbols of bread and wine, set apart and instituted for that very purpose by Christ himself. . . . And if Corah and his company met with so signal and sudden a punishment for invading but a part of Aaron's office, of how much sorer punishment shall they be thought worthy, as St. Paul argues in a like case, who dare thrust themselves, without any call, order, or commission, into the ministry of the Christian priesthood, and will take upon them to consecrate the symbols of the divine presence, and to stand as priests between God and the people? It is no wonder that such unruly invaders of the priesthood should do what they can to bring the sacrament of the divine presence into contempt, and should refuse to appear in any posture of adoration before it, since they cannot but know that God will not vouchsafe to be present in it, but in the way and method of his own appointment." According to this pure and enlightened theology, the divine presence, utterly withheld from all non-episcopalian assemblies of worshippers, is regularly manifested wherever a popish or half-popish priest "offers the unbloody sacrifice." It is truly pitiful that any man, calling himself a protestant, should be so besotted as to represent all this as the way and method of God's own appointment. It is the very essence of such an adulterated form of Christianity, that, without the supplementary aid of bishops and priests, Christ has died in vain, and in vain has risen from the dead. (x.)

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[1] Edwards's History of the Work of Redemption, p. 291. Edinb. 1774, 8vo

Skinner, *Stephen*, an English lexicographer, was born in the year 1622. He travelled, and studied in several foreign universities during the civil wars; and in 1654, he returned and settled at Lincoln, where he practised physic with success until the year 1667, when he died of a malignant fever. His posthumous work was published in folio in 1671, by Mr. Henshaw, under the title of *Etymologicon Linguæ Anglicanæ*.

SKIPTON, commonly called Skipton in Craven. It is in the wapentake of Staincliffe, in the West Riding of Yorkshire, 216 miles from London. It stands on the river Aire, in a wild and romantic district near two lofty mountains. Being on the canal from Leeds to Liverpool it has some trade with both these places, and of late years it has become the seat of some manufactures of glass, of silk, and of cotton goods. The ancient castle has been preserved, and is now a mansion of the Earl of Thanet. The quarter sessions for the West Riding are held here. It has a well supplied market on Saturdays, and several fairs for the sale of cattle. The inhabitants were, in 1801, 2305; in 1811, 2868; in 1821, 3411; and in 1831, 4181.

SKIROS, an island of Turkey, on the western side of the Archipelago, about twenty-three miles from the mainland. It is sixty-three square miles in extent, and contains 1800 Greek inhabitants, who grow oil and cotton, and feed cattle in the valleys between the rocky hills which cover the greater part of the surface. The chief town is of the same name, and has a small harbour.

SKYE, the largest of the western islands of Scotland, is situated between the outer range of the Hebrides, and the mainland of Scotland, from which it is separated by a narrow strait, varying from a gun-shot to three miles in breadth. It forms part of the county of Inverness, and is divided into seven parishes. The extreme length of the island is about forty-five miles, and its extreme breadth twenty-four miles; but a better idea of its dimensions will be formed, by measuring it across the middle, which will give a mean breadth of fifteen miles. These measurements do not, however, give any idea of the superficial extent of the island, in consequence of the remarkable indentations of the coast, no part of the island being distant four miles from the seashore. The area of the island is computed at 700 square miles, and contains therefore 448,000 acres, of which 30,000 are arable. It is divided into five districts. The south-east district, which is close upon the mainland, is called Sleat. The greater portion of the central part of the island is named Minginish, whilst the northern extremity is divided by Loch Snizort and Loch Follart into three extensive tracts of land, called Trotternish, on the north-eastern, Waternish on the north-west, and Kilmuir on the west side.

The position of Skye protects it in some measure from the storms that assail the outer range of islands. The numerous lochs provide it with a variety of excellent bays and harbours, which point it out as admirably adapted for carrying on the fisheries, but which, from the habits of the people, has never been prosecuted to any extent. The surface of the island is invariably hilly, and may be called one great mountainous moorland, presenting three distinct assemblages of mountains, which are separated by intervening tracts of high and undulating land. Kilmuir plain, and a small tract of land near Loch Braccadale, are the only exceptions.

In that part of the country, in the southern border of Minginish, occurs the greatest assemblage of mountains. They are divided into two portions, intimately united, but characterised by striking differences in their external outlines and general features. The range called the Cuchullins, so often mentioned by Ossian, average in height from 2000 to 3000 feet above the level of the sea. On the west side of the island, the land is from 600 to 1000 feet in height, and its surface is covered with brown heath. The north-eastern portion of the island, Trotternish, offers more variety, and it attains an altitude of 2000 feet in height. The shore scenery is famed for the caves with which they abound, and the mountainous parts of the island for wild and rugged scenery, equal in grandeur to any in the Highlands.

The south-east portion of the island, from the point of Sleat to Kyle-rhea, consists of regular stratified rock, which, whether primary or secondary, extend in a line from south-west to north-east; but the remaining mass of the island must be considered as formed of unstratified rock, all belonging to the family of trap, (including under that term syenite), and all incumbent on the stratified rocks, and of posterior date.

From the height of the hills, and the proximity of the sea, the air seldom continues long of the same temperature; sometimes it is dry, oftener moist, and in the latter end of winter and beginning of spring cold and piercing. At an average, three days in twelve, throughout the whole year, are scarcely free from rain, far less from clouds. These, attracted by the hills, sometimes break in useful and refreshing showers; at other times suddenly bursting, they pour down their contents with tremendous noise, and impetuous torrents deluge the plains below, and render the smallest rivulet impassable, which, together with the stormy winds so common in this country in the months of August and September, frequently blast the hopes of the husbandman. Snow has been often known to lie on the ground from three to seven weeks.

Skye is not well adapted for agriculture. The soil is good, but too light for the culture of wheat; oats are raised in considerable quantities, which, with barley and potatoes, form the agricultural produce of the island. Much might be done in the improvement of the land, for the subsoil is every where of the finest quality, and both in the trap and the gneiss districts, the calcareous rock is found to be decomposed to the depth of several feet, and yielding a loam of excellent quality. The greater part, however, is suffocated with peat or stones, and is swampy and rocky. The peat is nevertheless thin, and by burning the peat, and turning up the rock, either by manual labour, or by the subsoil plough, and proper drainage, the agriculture of the island, in course of time, would be much improved. The land is also rendered cold by the want of trees, for which the soil and climate are well adapted. Skye is unquestionably a grazing country, and the proprietors have wisely directed their attention to the improvement of the stock of black cattle and sheep, and to the enlargement of their farms, of which they have latterly in many places given leases. Kelp in former years was manufactured to a considerable extent, but that branch of industry is now nearly annihilated. The climate is, as already stated, damp, and the farmers in consequence are all provided with wattled barns, in which they may dry their scanty crops in the rainy season. The *caschrome*, or ancient crooked spade, is a good deal used by the poor, and the *quern*, or handmill, is still to be found in some of the remote districts of the island. The roads in Skye are much superior to those of Mull, and they traverse the island in various directions.

The people are of short stature, robust, and healthy. They generally profess the Protestat religion; but education is in a very low state. In 1831, one half of the population were unable to read in any language. Great numbers have lately emigrated to America. The towns in Skye are of no importance. The population in 1821 amounted to 20,627; and in 1831, to 22,796, of whom 11,883 were females.

There are two or three fairs held annually at Portree, the principal town, to which almost every part of Skye sends cattle. The commodities which are sold there are horses, cows, sheep, goats, hides, butter, cheese, fish, and wool. In Skye appear many ruins of Danish forts, watch-towers, beacons, temples, and sepulchral monuments. All the forts are known by the term Dun; such as Dun-Skudborg, Dun-Derig, Dun-Skeriness, Dun-David, and so on.

SLACKEN, in *Metallurgy*, a term used by miners to express a spongy and semivitrified substance which is mixed with the ores of metals, to prevent their fusion. It is the scoria or scum separated from the surface of the former fusions of metals. To this is frequently added limestone, and sometimes a kind of coarse iron ore, in the running of the poorer gold ores.

SLAVERY is a word, of which, though generally understood, it is not easy to give a proper definition. An excellent moral writer has defined it to be "an obligation to labour for the benefit of the master, without the contract or consent of the servant." But may not he be properly called a slave, who has given up his freedom to discharge a debt which he could not otherwise pay, or who has thrown it away at a game of hazard? In many nations, debts have been legally discharged in this manner; and in some savage tribes, it is no uncommon thing for a man, after having lost at play all his other property, to stake, on a single throw of dice, himself, his wife, and his children. That persons who have thus lost their liberty are slaves, will hardly be denied; and surely the infatuated gamester is a slave by his own contract. The debtor, too, if he was aware of the law, and contracted debts larger than he could reasonably expect to be able to pay, may justly be considered as having come under an obligation to labour for the benefit of a master with his own consent; for every man is answerable for all the known consequences of his voluntary actions.

But this definition of slavery seems to be defective as well as inaccurate. A man may be under an obligation to labour through life for the benefit of a master, and yet that master have no right to dispose of him by sale, or in any other way to make him the property of a third person; but the word slave, as used amongst us, always denotes a person who may be bought and sold like a beast in the market.[1]

As nothing can be more evident than that all men have, by the law of nature, an equal right to life, liberty, and the produce of their own labour, it is not easy to conceive what can have first led one part of them to imagine that they had a right to enslave another. Inequalities of rank are indeed inevitable in civil society; and from them results that servitude which is founded in contract, and is of temporary duration. He who has much property has many things to attend to, and must be disposed to hire persons to assist and serve him; whilst those who have little or no property must be equally willing to be hired for that purpose. And if the master be kind, and the servant faithful, they will both be happier in this connection than they could have been out of it. But from a state of servitude, where the slave is at the absolute disposal of his master in all things, and may be transferred without his own consent from one proprietor to another, like an ox or an ass, happiness must be for ever banished. How then came a traffic so unnatural and unjust as that of slaves, to be originally introduced into the world?

The common answer to this question is, that it took its rise amongst savages, who, in their frequent wars with each other, either massacred their captives in cold blood, or condemned them to perpetual slavery. In support of this opinion etymologists observe, that the Latin word *servus*, which signifies not a hired servant, but a *slave*, is derived from *servare*, to preserve; and that such men were called *servi*, because they were captives, whose lives were preserved on the condition of their becoming the property of the victor.

Origin of slavery.

That slavery had its origin from war, we think extremely probable, nor are we inclined to controvert this etymology of the word *servus;* but the traffic in men prevailed almost universally, long before the Latin language or Roman name was heard of; and there is no good evidence that it began amongst savages. The word עבד, in the Old Testament, which in our version is rendered servant, signifies literally a slave, either born in the family or bought with money, in contradistinction to שביר, which denotes a hired servant; and as Noah makes use of the word עבד in the curse which he denounces upon Ham and Canaan immediately after the deluge, it would appear that slavery had its origin before that event. If so, it may be plausibly conjectured that it began amongst those violent persons whom our translators have called *giants*,[2] though the original word נפלים literally signifies *assaulters of others*. Those wretches seem to have first seized upon women, whom they forcibly compelled to minister to their pleasures; and from this kind of violence the progress was natural to that by which they enslaved their weaker brethren amongst the men, obliging them to labour for their benefit, without allowing them fee or reward.

Prior to the deluge.

Nimrod enslaved his captives.

After the deluge the first dealer in slaves seems to have been Nimrod. "He began," we are told, "to be a mighty one in the earth, and was a mighty hunter before the Lord." He could not, however, be the first hunter of wild beasts; nor is it probable that his dexterity in the chase, which was then the universal employment, could have been so far superior to that of all his contemporaries, as to entitle him to the appellation of "the mighty hunter before the Lord." Hence most commentators have concluded, that he was a hunter of men; an opinion which they think receives some countenance from the import of his name, the word Nimrod signifying a rebel. Whatever be in this, there can be little doubt that he became a mighty one by violence; for it appears from Scripture, that he invaded the territories of Ashur the son of Shem, who had settled in Shinar; and, obliging him to remove into Assyria, he seized upon Babylon, and made it the capital of the first kingdom in the world. As he had great projects in view, it seems to be in a high degree probable that he made bond-servants of the captives whom he took in his wars, and employed them in building or repairing the metropolis of his kingdom; and hence may perhaps be dated the origin of postdiluvian slavery.

Slavery in the days of Abraham.

That it began thus early can hardly be questioned; for we know that it prevailed universally in the age of Abraham, who was born within seventy years after the death of Nimrod. That patriarch had three hundred and eighteen servants or slaves, born in his own house, and trained to arms, with whom he pursued and conquered the four kings who had taken captive his brother's son.[3] And it appears from the conversation which took place between him and the king of Sodom after the battle, that both believed the conqueror had a right to consider his prisoners as part of his spoil. "Give me," says the king, "the *persons*, and take the *goods* to thyself." It is indeed evident from numberless passages of scripture, that the domestics whom our translators call servants, were in those days universally considered as the most valuable part of their master's property, and classed with his flocks and herds.

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[1] The Roman orator's definition of slavery, Parad. V. is as accurate as any that we have seen. "Servitus est obedientia fracti animi et abjecti et arbitrio carentis suo;" whether the unhappy person fell into that state with or without his own contract or consent.

[2] Gen. vi. 4.

[3] Gen xiv.

Authorised by the Mosaic law.

That the practice of buying and selling servants thus early begun amongst the patriarchs descended to their posterity, is known to every attentive reader of the Bible. It was expressly authorised by the Jewish law, in which are many directions how such servants were to be treated. They were to be bought only of the heathen; for if an Israelite grew poor and sold himself either to discharge a debt, or to procure the means of subsistence, he was to be treated not as a slave צבר, but as a hired servant שביו, and restored to freedom at the year of Jubilee. Unlimited as the power thus given to the Hebrews over their bond-servants of heathen extraction appears to have been, they were strictly prohibited from acquiring such property by any other means than fair purchase. "He that stealeth a man and selleth him," said their great lawgiver, "shall surely be put to death."[1]

Spread over the whole world.

Whilst slavery, in a mild form, was permitted amongst the people of God, a much worse kind of it prevailed amongst the heathen nations of antiquity. With other abominable customs, the traffic in men quickly spread from Chaldea into Egypt, Arabia, and over all the east, and by degrees found its way into every known region under heaven.

Of this hateful commerce we shall not attempt to trace the progress through every age and country, but shall content ourselves with taking a transient view of it amongst the Greeks and Romans, and a few other nations, in whose customs and manners our readers must be interested.

Slavery amongst the Greeks.

One can hardly read a book of the Iliad or Odyssey, without perceiving that, in the age of Homer, all prisoners of war were liable to be treated as slaves. So universally was this cruel treatment of captives admitted to be the right of the conqueror, that the poet introduces Hector, in the very act of taking a tender and perhaps last farewell of his wife, when it was surely his business to afford her every consolation in his power, telling her, as a thing of course which could not be concealed, that, on the conquest of Troy, she would be compelled

> To bear the victor's hard commands, or bring
> The weight of water from Hyperia's spring..

At that early period, the Phœnicians, and probably the Greeks themselves, had such an established commerce in slaves, that, not satisfied with reducing to bondage their prisoners of war, they scrupled not, for supplying their foreign markets, to kidnap persons who had never kindled their resentment. In the fourteenth book of the Odyssey, Ulysses represents himself as having narrowly escaped a snare of this kind laid for him by a false Phœnician, who had doomed the hero to Lybian slavery; and as the whole narrative, in which this circumstance is told, is an artful fiction, intended to have the appearance of truth to an Ithacan peasant, the practice of kidnapping slaves could not then have appeared incredible to any inhabitant of that island.

Such were the manners of the Greeks in the heroic age; nor were they much improved in this respect at periods of greater refinement. Philip of Macedonia, having conquered the Thebans, not only sold his captives, but even took money for permitting the dead to be buried;[2] and Alexander, who had more generosity than his father, afterwards razed the city of Thebes, and sold the inhabitants, men, women, and children, for slaves.[3] This cruel treatment of a brave people may indeed be supposed to have proceeded, in the first instance, from the avarice of the conqueror; and in the second, from the momentary resentment of a man who was savage and generous by turns, and who had no command of his passions. We shall not positively assign it to other causes; but from the manner in which the Spartans behaved to their slaves, there is little reason to imagine that, had they received from the Thebans the same provocation with Alexander, they would have treated their captives with greater lenity.

Slave among the R mans.

It has been said, that in Athens and Rome slaves were better treated than in Sparta. But in the former city their treatment cannot have been good, or their lives comfortable, when the Athenians relished that tragedy of Euripides in which Hecuba, the wife of Priam, is introduced as lamenting that she was chained like a dog at Agamemnon's gate. Of the estimation in which slaves were held in Rome, we may form a tolerable notion from the well-known fact, that one of those unhappy beings was often chained at the gate of a great man's house, to give admittance to the guests invited to a feast. In the early periods of the commonwealth it was customary, in certain sacred shows exhibited on solemn occasions, to drag through the circus a slave, who had been scourged to death, holding in his hand a fork in the form of a gibbet.[4] But we need not multiply proofs of the cruelty of the Romans to their slaves. If the inhuman combats of the gladiators admit of any apology on account of the martial spirit with which they were thought to inspire the spectators, the conduct of Vedius Pollio must have proceeded from the most wanton and brutal cruelty. This man, who flourished not in the earliest periods of the republic, when the Romans were little better than a savage banditti, but in the polished age of Augustus, frequently threw such slaves as gave him the slightest offence into his fishponds to fatten his lampreys; and yet he was suffered to die in peace. The emperor, indeed, upon coming to the knowledge of his cruelty, ordered his lampreys to be destroyed, and his ponds to be filled up; but we do not recollect that any other punishment was inflicted on the savage master.

Origi Roma Slave

The origin of slavery in Rome was the same as in every other country. Prisoners of war were of course reduced to that state, as if they had been criminals. The dictator Camillus, one of the most accomplished generals of the republic, sold his Etrurian captives to pay the Roman ladies for the jewels which they had presented to Apollo. Fabius, whose cautious conduct saved his country when Hannibal was victorious in Italy, having subdued Tarentum, reduced thirty thousand of the citizens to slavery, and sold them to the highest bidder. Coriolanus, when driven from Rome, and fighting for the Volsci, scrupled not to make slaves of his own countrymen; and Julius Cæsar, among whose faults wanton cruelty has never been reckoned, sold at one time fifty-three thousand captives for slaves. Nor did the slaves in Rome consist only of foreigners taken in war. By one of the laws of the twelve tables, creditors were empowered to seize their insolvent debtors, and keep them in their houses till, by their services or labour, they had discharged the sum they owed. The children of slaves were the property not of the commonwealth, or of their own parents, but of their masters; and thus was slavery perpetuated in the families of such unhappy men as fell into that state, whether through the chance of war or the cruelty of a sordid creditor. The consequence was, that the number of bondmen belonging to the rich patricians was almost incredible. Caius Cæcilius Isidorus, who died about seven years before the Christian era, left to his heirs four thousand one hundred and sixteen slaves; and Augustus once put twenty thousand of his own slaves on board the corn ships.

Its d tion.

Though many laws were enacted by Augustus and other patriotic emperors to diminish the power of creditors over their insolvent debtors; though the influence of the mild spirit of Christianity tended much to meliorate the condition of slaves even under Pagan masters; and though the emperor Hadrian made it capital to kill a slave without a just reason, yet this infamous commerce prevailed universally in the empire for many ages after the conversion of Constantine to the religion of Christ. It was not indeed completely abolished even in the reign of Justinian; and in many countries which had once been provinces of the empire, it continued long after the empire itself had fallen to pieces.

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[1] Lev. xxi. 16.

[2] Justin, lib. iii. cap. 4.

[3] Justin et Arrian.

[4] Cicero de Div. lib. i. cap. 26.

Sl y a- mo t the an t G ans.

Amongst the ancient Germans, it was not uncommon for an ardent gamester to lose his personal liberty by a throw of the dice. This was indeed a strong proof of savage manners; but the general condition of slaves among those barbarians seems to have been much better than among the polished Greeks and Romans. In Germany the slaves were generally attached to the soil, and only employed in tending cattle, and carrying on the business of agriculture; for the menial offices of every great man's house were performed by his wife and children. Such slaves were seldom beaten, or chained, or imprisoned. Sometimes indeed they were killed by their masters in a fit of sudden passion; but none were considered as materials of commerce, except those who had originally been freemen, and lost their freedom by play.

In gland an Scot- la

Such is the account which Tacitus[1] gives of slavery amongst the ancient Germans. The Anglo-Saxons, however, after they were settled in this island, seem not to have carried on that traffic so honourably. By a statute of Alfred the Great,[2] the purchase of a man, a horse, or an ox, without a voucher to warrant the sale, was strictly forbidden. That law was, doubtless, enacted to prevent the stealing of men and cattle; but it shows us that so late as the ninth or tenth century a man, when fairly purchased, was, in England, as much the property of the buyer as the horse on which he rode, or the ox which dragged his plough. In the same country, now so nobly tenacious of freedom and the rights of man, a species of slavery similar to that which prevailed amongst the ancient Germans, subsisted even to the end of the sixteenth century. This appears from a commission issued by Queen Elizabeth in 1574, for inquiring into the lands and goods of all her bond-men, and bond-women, in the counties of Cornwall, Devon, Somerset, and Gloucester, in order to compound with them for their manumission, that they might enjoy their lands and goods as freemen. In Scotland there certainly existed an order of slaves, or bond-men, who tilled the ground, were attached to the soil, and with it were transferable from one proprietor to another, at a period so late as the thirteenth century: but when or how those villeins, as they were usually called, obtained their freedom, is a question not yet completely solved. Colliers and salters were, in the same country, in a state little removed from slavery, till near the end of the eighteenth century, when they were manumitted by the British legislature, and restored to the rights of freemen and citizens. Before that period the sons of colliers could follow no business but that of their fathers; nor were they at liberty to seek employment in any other mines than those to which they were attached by birth, without the consent of the lord of the manor, who, if he had no use for their services himself, transferred them by a written deed to some neighbouring proprietor.

S ery a ngst t Cartha- g ns.

That the savage nations of Africa were at any period of history exempted from this opprobrium of our nature, which spread over all the rest of the world, the enlightened reader will not suppose. It is indeed in that vast country that slavery has in every age appeared in its ugliest form. We have already observed, that about the era of the Trojan war, a commerce in slaves was carried on between Phœnicia and Libya; and the Carthaginians, who were a colony of Phœnicians, and revered the customs, manners, and religion of their parent state, undoubtedly continued the Tyrian traffic in human flesh with the inland tribes of Africa.

Slavery amongst the Numidians

With the ancient state of the other African nations we are but very little acquainted. The Numidians, Mauritanians, Getulians, and Garamantes, are indeed mentioned by the Roman historians, who give us ample details of the battles which they fought in attempting to preserve their national independence; but we have no particular account of their different manners and customs in that age when Rome was disputing with Carthage the sovereignty of the world. All the African states of which we know any thing, were in alliance with one or the other of those rival republics; and as the people of those states appear to have been less enlightened than either the Romans or the Carthaginians, we cannot suppose that they had purer morals, or a greater regard for the sacred rights of man, than the powerful nations by whom they were either protected or oppressed. They would, indeed, insensibly adopt their customs; and the ready market which Marius found for the prisoners taken in the town of Capsa, although Sallust acknowledges[3] that the sale was contrary to the laws of war, shows that slavery was then no strange thing to the Numidians. It seems indeed to have prevailed through all Africa from the very first peopling of that unexplored country; and we doubt if in any age of the world the unhappy negro was absolutely secure of his personal freedom, or even of not being sold to a foreign trader.

Slave-trade with the coast of Guinea.

It has been often said, that the practice of making slaves of the negroes is of a very modern date; that it owes its origin to the incursions of the Portuguese on the western coast of Africa; and that, but for the cunning or cruelty of Europeans, it would not now exist, and would never have existed. It is quite certain, however, that the negroes themselves, like all other savage tribes, have from ancient times enslaved their prisoners; and the establishment of a trade by foreigners in African slaves, may at an early period have tempted them, in some quarters, to make captives expressly for the purpose of selling them. But Christians were not the first tempters. It has been proved, that from the coast of Guinea a great trade in slaves was carried on by the Arabs some hundreds of years before the Portuguese embarked in that traffic. Even the wandering Arabs of the desert, who never had any friendly correspondence with the Christians of Europe, have from time immemorial been served by negro slaves. In all probability, indeed, these tribes have, without interruption, continued the practice of slavery from the days of their great ancestor Ishmael; and it seems evident, that none of the European nations had ever seen a woolly-headed negro till the year 1100, when the crusaders fell in with a small party of them near the town of Hebron in Judæa, and were so struck with the novelty of their appearance, that the army burst into a general fit of laughter.[4] Long before the crusades, however, we know with certainty that the natives of Guinea had been exposed to sale in foreign countries. In 651 the Mohammedan Arabs of Egypt so harassed the king of Nubia or Ethiopia, who was a Christian, that he agreed to send them annually, by way of tribute, a vast number of Nubian or Ethiopian slaves into Egypt. Such a tribute as this at that time, we are told, was more agreeable to the khalif than any other, as the Arabs then made no small account of these slaves.[5]

On the beginning of this commerce, or the dreadful cruelty with which it has been carried on to the present day, it is impossible to reflect without horror; but there is more consolation, however small, in knowing that its original authors were not Europeans. The purchase of Guinea blacks for slaves by foreign nations, commenced ages before the Portuguese had laid that country open to the intercourse of Europe. Even after they had made many incursions into it, the inhabitants were as regularly purchased for slaves by some of the adjoining states, as they were afterwards by the maritime Europeans.

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[1] De Mor. Germ. 24, 25.

[2] Wilkins' Collection of Laws from Ethelbert to Henry III.

[3] De Bello Jugurth. cap. 91.

[4] Malmsbury, fol. p. 83.

[5] Modern Universal History, vol. i. p. 525.

Present state of slavery.

Without prosecuting farther the history of slavery, we pass to the consideration of its present state in the world, and, in particular, the revolutions which have taken place in that worst department of the system which we have been last occupied in examining.

Slavery of white men.

Before describing the altered position now held by negro slavery, it must be remarked that the slavery of white men is by no means yet extinct. Details on this subject will be found in the articles devoted to those countries in which, under various modifications, bondage still prevails; and here a sentence or two must suffice for summing up the result. The nature of that slavery which still prevails among most Asiatic nations, modified in the Mohammedan states by some precepts of their religion, but nowhere entirely extirpated, is familiarly known to most readers, and information regarding it is sufficiently easy of access. The branch of it in which Europeans are most nearly interested, is that atrocious system of piracy which, carried on for centuries by Algiers and the other Barbary states, filled the cities of Northern Africa with Christian prisoners, but has in the present generation been nearly destroyed by the exertions of our own government, aided by the subsequent expeditions of the French. But the snake is scotched only, not killed; and European captives are still said to pine in Morocco, Tunis, and Tripoli. In a preceding paragraph we have considered the villeinage of the dark and middle ages as being a species of slavery. There is no sound reason for regarding it in any other light; and, however far the serf's condition may be superior to that of the slave who belonged to a Roman patrician or a West Indian planter, his servitude is still so utterly repugnant both to humanity and religion, as to make us ashamed of the fact that, in a shape not much improved, it exists still in Christian provinces of northern Europe. The article Russia has described the status of the boors or unfree peasants in that empire; and in more than one kingdom bordering on it, villeinage has never been completely abolished till our own times.

Negro slavery.

But slavery in its most horrible shape, long averted by the spirit of Christianity from those whom Christians were compelled to consider as their fellow-men, has, in regard to the unfortunate people of Africa, been maintained with unrelenting severity by men and nations professing to be disciples of the gospel. The present age has seen the truth mightily triumph in reference to this dark blot of the civilized world; but the evil is not yet entirely eradicated, even where its atrocities have been most decisively condemned; and in several extensive regions of the globe, no acknowledgment of error has yet been extorted.

Negro slavery in North and South America.

Slavery is still lawful over a large part of the American continent. It extends throughout the empire of Brazil, and is general in the southern provinces of the United States. On the declaration of independence, however, seven of the thirteen British provinces which then formed the confederation, abolished slavery absolutely; and the example was followed by two or three of the rest, as well as by several of those afterwards added to the Union. On the whole, including the remnants of bondage in some of the Spanish republics, it has been calculated that the continent of America now contains 4,000,000 of black and coloured slaves. Of these the United States possess about 2,000,000, making about a sixth part of their whole population; but, as the slaves are unequally distributed, they amount in several provinces to half the number of the free whites, and in some places make up a much larger proportion. The French and Spanish colonies in the West Indies, in which likewise slavery remains unabolished, have a slave population amounting to at least 400,000 souls.

Slaver the B coloni

For the British colonies, the exertions of benevolent and enlightened men during the last fifty years, have at length effected a mighty change, the history of which can here be but too briefly told.

Com- mence of effo for ab tion o slave-

1. The Slave Trade. If the merit of originating the great scheme of abolition is to be shared by every one who, either through word or writing, has expressed convictions of the inhuman injustice involved in the slave-trade, or suggested means for its destruction, our list of emancipationists would both be long, and would commence at an early date. But the honour of having planned that systematic co-operation, which alone could effect the end, does clearly belong to the Society of Friends; and in the series of efforts by which that religious body heralded the exertions of our eminent statesmen, the leading part was acted by Anthony Benezet, a French protestant, who, educated in England, became a Quaker and a citizen of Philadelphia; and to William Dillwyn, an American, and a member of the same sect. The former, besides unwearied personal exertions, published, in 1762, the work which first attracted in this country general notice to the slave-trade; the other, visiting England in 1774, opened communications between the American philanthropists and those of our own countrymen who had already engaged in the same cause Among these latter, the foremost place belongs to the honoured name of Granville Sharp.

Granvi Sharp a the sla Somers

This able and excellent man had been induced to interest himself in a class of questions, which arose about the middle of the eighteenth century. West Indian planters, after having brought negro slaves to England, were accustomed to carry them back to the colonies, or even to sell them to others for that destination; and the opinion of eminent lawyers had sanctioned the practice as legal. Instances of crying hardship aroused the sympathy of individuals: Granville Sharp rescued several victims; and, in the year 1772, he obtained a decision of the English judges in the famous case of the negro Somerset, that, as soon as a slave sets his foot on English ground, he becomes free.[1]

Societ the Su pressio the Sla Trade, 1787.

At length, in May 1787, there was instituted in London a Society for the Suppression of the Slave Trade. Besides Dillwyn and Sharp, its most distinguished member was Thomas Clarkson, a young graduate of Cambridge, who, led to study the subject as the theme of an academical essay, had solemnly devoted his life to the cause of negro emancipation. But the Society immediately numbered among its supporters several men of rank and influence; and, among other converts, its founders had gained, even before their organization, William Wilberforce, then member of Parliament for Hull, and afterwards for Yorkshire.

State o public nion.

Although our own days have witnessed a sharp contest in the last stages of those measures, it is not very easy for us to conceive the magnitude of the obstacles which then opposed themselves, even to the most cautious approach towards the subject. Fear of exposure felt by individuals who knew themselves guilty of malpractices, was aided by fear of pecuniary ruin, felt by many who had no other reason for dreading inquiry; and, among the public men of the nation, the corrupt influence of private interests biassed many, while others were influenced by more honest fears for the effects which change might have on the prosperity of the colonies. The Society determined, from the first, to keep the question of slave emancipation studiously in the background. They proclaimed their aim to be, simply, the abolition of the trade in slaves; maintaining, and endeavouring to convince the public, that the slave population of the colonies could be effectually kept up without new importations; and that, indeed, such importation was in itself not only injurious to the real interests of the planters, but eventually pregnant with ruin to the West India Islands as British dependencies. These topics, with others appealing more directly to moral principle and humane feeling, had already been treated in various publications, and they were now anxiously disseminated through the whole of Britain in pamphlets, newspaper articles, and personal communications; while the indefatigable Clarkson travelled everywhere collecting information as to the state of the slave trade.

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[1] It must be noticed, however, that, a very few years ago, it was decided by Lord Stowell, that slaves who had gained freedom in this way did, on their return to the colonies, become slaves anew.

An excitement was produced which enforced the attention of the government; and its results were still farther aided by the circumstance that Mr. Pitt, who was the intimate friend and political chief of Wilberforce, had already examined the question, and privately declared himself favourable to the views of the society. In February 1788, an order of the crown directed that a committee of the Privy Council should inquire into the state of the slave trade, and its consequences both to Africa, to the colonies, and to the general trade of the kingdom. Before the end of that season, there lay on the table of the House of Commons one hundred and three numerously signed petitions, praying for the abolition of the traffic in human life.

Mr. Wilberforce's ill health detaining him in the country, Mr. Pitt, on the 9th of May 1788, declining to state his own opinion, moved a resolution that the House would, early in the next Session, take into consideration the circumstances of the slave trade complained of in the petitions. This, excepting a motion made by David Hartley some years before, against slavery in the abstract, was the first time the subject had ever been mentioned in the British Legislature. The prayer of the petitions was warmly supported, and delay opposed by Mr. Fox, Mr. Burke, and others. In the meantime, a bill was introduced by Sir William Dolben, and carried through both Houses after virulent opposition, for regulating the burden of the slave-ships, and otherwise diminishing the horrors of the Middle Passage, as it was called, between Africa and the West Indian islands.

On the 12th of May 1789, Wilberforce made his first speech in the House upon the subject, introducing twelve resolutions deduced from the evidence which had been taken before the Privy Council. The propositions, all condemnatory of the trade, were supported by Burke, by Fox, by Granville, and by Pitt, who now declared his opinion unalterable; but the opponents gained their end of delay, by obtaining an order for hearing evidence. It was not till the spring of 1791, that Wilberforce was able to move for leave to bring in a bill, for preventing the further importation of slaves into the colonies in the West Indies. After a stormy debate, the motion was lost by 88 to 163. The enthusiasm of the people, and the favourable dispositions of the legislature, had alike cooled; insurrections of the negroes had broken out in Dominica, the leaders of the French revolution had corresponded with some members of the society, Clarkson had not only visited France, but was the friend of Brissot; and every means had been used for prepossessing the public against the abolitionists.

But the defeated party bated "no jot of hope;" and the public mind became calmer. In April 1792 the House of Commons received from England 330 petitions, and from Scotland 187; and Wilberforce moved an opinion of the House that the slave trade ought to be abolished. He was met by one of the most dangerous enemies of the measure, Mr. Dundas, afterwards Lord Melville, under whose dexterous management an amendment for *gradual* abolition was carried by a large majority; and a few days afterwards the House passed a resolution for abolishing the trade in 1796; but in the House of Lords even this tardy justice was frustrated by a resolution to hear further evidence.

Character of them and their opponents.

In 1793 the House of Commons refused to repeat their resolution of the previous year: in 1795, and each of the four following years, the motion for abolition was made and lost; and the abolitionists then resolved to wait for better times. And thus a measure, calculated to wipe off in part a foul disgrace from the nation,—a measure supported by men of all parties and of all sects,—a measure openly and encouragingly advocated, not only by all the men of highest talent in the country, but by the minister of the day himself, was defeated, after a struggle which, at the time, was aptly called the battle of the pigmies against the giants. Of the sincerity of the other great promoters of the scheme, no doubt has been expressed; but on Mr. Pitt's sincerity there have been thrown very grave suspicions, which it is not possible entirely to dispel. For, although the charge of absolute duplicity is sufficiently rebutted, both by his unbending character and by his admirable speeches on the question, it is unaccountable how he, the most peremptory of all rulers, should not, if he pleased, have forced to silence those subalterns, who trembled to oppose him in any plan but this. The proud son of Chatham loved truth and justice not a little, but he loved power and place greatly more; and he was resolved that negro emancipation should not lose him either a shred of political influence, or a beam of royal favour.

But the triumph was already at hand. The excitement of the war, indeed, still for a time diverted public attention; and, though the principles which had been so convincingly promulgated were silently making converts everywhere, nothing of importance took place for some years, except the appearance of a new and most able advocate in the person of Mr. Stephen, Wilberforce's friend and brother-in-law. In 1804, however, the annual motion of Wilberforce was renewed. The first reading of his Bill for immediate abolition was carried by 124 to 49, the majority containing all the Irish members; and the votes for the third reading were 99 to 33. On the second reading of the Bill in the House of Lords, it was adjourned, without a division, till the following session. In that session, (the spring of 1805,) a new Abolition Bill was thrown out by the House of Commons on the second reading; but, in the same year, a measure of Pitt's for abolishing, by an Order in Council, the slave trade in the newly conquered colonies, which had no charters, was carried into effect without the smallest resistance.

The abolition of the Slave Trade carried, 1807.

The next two years were to witness the final victory. Pitt died; and the ministry of Fox and Lord Grenville was formed. In June 1806, resolutions proposed by the new ministers, pledging the House of Commons to abolition "with all practicable expedition," were carried by more than 100 to 41; and an address to the king, for obtaining the co-operation of foreign powers, was adopted without a division. A bill, founded on the resolutions, was successful in both Houses, and received the royal assent on the 25th of March 1807.

Slave Trade of foreign powers.

The great measure of the British legislature was imitated, in the first instance, by the United States, who were next followed successively by the new South American Republics of Venezuela, Chili, and Buenos Ayres, by Sweden and Denmark, Holland and France. But Spain was brought no farther than to promise in 1814 that she would abolish the slave trade in eight years; while Portugal in 1815 abolished to the north of the equator, promising to abolish finally eight years afterwards, and receiving a sum of money as the price of her acquiescence.

Inefficiency of the Abolition Act; and improvements on it.

In the meantime, the abolitionists in England soon had the disappointment to discover, that the law had no sanction sufficient for enforcing its provisions; whilst the fact, that the horrible trade must now, if conducted at all, be carried on as an act of smuggling, augmented all its miseries, and introduced atrocities not less shocking than those which had prevailed before the passing of Sir William Dolben's carrying act. An energetic remedy was necessary, and such an one was suggested by Mr. Brougham, who, in 1811, introduced a bill, (carried unanimously through both Houses,) declaring the trade in slaves to be felony, and punishable with fourteen years' transportation, or five years' imprisonment. After a time, even this decided measure seemed not decided enough; an act of 1824 made slave-trading a capital offence, by the name of piracy; and the recent acts of 1837, for mitigating the criminal law, have left it punishable with transportation for life. "There is every reason to think," says Lord Brougham, "that no British subjects are now, or have for many years been, directly engaged in this execrable traffic, with the exception of those belonging to the Mauritius. In that island it is certain, that, with the connivance, if not under the direct encouragement, of the higher authorities of the colony, slave-trading to an enormous extent was for some years openly carried on."

Treaties with foreign powers for suppression of the Slave Trade.

The treaties with foreign powers, crippled by national jealousies, were found equally inefficient with our own law. The king of Spain, one of the two great offenders, after having had the meanness to accept, by a treaty of 1817, a large sum from our treasury, as the price of his promise to abolish his slave-trade on the north of the equator immediately, and to put a final stop to the traffic in 1820, had next the effrontery to refuse all performance of the engagement for which he had thus received the consideration; and a vote of abolition, passed by the Cortes in 1822, remained of course inoperative. The great difficulty,—the right of one nation's cruisers to search vessels under the flag of another power, when suspected of slaving,—was however mutually conceded in 1817, between Great Britain on the one hand, and Portugal and Spain (within the limits embraced in the subsisting treaties) on the other; and a similar treaty was effected with Holland in the succeeding year.

Faults and defects of our treaties

But, besides other faults, there were, in our treaties of this sort, two main defects, which, of themselves, rendered the whole system of checks quite inoperative. First, the cruisers, except under our treaty with the Netherlands, had no power to capture vessels not having slaves on board, although it might be fully proved that they were slaving-ships, or even that they had just delivered a cargo. In consequence of this, not only were notorious slavers frequently dismissed after examination, but, in several instances, which have been fully authenticated, the wretches in command were known to throw their slaves overboard on a chase, in the hope of thus removing the only ground on which their detention could be legally justified. Secondly, condemned vessels, instead of being broken up, were sold, and, being fitted for no trade but their own, fell again almost invariably into the hands of the slave-dealers.

New and more effectual treaties since 1830.

In neither of these particulars was any improvement effected till after the late revolution in France, whose subjects, since the restoration, had begun to rank amongst the most active of the contraband slave merchants. In 1833 a treaty was concluded between our government and that of France, by which the breaking up of the vessels was agreed to; and it was also declared, that all vessels ascertained by certain equipments to be intended for the slave trade, might be lawfully detained and confiscated, even though slaves had not been found on board, nor even embarked. France and England have since taken the lead in urging all other Christian powers to accede to these conventions; but as yet their success has been far from general. The five powers with which this country previously had conventions on the subject have come very reluctantly into the additional measures; and one of them, namely, Portugal, has shown a most disgraceful want of faith in fulfilling her engagements. The protection of the Portuguese flag was and is sold by the authorities of that government on the African coast; and miscreants, thus furnished with papers apparently regular, and not having yet received their slave-cargoes, insolently defy our cruisers, or even prosecute our captains for damages, on account of illegal detention. Our government, however, have recently shown a determined front; and we may perhaps hope that the feeble and faithless power which insults us and outrages humanity, will at length suffer condign punishment. As to Spain, between 1823 and 1832, her slavers imported into Cuba 100,000 slaves at least. The equipment clause was always refused by the cabinet at Madrid; and it was not till 1835, after the death of Ferdinand, that our minister at that court was able to extort the accession of the Spanish government to that essential article. The effects of this new treaty have been exceedingly encouraging: within six months after its execution, as many Spanish slavers lay waiting the sentence of our Confiscation Court at Sierra Leone, as had been taken during any three years under the previous conventions. The Brazilian government, although professedly anxious to discourage the importation of new slaves, on account of the danger the whites already incur from an increasing black population, have pleaded, with some plausibility, their want of power to check the trade effectually, so long as the Portuguese flag shall be allowed to protect the slavers. Sweden and the Netherlands were not prevailed on to accede to the French conventions till the year 1838.

Of those powers with which we had previously no agreement, Denmark and the Sardinian States both acceded in 1834. Prussia has shewn a reluctance, for which it is not easy to account. The display of the same spirit by Russia was not so much matter of surprise. Austria, though the emperor has imitated our laws, declaring any slave free who touches Austrian ground, and also making the slave-trade heavily punishable, has acted with its accustomed jealousy, in refusing co-operation with other states. Tuscany and the Two Sicilies joined the league in 1838. With the republics of the New World our negociations have been exceedingly unsuccessful. The United States have peremptorily refused to combine with any foreign power for the suppression of the slave-trade; and, amongst the Spanish commonwealths, Venezuela is the only one which has come cheerfully forward, although the objections started by some of the rest do not seem to be insuperable.

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Altogether, those efforts which philanthropists have so long continued for removing this blot from the name of Christianity, have not yet by any means produced such results as can allow us to believe that the struggle is nearly at an end. Partly through defects in the machinery of the laws and treaties,—partly through dishonesty or lukewarmness in the contracting powers or their officials,—partly through causes which can never be removed while the foul shape of slavery itself darkens any corner of the earth,—the traffic in human blood still goes on with an activity that is incredible to all but those who have studied the subject. The proofs of this lamentable fact are nowhere so convincingly stated as in a work on *The African Slave Trade*, published in 1839, by Mr. Fowell Buxton, from which we can afford to abstract but a very few statements, observing, at the same time, that there is not one of them but is below the truth. According to the highest of those estimates which have been founded on assured data, the Christian slave trade still robs Africa every year of 250,000 human beings. According to the very lowest computation, it absorbs 150,000. To this number must be added that of the Mohammedan trade, which exports at least 50,000 annually; so that we are much below the mark when we assert, that, in the course of every year, 200,000 negroes, at least, are carried off into hopeless slavery. But this is not all. It may be safely asserted, that, for every slave who is exported, there is sacrificed one human life, and perhaps much more. Mr. Buxton's calculation is the following: First, the slaughter of the wars which supply the slaves, the ill-usage of the captives on their march, and their sufferings while detained on the coast, cause together a mortality of 100 per cent. Secondly, the disease and cruelty of the voyage, now worse than ever it was, carries off, at the very least, 25 per cent. Thirdly, the loss after landing in the colonies, and during what planters used to call the "seasoning," amounts to at least 20 per cent. Upon these assumptions, "for every 1000 negroes alive at the end of a year after their deportation, and available to the planter, we have a sacrifice of 1450. Of 150,000 negroes, landed annually in Cuba, Brazil, &c. 30,000 die in the seasoning, leaving 120,000 available to the planter. If 150,000 were landed, there must have been embarked 37,500 more, who perish in the passage; and if 187,500 were embarked, 187,500 more must have been sacrificed in the seizure, march, and detention. It is impossible for any one to reach this result, without suspecting, as well as hoping, that it must be an exaggeration; and yet there are those who think that this is too low an estimate." Putting these facts in another shape, we find, that the slave trade between Africa and America subjects annually to the miseries of permanent bondage, no fewer than 120,000 negroes; whilst, during the same period, it destroys the lives of 255,000 more.

II. Slavery. But, leaving here the consideration of the slave trade, we pass to the history of those measures which, following up its abolition in our own colonies, have destroyed it effectually as to them, by eradicating slavery itself.

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Immediately on the passing of the act 1807, there was formed by the abolitionists a new association, which they called "The African Institution." Besides objects connected with the recent measure, and embracing the tasks of watching its execution, of prevailing on foreign powers to imitate our policy, and of aiding in the civilization of Africa, this body gradually began to bestow great attention on the state of slavery in our own colonies, having an especial view to its ultimate abolition, which was afterwards taken up by the Anti-Slavery Society; for their hopes soon waxed very low as to that progressive amelioration in the treatment and even the enlightenment of the slaves, to which some among them had looked forward as one consequence to flow from the stoppage of the foreign supply. The abolitionists were speedily united in the great aim of emancipation; Clarkson renewed his agitation in the provinces; local societies were formed every where, and tracts and larger works were circulated; while in Parliament, Wilberforce, the apostle of the cause, was now seconded by Messrs. Brougham, Mackintosh, Buxton, Lushington, William Smith, and others, in pressing vainly on the House of Commons the adoption of measures tending to prepare the slave for eventually obtaining freedom.

Firs ro. cee s in Par nent for an- cipa n.

At length the trenches were opened in Parliament; and in this new attack, as in the former, the van was led by the Quakers, whose petition for the extinction of slavery was presented by Mr. Wilberforce to the House of Commons in March 1823. Soon afterwards, a motion by Mr. Buxton, for a resolution declaring slavery repugnant both to Christianity and to the British constitution, was defeated by Mr. Canning on counter resolutions, recommending certain necessary reforms. These and other improvements, it was asserted, might be safely left to the colonial legislatures; and the ministry at the same time intimated, that, if the West Indian Assemblies refused to do their duty, it would become necessary for the British Parliament determinedly to interfere.

That no effectual reforms could proceed from the planters themselves, the abolitionists had been long convinced. The government and their supporters, said they, had forgotten two of the prominent features of society in the West Indies; the management of estates by agents for absentee proprietors, and that spirit of reckless adventure which was at once a cause and an effect of West Indian embarrassments. It might have been added, and some had the firmness to add it, that the planters, supposing them ever so well disposed, dared not to introduce any such mitigation of rigour as would afford sufficient protection against individual oppression. The slavery of multitudes was never in any country maintained but by the reign of terror; and, when an enslaved population has reached a certain limit in strength and intelligence, society must inevitably undergo one or another of three changes;—inhumanly increased severity, or universal emancipation, or universal revolution.

Case of the Missionary Smith.

In 1824, Mr. Canning, who, though he had been a zealous abolitionist, acted in regard to the new question a part totally unworthy of him, defeated, by a ministerial majority, Mr. Brougham's very guarded motion of censure on the authorities of Demerara for the infamous and cruel injustice which destroyed the missionary Smith. But the publicity which the debates in Parliament, in this case, gave to the atrocities which, although certainly not common in the colonies or any where upon earth, the colonial laws allowed, when they did occur, to pass with perfect impunity, did more than any thing ever yet had done to excite the indignation of the British people.

New state of public opinion.

The question, in fact, was surprisingly narrowed. When, in 1788, the abolitionists attacked the outworks which flanked the edifice of slavery, the fortress itself was pronounced by its defenders to be absolutely impregnable. The good of the empire, the good of the slave, the principles of all governments, the very Bible itself, were appealed to as authorising the property in human flesh. But now, for many years, no man had breathed any argument of the sort. It was plain that emancipation must come, and that speedily; the parties were only at issue as to the time and the manner. Even the more intelligent among the planters, who saw the negroes swarming around them in hundreds of thousands, and already beginning to think dangerously, (that is, justly,) seem scarcely to have extended their hopes farther than to obtaining liberal compensation for all their losses, present or prospective, certain or conjectural. But the attitude which they chose, almost universally, to assume, was that of defiance towards the mother-country; and, accordingly, the right of the Colonial Assemblies to legislate for their own islands, and the danger which would be incurred by irritating them, were urged alternately with those other topics, of the risk of revolution through hasty changes, the unfitness of the uninstructed negroes to act as freemen, and such other grounds, which now became the arguments of those who wished the British Parliament to decline interfering.

Review of reforms effected in the slave-law of the colonies from 1823 to 1830.

Down to the year 1830, how much had been done, either in the chartered colonies, or in those governed immediately by the crown, for carrying into effect the reforms embodied in the resolutions of 1823, and in the subsequent recommendations of the government?—1. For providing the means of education and religious instruction for the slaves, no one effectual measure had been taken in the colonies of either class. The consolidated slave law for the crown colonies, contained in an Order in Council, dated 8th February 1830, was held out as an improvement on the Trinidad Order in Council of 1824, and was proposed to the chartered colonies as a model for their adoption. It contained no provision for this purpose. 2. The Sunday markets were abolished in the crown colonies by the order of 1830, and they were also abolished by Grenada and Tobago, two of the chartered islands. The other colonies of this class had expressly legalised them. 3. Even this partial abolition was rendered useless, by the total omission of any allowance of equivalent time to the negroes in lieu of Sunday, for marketing or for cultivating their provision grounds. 4. The new order wisely made the evidence of slaves admissable in the crown colonies to the same extent as that of free persons, subject only to remark on the slave's status as affecting credibility. Grenada and Tobago had adopted a similar law; while, in the other colonies of their class, the admission of slave evidence was hampered and restricted so much as to make the grant perfectly useless. 5. In the crown colonies the marriages of slaves were legalized under certain restrictions; in all others such marriages were everywhere exposed to harassing impediments. 6. In the crown colonies the separation of families had been peremptorily provided against, the order, however, being somewhat vague as to the description of persons whom it should embrace. In the chartered colonies the provisions of this kind were universally insufficient. 7. The right of acquiring property was conferred on the slaves in the crown colonies; on those in the others it was also conferred, but under limitations which made the privilege quite illusory. 8. The order in council gave the slaves the right of redeeming themselves and their families, at a fair appraisement, even against the will of the owners; but it imposed, in reference to this grant, several very harsh conditions. The chartered colonies refused unanimously to introduce any such compulsory manumission. 9. The new order most unfortunately omitted that provision in the Trinidad code, which forbade the master to punish the slave corporally more than once in twenty-four hours; but it limited him to twenty-five lashes at a time. This latter enactment was imitated in two or three of the chartered colonies; and in all the rest the old law remained, which allowed the master to inflict thirty-nine lashes at once on any slave, of any age, or of either sex, for any offence, or for none; and the same law allowed him to imprison in the stocks or workhouse as long as he pleased. 10. In the crown colonies there was required a return, as well as a record, of arbitrary punishments inflicted on the slaves on the plantations; but no such check was imposed as to any other classes, such as mechanics or domestics. In the other colonies there was no return, and no adequate record. 11. By the order in council, the flogging of females was abolished; in every one of the chartered colonies it was still permitted and practised. 12. The order forbade, though not in sufficiently explicit terms, the use of the driving-whip in the field. The legislature of the Bahamas did the same thing. The other legislatures retained the old instruments of punishment. 13. Official protectors of the slaves, none of whom could be slave-holders, were appointed in the crown colonies. The chartered colonies all refused to appoint such functionaries; though in some of them the local magistrates (composed of slave-holders) acted in a similar capacity. 14. Another proposed reform was, the providing that no slave-holder should be appointed to any function connected with the administration of the slave-laws. The order in council, though it obeyed this salutary rule in respect to the protector, disregarded it as to his assistants, on whom devolved a great part of his ordinary duty. In the chartered colonies the rule was little attended to, except in the leading appointments made by the crown. 15. It was also proposed that, in cases involving the status of individuals, the legal presumption should be for freedom and against slavery. This rule, adopted in the crown colonies, was also imitated by Tobago and Grenada, but by no other chartered island. 16. For purifying the administration of justice, which called most grievously for amendment, nothing was done in any colony of either class.

Parliamentary proceedings in 1830–31–32.

In July 1830, Mr. Brougham brought forward his motion, that the House should resolve, at the earliest possible period in next session, to take into consideration the state of the slaves, in order to the mitigation and final abolition of slavery, and more especially in order to the amendment of the administration of justice. It was lost by a large majority, in a very thin House. The great changes in the ministry soon came on; and, during the eventful years 1831 and 1832, the subjects of Great Britain and Ireland had their own battles to fight at home, instead of extending aid to foreign dependents. The only steps taken in that period were, the issuing of new orders in council by the Whig ministry in 1831, which proved as ineffectual as those of their predecessors; and the appointment of committees, both in the Lords and Commons, before both of which a large mass of evidence was taken.

Introdu- tion of measur- the abo- tion of very, 18

At length, after the friends of emancipation had repeatedly pressed the ministry to redeem their pledge of bringing forward a government measure, the ministerial proposition was introduced in May 1833, by Mr. Stanley, then secretary for the colonies. The parts of the resolutions on which the emancipationists were most divided were two; first, the plan of an intermediate state, called an apprenticeship, into which the slave was to be received on his manumission, and which, according to the first draft of the measure, was to last for no less than twelve years; secondly, the proposal of compensation to the slave-owners, which, brought forward at first hesitatingly, at last developed itself into a grant of twenty millions sterling. On the principle of compensation most men were agreed; there was guilt, it is true, in the very act upon which the claim was grounded, but the nation was a thousand times guiltier than the planters, and it would have ill become us to make the minor offenders the only sufferers. The amount and application of the grant were matters less certain. On the question of the apprenticeship there was much more room for doubt; and the most consistent opponents of slavery were decidedly against it. Lord Howick, the under secretary for the colonies, threw up his place rather than advocate it; and it was strenuously resisted in the House by him, Mr. Buxton, and Mr. O'Connell, whose opposition, however, was defeated by an overwhelming majority. Among those who advocated the great principle of the resolutions, the most prominent were, besides the members already named, Mr. Buckingham, Dr. Lushington, Admiral Fleming, and Mr. T. B. Macaulay. The opposition, which scarcely amounted to more than exhortations to caution, with insinuations of insurmountable difficulties, was headed temperately and skilfully by Sir Robert Peel, whose most decided supporters were, Sir Richard Vyvyan, Mr. Godson, Mr. W. E. Gladstone, and Mr. Hume. No division was attempted on any question involving the principle.

The resolutions, on being communicated to the House of Lords, where they were carried without a vote, were supported by the Earl of Ripon, Lord Suffield, Earl Grey, and Lord Chancellor Brougham, and cautiously opposed by the Duke of Wellington, the Earl of Harewood, Lord Ellenborough, and Lord Wynford.

A bill was next brought forward, founded on the resolutions. In the discussion on this bill in the Commons, the most important change effected was, the limitation of the apprenticeship to the term of six years for the plantation-negroes, and four for all others. In the House of Lords, the amendments unsuccessfully proposed by the Duke of Wellington were moderate in themselves, and candidly advocated. On the 28th of August 1833, William the Fourth, giving his royal assent to the act, atoned in some measure for the opposition which, in his early days, he, in common with his whole family, except the Duke of Gloucester, had offered to the abolition of the slave trade. William Wilberforce died while the resolutions preparatory to the bill were at their last stage in the House of Commons.

The leading provisions of the great measure for the abolition of slavery were the following.

Summ of the for abo ing sla in the tish do nions.

The act was to take effect on the first day of August 1834, on which day slavery was to cease throughout the British colonies. And, in the first place, all registered slaves, who should at that date be within any of our colonies, and should appear to be six years old and upwards, were to become "apprenticed labourers" to those who had been their owners in slavery; while slaves who had been already brought, or apprenticed labourers who hereafter might be brought, into the United Kingdom, with the consent of their possessors, were to be absolutely free from the date of the act. The apprentices were divided into three classes. The first two classes, called "prædial apprenticed labourers," comprised all slaves "usually employed in agriculture, or in the manufacture of colonial produce," upon the lands in the colonies; the first class being slaves of this sort, who were usually employed on lands belonging to their owners, and who were declared to be "attached to the soil;" the second class, declared to be "not attached to the soil," being such slaves as were similarly employed on lands not belonging to their owners. The third class, called "non-prædial apprenticed labourers," embraced all slaves not included in either of the two other classes. The apprenticeship of the first and second classes was not to continue beyond the first day of August 1840; and such apprentices were not to be liable, in virtue of their apprenticeship, to labour for their employers for more than forty-five hours in any one week. The apprenticeship of the third class was not to continue beyond the first day of August 1838. Voluntary discharges by the employers, before the expiration of these periods, were allowed, under provisions to secure old and infirm apprentices against destitution; and the apprentice was to be entitled to claim his discharge, even against his employer's consent, on payment of the appraised value of his services. No apprentices were to be removed from the colony to which they belonged; and those of the first class were not to be removable even from their own plantation, except that they might be removed to other plantations of the same owner in the same colony, on a certificate of justices of the peace that the removal would not injure their health or welfare, nor separate members of the same family. Under similar restrictions and conditions, the services of the apprentices during their term were to be transferable property. It was conditioned that the employers were to furnish the apprentices with food, clothing, lodging, and other necessaries, according to the existing laws of the several colonies, and to allow them sufficient provision-ground, and time for cultivating it, in cases where that mode of maintenance was adopted. Children born upon or after the first of August 1834, as also all those under six years of age at that date, although they became at once free, might, if proved destitute to the satisfaction of a magistrate, be bound out by the magistrate as apprentice to the employer of the mother, by indenture, to continue in force till the child had completed its twenty-first year. For giving effect to the act, the crown was declared entitled to name, or to authorise governors of colonies to name, justices of the peace by special commission, and to give salaries not exceeding L.300 a-year, to such justices, not exceeding one hundred in all.

The act limited itself to general principles, such as those now specified, declaring that, for carrying the principles into effect, enactments by the several local authorities were the most proper means; and it therefore provided for having such regulations made by the local legislatures for the colonies which had charters, and by the king in council for the crown colonies. It was provided, however, that no such local acts were to authorise the employers, or any one but the special justices, to punish the apprentices by whipping, beating, imprisonment, or addition to the hours of labour; and that they were not to authorise corporal punishment of females on any account, or by sentence of any court. The special justices were made exclusive judges, in the first instance, in all questions between the employer and the apprentices; and no sentence was to impose as punishment extra-work for more than fifteen hours in any week, nor prolongation of apprenticeship, except in the case of runaways, whose prolonged service should not be compellable after the termination of seven years from the end of the apprenticeship. No apprentice was, whether under the act, or by way of punishment, or otherwise, to be compelled to labour on Sundays, except for certain necessary purposes; and none was to be prevented from attending anywhere on Sundays for worship at pleasure.

The remaining sections of the act provided for the raising and application of the twenty millions of compensation-money. The sum might be raised by loans, under the usual restrictions on the government; and commissioners, not fewer than five, were to be appointed by the crown for distributing it, while assistant commissioners were to act for the same purpose in the colonies. No money was to be payable to any slaveholder in any colony, until it should have been declared by an order in council, that satisfactory provision had been made by law in such colony, for giving effect to the act by special or supplementary regulations. The whole money was to be divided into nineteen shares, one for each of the colonies, each share being proportional to the number of registered slaves in the colony, taken in connection with the market-price of slaves in each colony, on an average of eight years ending with 1830.

Proceedings taken under the act.

In virtue of this act, upon the first of August 1834, nearly 800,000 negroes became nominally free; but both the friends and the opponents of emancipation watched with much anxiety what would be their conduct during that probationary state which it had been deemed proper for them to pass through,—a state which, by the very removal of some evils, opened the way for certain others, and which, while it gave increased protection against some kinds of oppression, left the negroes more helpless against severities and neglect of other kinds. Two subsequent acts of Parliament provided as far as possible against abuse; and, although many conflicting accounts have reached this country, there does seem to be no sufficient reason for believing that the treatment of the apprentices was really in any material respect worse than it had been during their slavery; while there appears to be as little reason for doubting, that the slaves in general conducted themselves with thankfulness and decency on their change of condition.

Shortening of the apprenticeship by some colonial legislatures.

But in different islands the policy of the local legislature was very various. Many of the colonists were as well satisfied as the most zealous members of the Anti-Slavery Society, that the apprenticeship was wrong and dangerous. Antigua had the honour of leading the way in making this opinion operative. The legislature of that island declined to take advantage of the apprenticeship at all; its slaves were emancipated at once, and "on Christmas-day 1834, for the first time these thirty years, martial law was not proclaimed in Antigua." Bermuda followed the example, which was next imitated by the small isles, and afterwards by the great island of Barbadoes. Still some colonies held out, with Jamaica at their head; and, particularly from this island, there reached us not only threatening resolutions of the Assembly, but reports of extreme severities towards the slaves, and of decided hostility to the stipendiary magistrates; while one or two of the colonies would not even condescend, for several years, to take such steps as the act declared to be necessary for entitling their landholders to payment of the compensation-money.

In the spring of 1838, the question of immediate abolition of the apprenticeship was stirred, on those and other grounds, in both Houses of Parliament. Lord Brougham's motion to this effect, supported by Lord Lyndhurst and others, was met by the previous question. Sir George Strickland's, in the House of Commons, was also negatived; and, although a similar resolution was afterwards carried in the Commons, the ministry intimated that they would throw every obstacle in the way of any measure founded on it, and the attempt was therefore given up.

Final and complete emancipation of the negroes, 1838.

But the colonists were warned in time, by the spirit which reigned here, and by that which appears to have been rising among the negroes. They proceeded forthwith to abolition; and, on the first of August 1838, there was not a slave left in any British colony, except the Mauritius alone, in which instructions from the home government have since carried the enfranchisement into effect. The act of the Assembly of Jamaica for putting an end to the apprenticeship was accompanied by a protest, which, in its tone of mingled sullenness and pertness, is assuredly the strangest document that ever emanated from any legislative body.

Of the results of this mighty change, we are not yet in a condition to speak. From Jamaica the accounts have been of various complexions; from the other islands almost universally favourable. The negroes have scarcely anywhere shown a disinclination to work, except during the few weeks immediately succeeding their complete manumission; and we look forward with a confident hope to improvement both of society and statistics, believing firmly that the planters have now fairer prospects before them than they have enjoyed at any time during the last half century. If the event shall be otherwise, justice has at least been done; and some atonement has been made for the most heinous crime which our nation ever committed. Nay more, a revolution has been averted, which, before many generations, would assuredly have repeated in our Caribbean Islands all the horrors of Saint Domingo. (B. L.)

Of the Twenty Millions voted by Parliament as compensation to the owners of slaves, the following Table shews the proportions assigned to each colony by the Commissioners appointed by the Act for the Abolition of Slavery, with the value and numbers of slaves in each.

COLONY.	Average Value of a Slave from 1822 to 1830.			Number of Slaves by the last registration in this country.	Relative Value of the Slaves.			Proportion of the L.20,000,000, to which the colony is entitled.		
	£	s.	d.		£	s.	d.	£	s.	d.
Bermuda	27	4	11¾	4,203	114,527	7	5¼	50,584	7	0½ ·41
Bahamas	29	18	9¾	9,705	290,573	15	3¾	128,340	7	5¾ ·47
Jamaica	44	15	2¼	311,692	13,951,139	2	3	6,161,927	5	10¾ ·58
Honduras	120	4	7½	1,920	230,844	0	0	101,958	19	7½ ·92
Virgin Islands	31	16	1¾	5,192	165,143	9	3	72,940	8	5¼ ·76
Antigua	32	12	10½	29,537	964,198	8	10½	425,866	7	0¼ ·13
Montserrat	36	17	10¾	6,355	234,466	8	0¼	103,558	18	5$\frac{0}{0}$ ·38
Nevis	39	3	11¾	8,722	341,893	6	3½	151,007	2	11¾ ·35
St. Christopher's	36	6	10¼	20,660	750,840	7	1	331,630	10	7¼ ·82
Dominica	43	8	7½	14,384	624,715	2	0	275,923	12	8½ ·30
Barbadoes	.47	1	3½	82,807	3,897,276	19	0½	1,721,345	19	7$\frac{0}{0}$ ·87
Grenada	59	6	0	23,556	1,395,784	16	0	616,444	17	7$\frac{0}{0}$ ·03
St. Vincent's	58	6	8	22,997	1,341,491	13	4	592,508	18	0¼ ·93
Tobago	45	12	0¼	11,621	529,941	16	2½	234,064	4	11¾ ·55
St. Lucia	56	18	7	13,348	759,890	10	4	335,627	15	11¾ ·19
Trinidad	105	4	5¼	22,359	2,352,655	18	0¾	1,039,119	1	3½ ·11
British Guiana	114	11	5¾	84,915	9,729,047	13	5¼	4,297,117	10	6½ ·30
Cape of Good Hope	73	9	11	38,427	2,824,224	7	9	1,247,401	0	7¾ ·76
Mauritius	69	14	3	68,613	4,783,183	15	3	2,112,632	10	11¾ ·06 * ·08
				780,993	45,281,738	15	10¼	20,000,000	0	0

SLEAFORD, a town in the hundred of Fleswell, part of Kesleven of the county of Lincoln, 116 miles from London. It was once the residence of the bishops of Lincoln. It has a fine ancient Gothic church, adorned with many monuments. It has a good market on Fridays. The inhabitants were, in 1801, 1596; in 1811, 1904; in 1821, 2220; and in 1831, 2587.

SLEBEZE, a small island in the straits of Sunda. Long. 105. 24. E. Lat. 5. 54. S.

SLEDGE, a kind of carriage without wheels, for the conveyance of weighty things, as stones, bells, and the like. The sledge for carrying criminals, condemned for high treason, to execution, is called a hurdle. The Dutch have a kind of sledge on which they can carry a vessel of any burden by land. It consists of a plank of the length of the keel of a moderate ship, raised a little behind, and hollow in the middle; so that the sides go a little aslope, and are furnished with holes to receive pins. The rest is quite even.

SLEDGE is a large smith's hammer, to be used with both hands. Of this there are two sorts, the up-hand sledge, which is used by under workmen, when the work is not of the largest sort. The other, which is called the about-sledge, and which is used for battering or drawing out the largest work, is held by the handle with both hands, and swung round over their heads, at their arm's end, to strike as hard a blow as they can.

SLEEP, that state of the body, in which, though the vital functions continue, the senses are not affected by the ordinary impressions of external objects. See DREAMS, PHYSIOLOGY, and SOMNAMBULISM.

SLEEPERS, in *Natural History*, a name given to those animals which sleep all winter, such as bears, marmots, dormice, bats, hedgehogs, swallows, and the like. These do not feed in winter, have no sensible evacuations, breathe little or none at all, and most of the viscera cease from their functions. Some of these animals seem to be dead, and others return to a state like that of the fœtus before birth. In this state they continue, till, by an increase of heat, the animal is restored to its former functions.

SLEIDAN, JOHN, an excellent German historian, born of obscure parents, in 1506, at Sleidan, a small town on the confines of the duchy of Juliers. After studying some time in his own country, together with his townsman, the learned John Sturmius, he went to France, and in

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* Deficient fractions.

1525 entered into the service of the cardinal and archbishop John du Bellay. He retired to Strasburg in 1542, where he acquired the esteem and friendship of the most considerable persons, particularly of James Sturmius, by whose advice and assistance he was enabled to write the history of his own time. He was employed in some public negociations; but the death of his wife, in 1555, plunged him into so deep a melancholy, that he entirely lost his memory, and died the year following. In 1555 came out, in folio, *De Statu Religionis et Reipublicæ sub Carolo Quinto*, in fifteen books, from the year 1517, when Luther began to preach, to the year of its publication, and this history was presently translated into most of the languages of Europe. Besides this great work, he wrote, *De quatuor summis Imperiis, libri tres;* with some other historical and political pieces.

SLESWICK, or SCHLESWIG, a province in the kingdom of Denmark, in that division usually denominated the Duchies, including, with this province, Holstein and Lauenberg, all of which are inhabited by people of German origin, who speak that language, and are regulated by different laws from the rest of Denmark. This province is bounded on the north by Jutland; on the north-east by the Little Belt, wherein the Island of Aroe, which is a part of it, lies; on the east by the Baltic sea, wherein are the Islands Alsen and Femern; on the south by Holstein, from which it is divided by the river Eyder and the Sleswick canal; and on the west by the German Ocean, in which are the islands of Nordstrand, Pellworm, and some other smaller ones. The whole extent is 3515 square miles. It comprehends thirteen cities, fourteen market-towns, and 1500 hamlets or villages, divided into 257 parishes, which contained 36,000 inhabitants in 1832. It is in general a level district, having on the western side many tracts of rich meadow land; while, on the eastern side, its agricultural produce are corn, butter, cheese, and meal; but through the middle of the province runs a ridge of sandy hills, which scarcely repay the cost of cultivation. There are many lakes and marshes, and on the eastern side, fiorden or bays, formed by projecting woody headlands, which have a picturesque appearance. The climate is cold in winter, but remarkably variable. There are few manufactures, and the trade chiefly consists of the export of the products of the soil. or of the fisheries; which last forms an important part of the occupation of a great number of the inhabitants. The principal towns, besides the capital, are Hadersleben, Apenrade, Tondern, Bredsted, Husum, Nordstrand, Toning, Fredrichstadt, Flensburg, and Eckenfiorde.

SLESWICK, a city, the capital of the province of that name in the continental dominions of Denmark. It stands on an arm of the sea on the German Ocean, and the buildings are erected in the form of a crescent. It is an open town, most irregularly built, and is divided into four distinct parts. It is the seat of a Lutheran bishop, has a domkirche or cathedral, and four other churches, and several collegiate institutions for education. The harbour has only nine feet water, and is of small extent. The trade is inconsiderable. There are sugar refineries, tanneries, distilleries, and breweries, all for the home consumption. It contains 1320 houses, with 10,640 inhabitants. Lat. 54. 31. 15. Long. 9. 29. 25. E.

SLEUT-HOUND, the ancient Scots name of the bloodhound. The word is derived from the Saxon *slot*, the impression that a deer leaves of its foot in the mire, and *hound*, a dog; so they derive their name from following the track.

SLICH, in *Metallurgy*, the ore of any metal, particularly of gold, when it has been pounded and prepared for further working.

The manner of preparing the slich at Chremnitz in Hungary, is this. They lay a foundation of wood three yards deep; upon this they place the ore, and over this there are twenty-four beams, armed at their bottoms with iron; these, by a continual motion, beat and grind the ore, till it is reduced to powder. During this operation, the ore is covered with water. There are four wheels used to move these beams, each wheel moving six; and the water, as it runs off, carrying some of the metalline particles with it, is received into several basons, one placed behind another; and finally, after having passed through them all, and deposited some sediment in each, it is let off into a very large pit, almost half an acre in extent; in which it is suffered to stand as long as to deposit all its sediment, of whatever kind, and after this is let out. This work is carried on day and night, and the ore is taken away and replaced by more as often as occasion requires. That ore which lies next the beams, by which it was pounded, is always the cleanest or richest.

When the slich is washed as much as they can, a hundred weight of it usually contains about an ounce, or perhaps but half an ounce of metal, which is not all gold; for there is always a mixture of gold and silver, but the gold is in a larger quantity, and is usually two-thirds of the mixture. They then put the slich into a furnace with some limestone, and slacken, or the scoria of former meltings, and run them together. The first melting produces a substance called *lech*, which they burn with charcoal, to make it lighter, to open its body, and render it porous, after which it is called *rost;* to this they add sand in such quantity as they find necessary, and then melt it over again.

At Chremnitz many other methods are practised of reducing gold from its ore, but particularly one, in which they employ no lead during the whole operation: whereas, in general, lead is always necessary, after the before-mentioned processes.

SLICKENBURG, a small island near the north-west coast of Borneo. Long. 112. 31. E. Lat. 3. 59. N.

SLIDING-RULE, a mathematical instrument, serving to work questions in gauging, measuring, and the like, without the use of compasses; merely by the sliding of the parts of the instrument one by another, the lines and divisions of which give the answer by inspection. This instrument is variously contrived and applied by various authors, particularly Everard, Coggeshall, Gunter, Hunt, and Partridge; but the most common and useful are those of Everard and Coggeshall.

SLIGO, a maritime county in the province of Connaught in Ireland, is bounded on the north by the Atlantic Ocean, on the east by Leitrim, on the south-east by Roscommon, and on the south and west by Mayo. It extends from 53° 54′ to 54° 28′ north latitude, and from 8° 10′ to 9° 10′ west longitude; being thirty-eight miles in its greatest length from north to south, between Mullaghmore Head and Lough Gara, and forty-one in breadth from west to east, between Ardmaree and the junction of the three counties of Sligo, Roscommon, and Leitrim, and comprehending an area of 461,753 acres, or 721 square miles.

According to Ptolemy the geographer, this district was inhabited by the tribe of the Nagnatæ, whose chief city, Nagnata, is supposed to have been situated somewhere in the vicinity of the town of Sligo. It afterwards formed part of the kingdom of Connaught, one of the five into which the island was divided previously to the arrival of the English, in the reign of Henry II. It was afterwards possessed by one of the family of the O'Conors, kings of Connaught, who was called O'Conor Sligo, to distinguish him from the other chieftains of the same family; and under him the heads of the septs of O'Bean, O'Doud, O'Gara, O'Hara, M'Donogh, and M'Firbis, were subordinate chieftains in their respective districts. After a protracted struggle between the natives and the English, it fell into the hands of the De Burgos, who, either by force or treaties, had made themselves masters of the greater part of the ancient kingdom of Connaught. When the province was made shire-ground by Elizabeth, in 1569, Sligo formed one of the seven counties into which it was divided; but so far from being thus rendered amenable to the jurisdiction of that queen, it became the theatre of several conflicts in the war against O'Heil, chieftain of Tyrone, in the latter part of her reign. The most remarkable of these was that with Sir Conyers Clifford, who, in attempting to pass into the county from Roscommon with a body of from 1500 to 2000 men, in order to relieve Belleek, was attacked in a defile of the Curlew mountains by O'Roark, chieftain of Breffney, was himself killed, and his troops were driven back with considerable loss. During the civil wars of 1641, the Irish kept possession of the open country until nearly its close, when they were reduced to submission by the parliamentary forces under Ireton. In the subsequent war of 1688, the county was held by the forces of King James for some time, but ultimately yielded to the victorious arms of William III. The French force which landed at Killalla under General Humbert in 1798, had a severe skirmish at Colooney with the Limerick militia, commanded by Colonel Vereker, which ended in the retreat of the latter.

The county includes an extensive line of sea-coast along its northern border, in which are the bays of Classyvaun and Milkhaven in the north, and Brown Bay, which branches into the smaller and less frequented indentations of Drumcliff, Sligo, and Ballysadare Bays. Killalla Bay, to the west of the county, belongs also to Mayo. The island of Innismurray lies about five miles off the northern coast, being separated from the mainland by a passage dangerous, except in moderate weather, from the number of reefs under water. The island itself rises precipitously on the ocean side, but shelves gradually downwards on that of the land: there is but one practicable landing-place. The whole surface extends over 209 acres, of which about 120 are arable, affording pasturage to a few cattle and sheep. There is also a large extent of bog. The inhabitants depend chiefly on the fishery, which in most seasons is abundant. The place is peculiarly remarkable for a small chapel or cell, celebrated for an image of its patron, St. Molasse. Near the chapel is a singular relic, called the cursing-stone, so named from a superstitious opinion of its efficacy in punishing guilt if appealed to according to an established form. The island is also a favourite burial-place: males and females are interred in separate cemeteries.

Mountains.

The land rises into mountains of considerable height in its northern extremity. The principal of these are Benbulben, 1722 feet high; King's mountain, 1527; Cullogherboy, 1430; and Truskmore, part of which is in Leitrim, 2072. In the west are the ranges of the Slieve, Gamph, and Ox mountains, the highest points of which are 1321 and 1446 feet respectively. In the east Kisheorrin and Carriskea rise to the heights of 1183 and 1062 feet. The Curlew mountains in the south-east, between Roscommon and Sligo, only rise to the height of 863 feet. The entire surface of the county contains 449,013 acres of land, of which about 272,000 are capable of cultivation, and the remainder mountain or waste, and 12,740 acres under water. The principal rivers are the Moy, which forms the western boundary, separating the county from Mayo, and emptying itself into Killalla Bay; it is navigable to Ballina, six miles inland, for vessels of ten feet draught; the Tinned, the Easkey, the Ballybeg, the Dunneill, the Ballysadare river, with its branches the Owenmore, Owenbeg, and Arrow, or Unshin, and the Garvogue, a short but rapid stream, rising in Lough Gill, and passing through Sligo town into the bay of the same name. All these rivers have their sources within the county. The lakes are numerous, and several of them large ard highly picturesque. Lough Gill, the most northern, spreads over 3130 acres, besides a small portion in Leitrim; its western side is richly planted, and in it are ten islands, the largest of which are Church Island, 41 acres, and Cottage Island, 13. Lough Arrow, in the east, 3010 acres, is of very irregular form, and contains the islands of Annagowla, 34 acres, Muck, 21, and Inish, 20; Lough Gara, in the south-east, 3683 acres, contains the islands of Derrymore, 33 acres, Inchmore, 21, and the smaller islands of Inch, Inchbeg, Eagle, Crow, and Derrynatallan. Lough Talt, in a basin of the Ox mountains, surrounded by projecting cliffs, 300 acres, and 455 feet above sea level, is remarkable for its abundance of trout, which vary in shape and flavour in various parts of the lake. Lough Easkey, 337 acres, lies in the same mountain range; Templehouse lake contains 356 acres, Cloonacleigha, 177. Smaller lakes are numerous in all parts.

Geolog

The carboniferous, or mountain limestone, including the lower limestone, calp or black shale series, and the upper limestone, forms the basis of by much the greater portion of the county. A small tract of the yellow sandstone and conglomerate shews itself in the extreme north, as also on the north and east of Lough Gara, whence it penetrates, extending into Mayo. The old red sandstone, and sandstone conglomerate, appears in two masses near Lough Arrow, the southern and larger portion plunging deeply into the adjoining county of Leitrim. A very small portion of the granite formation, which lies between Lough Conn and Foxford, enters the county, giving place to a broad belt of trap porphyry, bounded by a narrow fringe of old red sandstone, and stretching in a north-eastern direction, along the line of the Ox mountains to Ballysadare Bay; a mass of granite protrudes through the middle of this formation. To the south of the same bay, and west of Ballysadare town, is a small field of quartz rock. The sandstone in some tracts assumes an appearance which gave rise to the opinion that coal existed under it, but, on making the experiment, the hopes of the speculator were always baffled. Iron was procured in large quantities, particularly at the base of the Ox mountains, until the timber used as fuel for smelting was exhasted. Sulphate of copper and iron pyrites are frequently found in small pieces; and pure copper occasionally in the beds of some of the rivers. Manganese has also been found in various places, and amethysts of large size near Ballymote.

Climat

The climate, owing to the proximity of the sea and the lofty tracts of mountains with which the county is intersected, is moist, and the weather extremely variable, the atmospheric changes being so frequent and sudden, as often to render the barometer an unsatisfactory test of the weather. The soil, in the mountainous districts, is a light sandy loam on a freestone bottom, interrupted by large patches of bog, and often overspread with a thin coat of turf mould. In the low country it is rich and deep, resting on a substratum of limestone, and suitable to the growth of every kind of agricultural produce. In many parts a superior stratum, called by the people lac-leigh, or the grey flag, is found incumbent on the limestone bottom. It is principally composed of silicious marl, in a state so compact, as to be impenetrable to water; thus, by preventing the drainage of the surface, opposing what was for some time deemed an insurmountable obstacle to the successful culture of the land. But it was afterwards discovered, that deep trenching, so as to cut through the adhesive layer, not only served to carry off the water effectually, which now passed freely through the subjacent limestone gravel, but to add to the fertility of the soil; the marl, when broken up and mixed with the surface mould, proving a valuable compost. Timber was abundant, until destroyed by the consumption of it required for the iron works, and by its lavish use for domestic and agricultural purposes, without any regard to the formation of a fresh supply. That the land is capable of furnishing plenty of this valuable article, is evident from the manner in which young forest trees of various kinds shoot up in the mountainous districts, and in the escars which traverse the county in various directions, checked in their growth only by want of due care to protect the young shoots from the depredations of cattle. But this defect in the picturesque and agricultural character of the surface is daily diminishing. The attention of the principal landholders is now particularly directed to the increase of forest timber, and numerous plantations are to be seen round the mansions and villas of the gentry, particularly on the borders of the beautiful lakes which grace the landscape. The prevalence of western gales from the Atlantic forbids the full growth of any trees near the shore, éxcept the willow and sycamore, which are observed to incline in the direction of the prevailing blast. Arbutus of small size grows freely in most parts, as does the myrtle in more favoured aspects. Many parts of the beach along the sea-shore is covered with a coraline sand, interspersed with numerous beds of oyster-shells of considerable extent. These beds are also found in some parts of the interior, at elevations of more than fifty feet above high water mark.

Pola- tio

The population, like that of every other county in Ireland, has been steadily on the increase, ever since the observations of statistical writers have been directed to this subject. The numbers of inhabitants at several periods, are as follows:

Year.	Authority.	No.
1760	De Burgo	38,736
1792	Beaufort	60,000
1812	Parliamentary census	119,265
1821	ditto	146,229
1831	ditto	171,508

According to the last of these results, the population is to the acreable extent of the cultivated land, as one to 1.585 acres, and to that of the total landed surface, as one to 2.693; or, in other words, there is one inhabitant to every acre and a-half in the first case, and to every two acres and a-half in the second. The census taken by the commissioners of Public Instruction in 1834, being arranged in dioceses instead of counties, cannot be depended on as strictly accurate. According to it, the population may be estimated at 174,400, of which number 17,900 were Protestants, and 156,500 Roman Catholics; the former being to the latter as one to nine nearly. The number of presbyterians and other dissenters, who are included in the preceding statement of numbers among the protestants, amounts only to 560. The number of children receiving instruction in public schools, was as follows, according to the returns made under the Population act in 1821, the Commission of Education in 1824–6, the Commission of Public Instruction in 1834, and the Report of the Commissioners of National Education in 1839:

	Males.	Females.	Sex not ascertained.	Total.
1821	5849	3010	—	8,859
1824–6	6516	3686	221	10,432
1834	8562	5259	—	13,821
1838	1551	1102	—	2,653

In the return of 1824–6, the only one in which the difference of religious persuasion is noted, the numbers of each of these are, of the Established Church, 2558; Protestant dissenters, 200; and Roman Catholics, 7495; the religion of the remaining one hundred and eighty not having been ascertained. Of the total number of schools, two hundred and twenty-six, included in the same return, one hundred and thirty were pay-schools, in which the teachers were remunerated by the pupils' fees, seventy-four were supported, either wholly or partially, by voluntary subscriptions, and but twenty-two by grants of public money.

Divisions.

The county is divided into the six baronies of Carbery, Coolavin, Corran, Leney, Tiraghrill, and Tyreragh, which are subdivided into thirty-nine parishes: of these, twenty-three are in the diocese of Tuam, and sixteen in that of Elphin. The county was represented in the Irish Parliament by four members; two for the county and two for the borough of Sligo. By the act of Union, the number was reduced to three, one being deducted from the borough. The Reform act made no change in this respect. The constituency of the county, as registered under the same act at different periods, together with the numbers under the previous act of 1829, by which the forty-shilling constituency had been abolished, was as follows:

	£50.	£20.	£10.	Total.
1831	399	315	299	1013
1832	168	151	370	695
1834	—	—	—	804
1837	273	220	546	1039

According to the last specified return, the number of electors is to the total population as one to one hundred and fifty, and to the number of heads of families as one to twenty-five. The county is in the Connaught circuit; the assizes, and some of the sessions of the peace, are held in the town of Sligo, which contains the county court-house and prison. Sessions of the peace are also held at Ballymote and Easkey, where there are likewise court-houses and bridewells. The county infirmary, and four hospitals are in the first-named town. The lunatic asylum is in Ballynasloe, but several of the unhappy creatures, for whose protection and recovery it was designed, are still kept in the county jail. There are nine dispensaries in various places.

Agriculture.

Most parts of the county afford ample scope for agricultural improvements, either in tillage or pasturage. Oats and potatoes are the principal crops on the tillage land. The culture of wheat was long unknown, the coldness and humidity of the climate having been deemed insuperable bars to its successful treatment, but it is now raised in considerable quantities on the rich lowlands. Green crops, under the rotation system, are also more and more attended to every year. Ploughing is usually effected by two horses, and, in some light soils, two asses are substituted for them; oxen are never used for this purpose. The spade, in many of the mountain districts, still supplies the place of the plough. Fences of every kind are usually constructed; those of dry stones being most common, particularly in the more elevated districts, where the farmers adopt this mode of structure as well to clear their fields of surface stones, as to secure them from trespass. Sea-weed, collected on the shore, which, some years ago, had been manufactured into kelp, is now used as manure, and is in such repute, that it is carried twenty miles up the country. The beds of oyster shells and the coraline sand on some stretches of the beach, are applied to the same purpose. Tillage farms are from five acres, and even lower, to two hundred or three hundred in size. Those used chiefly for pasturage are often of much greater extent, and, until lately, were mostly held by a number of tenants in a species of partnership, according to which, each had an exclusive portion of tillage ground, while a large tract of mountain or coarse bottom-land was depastured in common; but this system has been for several years so much discouraged as to be nearly if not altogether obsolete. The average rent of land is ten shillings and eightpence per acre. Though the tillage system, as stated, is much encouraged and rapidly extending, it is still subordinate to that of pasturage, which is adopted in all parts of the county, and on every description of soil. Horned cattle of the largest size are fattened in the rich lowland plains; young cattle are reared in the hilly and mountain districts; sheep also are kept in large flocks, particularly in the western baronies. Much butter is made, both in dairy farms and by small landholders. Swine, which are reared in great numbers, are looked upon as a very profitable source of income. Goats are not common. The native breed of horses has little to recommend it, unless when improved by crosses from those of the neighbouring counties, in which more attention is paid to them. The maritime situation of the county is well adapted for increasing the quantity of human nutriment, in addition to that derived from agriculture. The bays abound with both round and flat fish. The herring visits the coast in large shoals, and the sun-fish and some species of whales are frequently seen in the offing. But this source of profitable industry is far from being rendered as productive as the natural capabilities of the place would lead us to infer. The want of capital paralyzes the exertions of the fisherman. As long as the boatmen were enabled to procure materials for the making and reparing of their craft, and for the purchase of the necessary fishing gear by the aid of bounties and loans, the occupation was profitable, and the numbers engaged in it increased annually, but since the withdrawing of those encouragements in 1830, the fisheries have retrograded, both as to numbers of men, and as to rate of profit. Of the larger fish, cod, hake, haddock, skate, and turbot, are the most abundant. Sprats are taken in great quantities. The Lissadill oyster is so much esteemed, that there is a regular demand for it in Dublin and other large towns. This fish, with many others of the shell kind, as lobsters, crabs, scallops, &c., are found in many other parts of the coast. There are large and profitable salmon fisheries at Ballina, Sligo, and Ballysadare; and the numerous lakes and rivers supply the usual species of fresh water fish in equal abundance. The increase of agricultural improvement of late years is mainly attributable to the facilities for export afforded by the ports of Sligo and Ballina, but more especially the former, it being the great mart of commerce for the whole county, except its western districts, which, for the same purpose, take advantage of their vicinity to the latter. The statements relative to the external trade will be found in the subsequent description of the town and port of Sligo. The inland trade, in consequence of the want of communication by inland navigation or railroads, is confined to that of coarse cloths, woollens, and stockings from Connaught, and to the sale of linen, mostly for domestic use. The chief trade of this description is from Sligo town to Boyle in Roscommon, and thence, by the Shannon and the two canals, to more distant counties. A more confined traffic is carried on with Colooney. Among the late plans for stimulating national industry by inward channels of communication, it is proposed to carry a railroad from Sligo through Ballysadare, Colooney, and Drumsna to Longford, thence to be divided into two branches; 1st, by Granard, to join the proposed main railroad from Dublin to Enniskillen at Kells in Meath; 2d, through Mullingar, to join the proposed south-western railroad from Dublin to Kilkenny at Celbridge. No measures have been yet adopted to effect this plan.

Manufactures.

The linen manufacture was introduced into the county so lately as the middle of the last century, when a number of weavers were located at Ballymote by Lord Shelburne. It continued to flourish for many years, but at length suffered, as in other parts, by the depression of the trade, and by the introduction of that of cotton; it is now reviving. Coarse woollens are made for domestic consumption. In the neighbourhood of the larger towns are several thriving tanneries, distilleries, and breweries; and the manufacture of flour has caused the erection of numerous mills, which prepare large quantities of grain, both for home consumption and export. The manufacture of kelp is nearly extinct.

There is a considerable number of resident gentry in the county in proportion to its size, and consequently many elegant mansions and well planted demesnes, which contribute more and more every year to diminish the former denuded appearance of the landscape, arising from the improvident destruction of its ancient timber. The houses of the smaller farmers are plain, but comfortable; but the cottages of the peasantry generally present indications of poverty. They are either of stone or mud, rudely thatched with straw or rushes. The food of the labouring classes are potatoes and oaten bread, with some milk and fish, and meat on extraordinary occasions. Fuel from the bogs is abundant. Coal, imported from Great Britain by the vessels which take in return cargoes of agricultural produce, is used in the larger towns, and by the respectable families in their vicinity; but the high price precludes its general use throughout the county. The garments of the men are chiefly of home-manufactured wool, and so were those of the women until lately, when the native fabrics have been nearly supplanted by cheap cottons. Irish is scarcely spoken, except in some of the retired mountain tracts. Early marriages are much encouraged: they generally take place in the winter and spring. The rustic customs and amusements resemble those of the other north-western counties, in which the language and habits introduced from Scotland are less prevalent than in the eastern parts of Ulster.

Antiquities.

There are numerous relics of ancient structures. A round tower at Drumcliff, in Carbery barony, differs from all others in Ireland, in being of smaller size, and inferior architecture. Near the church where it stands, are two stone crosses. On Knocknaree mountains are several cairns; and in the same mountains, a deep valley, thickly planted and watered by several romantic falls, appears to have been formed by a violent organic shock, causing a fissure through the mountain. Some grottoes, hollowed out of the side of a hill near Carron, are of unknown antiquity. Near Sligo town is a cromlech, and a number of circular structures, popularly called giants' graves. Near Castleconnor, in Tyreragh barony, are several vaults of a square form, whether built for cemeteries or storehouses, is uncertain. There are several remains of ancient castles. That of Knocknamoyle, crowning an elevated hill near Skreen, is supposed to have existed before the arrival of the English; the others are thought to have been built since. Upwards of forty monastic buildings are noticed by antiquaries, the ruins of ten of which are still visible; eight others have been converted into parochial churches, but the remainder are known only by name, even the site of some of them being either doubtful or undiscoverable. Close to the ruins of an ancient chapel on Church Island, in Lough Gill, is a kind of chamber, or cavity, called the "lady's bed," to which is attached the superstitious notion, that women who have lain in it will be preserved from the risk of death in child-bed. A well called Tubber-art, in Kilmacteige parish, has the character of performing cures in diseases that have set at defiance the ordinary resources of medicine.

Sligo, the assize town of the county, became a place of importance by the building of a castle there, by the earl of Kildare, soon after the English settlement: its consequence was increased by the subsequent foundation of a Dominican monastery; but its progress was subsequently much impeded by fires, and by the hostilities produced by the struggles for superiority between the English and the natives. It was incorporated and invested with the privileges of a parliamentary borough in 1613, and in 1621 obtained a charter of the staple. In the early period of the war of 1641, it was taken by the parliamentarians, under Sir Charles Coote, but after some time evacuated by them, and thence continued in the possession of the royalists till the termination of the war. In 1688 it declared in favour of King James, was taken for King William by the Enniskilleners, who, in turn, were driven out by General Sarsfield; but the place ultimately surrendered to the earl of Granard. The town is situated on both sides of the mouth of the Garvogue, where it discharges itself into the bay. The river is crossed by two bridges. The streets are narrow, winding, and irregularly built. Its public buildings are, two protestant churches, a Roman Catholic chapel, a Dominican friary, Presbyterian, Independent, and Methodist meeting-houses. The existing remains of the ancient monastery of Sligo still exhibit a fine specimen of the architecture of the period in which it was erected. Near its high altar is the tomb of the O'Conor Sligo, embellished with effigies. The town contains the county infirmary and fever hospital, two dispensaries, cavalry barracks for a hundred men, a library, and a small theatre. There is a mendicity association, which has been for some time in existence, but will shortly be closed, as Sligo is selected for the site of the workhouse for a union that extends over the whole county, except a few detached parts on its borders that are annexed to unions in the adjacent counties. The town is divided, under the poor law act, into three wards, with two guardians to each; the rest of the union being divided into twenty wards, with thirty-three guardians. The markets, which are held daily, the principal being on Thursday and Saturday, are well supplied with grain, meat, fish, and vegetables. Fairs are held five times in the year. The town is a chief station for the constabulary, and for the coast-guard. The paving, lighting, and other departments of the municipal police, are under the direction of commissioners, appointed by several acts of parliament; their jurisdiction extends a mile in every direction from the market cross. Previously to the union, the borough returned two members to parliament; subsequently the number was reduced to one, the right of franchise being vested in the mayor and twenty-seven burgesses and freemen, till the passing of the reform act, when it was extended to the L.10 householders. The number of electors in 1832 was 418; and in 1834, 694. The assizes and sessions of the peace for the county are held here in the court-house, an elegant modern building, and petty sessions are likewise held weekly. The county prison is commodious, well arranged, and under a good system of discipline. It has a tread-mill.

Sligo bay, in its more extended bearings, stretches from Rinoran to Gessige point, at its opening, a distance of about six miles, and is divided into three branches, the central, largest, and deepest of which terminates at the town of Sligo. The entrance of this branch is screened from the violence of the ocean waves by two small islands, Oyster island and Coney island. There are three lighthouses at the mouth of the harbour. Across its main entrance is a bar, with but ten feet depth at low water. Though the entrance of ships of deep draught is thus prevented, yet vessels of 300 tons can come up to the quays in the turn of spring tides. The increase of trade has been very considerable of late years. The number of vessels that entered in 1800, was 65; in 1830, 540, but in 1834 the number fell to 391. The export of oats in 1831, was 130,000 quarters; in 1832, 134,000; and in 1833, 154,000. That of wheat trebled itself in the three years ending with 1833, but the quantities were still small as compared with the oats, amounting in 1833 to no more than 3127 quarters. The export of butter and pork is also increasing rapidly, and steadily; no fewer than 150,000 casks of the former, and 8547 barrels of the latter, having been shipped in 1833. The increased demand in Great Britain for grain and provisions, has produced a considerable change in the cultivation of the soil, both in enlarged extent, and superior skill applied to tillage-land. The exports in 1835 amounted to L.369,490, estimated value, the principal being of grain, 504,803 cwts., value L.25,240; and provisions, 55,389 cwts., value L.181,836. The imports of the same year amounted to L.124,692, of which the principal were, tobacco, 101,066 lbs., L.16,450; salt, 90,640 bushels, L.6,728; British spirits, 33,000 gallons, L.11,000; and tea, 20,186 lbs., L.4037. Both exports and imports are chiefly confined to the cross-channel trade. The revenue of customs and excise duties has not increased in the same proportion. The amount of each, at various periods, is as follows:

Customs.

1802	L.14,690	1821	L.26,083
1803	14,747	1824	33,619
1804	11,462	1829	46,151
1805	16,201	1830	39,438
1806	16,772	1831	33,162
1807	14,567	1832	26,631
1808	18,699	1833	28,954
1809	20,309	1834	34,916
1810	15,133	1835	33,703
1811	13,101	1836	35,864
1812	10,651	1837	32,120
1813	16,138		

Excise.

1828	L.39,484	1832	L.31,654
1829	37,823	1833	24,040
1830	40,069	1835	33,507
1831	39,741	1836	35,864

The regulations of the port and harbour are placed under the commissioners of the town police, already noticed, who are authorised to assess a tax at a maximum of 2s. 6d in the pound, on all houses of L.5, and upwards, annual value, for all the purposes under the acts.

The population of Sligo town, and of the only other town of any note in the country, was in 1831, Sligo, 15,152; Ardmaree, 2,47.

SLING, an instrument serving for casting stones with great violence. The inhabitants of the Balearic islands were famous in antiquity for the dexterous management of the sling. It is said they used three kinds of slings, some longer, and others shorter, which they used according as their enemies were either nearer or more remote. It is added, that the first served them for a head-band, the second for a girdle, and the third they constantly carried in their hand.

SLINGING is used variously at sea, but chiefly for hoisting up casks or other heavy things with slings, that is, contrivances of ropes spliced into themselves at either end, with one eye big enough to receive the cask or whatever is to be slung. There are other slings, which are made longer, and with a small eye at each end, one of which is put over the breech of a piece of ordnance, and the other comes over the end of an iron crow, which is put into the mouth of the piece, to weigh and hoist the gun as they please. There are also slings by which the yards are bound fast to the cross-trees aloft, and to the head of the mast, with a strong rope or chain, that if the tie should happen to break, or to be shot to pieces in fight, the yard, nevertheless, may not fall upon the hatches.

Slinging a Man overboard, in order to stop a leak in a ship, is managed thus. The man is trussed up about the middle in a piece of canvass, and a rope to keep him from sinking, with his arms at liberty, a mallet in one hand, and a plug, wrapped in oakum and well tarred in a tarpauling clout, in the other, which he is to beat with all dispatch into the hole or leak.

SLIPPER Island, a small island in the Eastern sea. Long. 93. 30. E. Lat. 14. 8. N.

SLOANE, Sir Hans, eminently distinguished as a physician and a naturalist, was of Scotish extraction, his father, Alexander Sloane, having been at the head of that Scotish colony which King James I. settled in the north of Ireland, where the son was born, at Killieagh, on the 19th of April 1660. At a very early period, he displayed a strong inclination for natural history; and this propensity being encouraged by a suitable education, he employed those hours which young people generally lose by pursuing low and trifling amusements, in the study of nature, and contemplating her works. When about sixteen, he was attacked by a spitting of blood, which threatened to be attended with considerable danger, and which interrupted the regular course of his application for three years. He had, however, already learned enough of physic to know that a malady of this kind was not to be suddenly removed, and he prudently abstained from wine and other liquors that were likely to increase it.

By strictly observing this severe regimen, which he in some measure continued ever afterwards, he was enabled to prolong his life beyond the ordinary bounds; being an example of the truth of his own favourite maxim, that sobriety, temperance, and moderation, are the best and most powerful preservatives that nature has granted to mankind. As soon as he recovered from this infirmity, he resolved to perfect himself in the different branches of physic, which was the profession he had made choice of; and with this view he repaired to London, where he hoped to receive that assistance which he could not find in his own country.

On his arrival in the metropolis, he entered himself as a pupil of Stafforth, an excellent chemist, bred under the illustrious Stahl; and by his instructions he gained a perfect knowledge of the composition and preparation of the different kinds of medicines then in use. At the same time, he studied botany at the garden at Chelsea, assiduously attended the public lectures of anatomy and physic, and in short neglected nothing that he thought likely to prove serviceable to him in his future practice. His principal merit, however, was his knowledge of natural history; and it was this part of his character which introduced him early to the acquaintance of Mr. Boyle and Mr. Ray, two of the most eminent naturalists of that age. His intimacy with these distinguished characters continued as long as they lived; and as he was careful to communicate to them every object of curiosity that attracted his attention, the observations which he occasionally made often excited their admiration and obtained their applause.

After studying four years at London with unremitting severity, Mr. Sloane determined to visit foreign countries for further improvement. In this view he set out for France in the company of two other students, and having crossed to Dieppe, proceeded to Paris. In the way thither they were elegantly entertained by M. Lemery the elder; and in return Mr. Sloane presented that eminent chemist with a specimen of four different kinds of phosphorus, of which, upon the credit of other writers, M. Lemery had treated in his book of chemistry, though he had never seen any of them. At Paris Mr. Sloane lived as he had done in London. He attended the hospitals, heard the lectures of Tournefort, De Verney, and other eminent masters; visited all the literati, who received him with particular marks of esteem; and employed himself wholly in study.

From Paris he proceeded to Montpellier; and, being furnished with letters of recommendation from M. Tournefort to M. Chirac, then chancellor of that university, he found easy access, through his means, to all the learned men of the province, particularly to M. Magnol, whom he always accompanied in his botanical excursions in the environs of that city, where he beheld with pleasure and admiration the spontaneous productions of nature, and learned under his instructions to class them in a proper manner.

Having here found an ample field for contemplation, which was entirely suited to his taste, he took leave of his two companions, whom a curiosity of a different kind led into Italy. After spending a whole year in collecting plants, he travelled through Languedoc with the same design; and passing through Toulouse and Bordeaux, returned to Paris, where he made a short stay. About the end of the year 1684 he set out for England, with an intention of settling there as a physician. On his arrival in London, he made it his first business to visit his two illustrious friends Mr. Ray and Mr. Boyle, in order to communicate to them the discoveries which he had made in his travels. The latter he found at home, but the former had retired to Essex; to which place Mr. Sloane transmitted a great variety of plants and seeds, which Mr. Ray has described in his *History of Plants*, and for which he makes a proper acknowledgment.

About the year 1706 Sloane became acquainted with Sydenham, who soon contracted so warm an affection for him that he took him into his house, and recommended him in the strongest manner to his patients. He had not been long in London before he was proposed by Dr. Martin Lister as a candidate to be admitted a fellow of the Royal society, on the 26th of November 1684; and being approved, he was elected on the 21st of January following.

In 1685 he communicated some curiosities to the Society; and in July the same year he was a candidate for the office of assistant secretary, but without success, as he was obliged to give way to the superior interest of his competitor Dr. Halley. On the 12th of April 1687, he was chosen a fellow of the College of Physicians in London; and the same year his friend and fellow traveller Dr. Tancred Robinson, having mentioned to the society the plant called the star of the earth as a remedy newly discovered for the bite of a mad dog, Dr. Sloane acquainted them that this virtue of the plant was to be found in a book called De Grey's *Farriery;* and that he knew a man who had cured with it twenty couple of dogs. This observation he made on the 13th of July, and on the 12th of September following he embarked at Portsmouth for Jamaica with the duke of Albemarle, who had been appointed governor of that island. The doctor attended his grace in quality of physician, and arrived at Jamaica on the 19th of December following. Here a new field was opened for fresh discoveries in natural productions; but the world would have been deprived of the fruits of them, had not Sloane, by incredible application, converted, as we may say, his minutes into hours. The duke of Albemarle died soon after he landed, and the duchess determined to return to England whenever an answer should be received to the letter which she had sent to court on that melancholy occasion. As he could not think of leaving her grace in her distress, whilst the rest of her retinue were preparing for their departure, he improved it in making collections of natural curiosities; so that, though his whole stay in Jamaica was not above fifteen months, he brought together such a prodigious number of plants, that on his return to England, Mr. Ray was astonished that one man could procure in one island, and in so short a space, so vast a variety.

On his arrival in London, he applied himself to the practice of his profession, and soon became so eminent, that he was chosen physician to Christ's Hospital on the 17th October 1694; and this office he held till the year 1730, when, on account of his great age and infirmities, he found it necessary to resign. It is somewhat singular, and redounds much to the doctor's honour, that though he received the emoluments of his office punctually, because he would not lay down a precedent which might hurt his successors, yet he constantly applied the money to the relief of those who were the greatest objects of compassion in the hospital, that it might never be said he enriched himself by giving health to the poor. He had been elected secretary to the Royal Society on the 30th of November 1693; and upon this occasion he revived the publication of the *Philosophical Transactions*, which had for some time been neglected. He continued to be the editor of this work till the year 1712; and the volumes which appeared during that period are monuments of his industry and ingenuity, many of the pieces contained in them being written by himself.

In the mean time he published *Catalogus Plantarum quæ in Insula Jamaica sponte proveniunt; seu Prodromi Historiæ Naturalis pars prima;* which he dedicated to the Royal Society and the College of Physicians. About the same time he formed the plan of a dispensary, where the poor might be furnished at prime cost with such medicines as their several maladies might require; and this he afterwards carried into execution, with the assistance of the president and other members of the College of Physicians.

His eager thirst for natural knowledge seems to have been born with him, so that his cabinet of curiosities may be said to have commenced with his being. He was continually enriching and enlarging it; and the fame which, in the course of a few years, it had acquired, brought every thing that was curious in art or nature to be first offered to him for purchase. These acquisitions however increased it but very slowly in comparison of the augmentation which it received in 1701 by the death of Mr. William Courten, a gentleman who had employed all his time, and the greater part of his fortune, in collecting rarities, and who bequeathed the whole to Dr. Sloane, on condition of his paying certain debts and legacies with which he had charged it. These terms our author accepted, and he executed the will of the donor with the most scrupulous exactness; on which account some people have said, that he purchased Mr. Courten's curiosities at a dear rate.

In 1707 the first volume of Dr. Sloane's Natural History of Jamaica appeared in folio, though the publication of the second was delayed till 1725. By this very useful as well as magnificent work, the materia medica was enriched with a great number of excellent drugs not before known. In 1708 the author was elected a foreign member of the Royal Academy of Sciences at Paris, in the room of Mr. Tschirnaus; an honour so much the greater, as we were then at war with France, and the queen's express consent was necessary before he could accept it. In proportion as his credit rose among the learned, his practice increased among the people of rank. Queen Anne herself frequently consulted him, and in her last illness was blooded by him.

On the advancement of George I. to the throne, that prince, on the 3d of April 1716, created Sloane a baronet, an hereditary title of honour to which no English physician had before attained; and at the same time made him physician-general to the army, in which station he continued till 1727, when he was appointed physician in ordinary to George II. He attended the royal family till his death; and was particularly favoured by Queen Caroline, who placed the greatest confidence in his prescriptions. In the mean time he had been unanimously chosen one of the elects of the College of Physicians on the 1st of June 1716, and he was elected president of the same body on the 30th of September 1719, an office which he held for sixteen years. During that period he not only gave the highest proofs of his zeal and assiduity in the discharge of his duty, but in 1721 made a present to that society of L.100, and so far remitted a very considerable debt, which the corporation owed him, as to accept it in such small sums as were least inconvenient to the state of their affairs. Sir Hans was no less liberal to other learned bodies. He had no sooner purchased the manor of Chelsea, than he gave the company of apothecaries the entire freehold of their botanical garden there, upon condition only that they should present yearly to the Royal Society fifty new plants, till the number should amount to two thousand.[1] He gave besides several other considerable donations for the improvement of this garden, the situation of which, on the banks of the Thames, and in the neighbourhood of the capital, was such as to render it useful in two respects; first, by producing the most rare medicinal plants; and, secondly, by serving as an excellent school for young botanists, an advantage which he himself had derived from it in the early part of his life.

The death of Sir Isaac Newton, which happened in 1727, made way for the advancement of Sir Hans to the presidency of the Royal Society. He had been vice-president, and frequently sat in the chair for that great man; and by his long connection with this learned body he had contracted so strong an affection for it, that he made them a present of an hundred guineas, caused a curious bust of Charles II. its founder, to be erected in the great hall where it met, and, as is said, was very instrumental in procuring Sir Godfrey Copley's benefaction of a medal of the value of five guineas, to be annually given as an honorary mark of distinction to the person who communicates the best experiments to the Society.

On his being raised to the chair, Sir Hans laid aside all thoughts of further promotion, and applied himself wholly to the faithful discharge of the duties of the offices which he enjoyed. In these laudable occupations he employed his time, from 1727 to 1740, when, at the age of fourscore, he formed a resolution of quitting the service of the public, and of living for himself. With this view he resigned the presidency of the Royal Society much against the inclination of that respectable body, who chose Mr. Martin Folkes to succeed him, and in a public assembly thanked him for the great and eminent services which he had rendered them. In the month of January 1741, he began to remove his library, and his cabinet of rarities, from his house in Bloomsbury to that at Chelsea; and on the 12th of March following, having settled all his affairs, he retired thither himself, to enjoy in peaceful tranquillity the remains of a well-spent life. He did not however bury himself in that solitude which excludes men from society. He received in Chelsea, as he had done in London, the visits of people of distinction, of learned foreigners, and of the royal family, who sometimes did him the honour to wait on him; but, what was still more to his praise, he never refused admittance or advice to rich or poor who came to consult him concerning their health. Not contented with this contracted method of doing good, he now, during his retreat, presented to the public such useful remedies as success had warranted, during the course of a long-continued practice. Among these, is the efficacious receipt for distempers in the eyes, and his remedy for the bite of a mad dog.

During the whole course of his life, Sir Hans had lived with so much temperance, as had preserved him from feeling the infirmities of old age; but in his ninetieth year he began to complain of pains, and to be sensible of a universal decay. He was often heard to say, that the approach of death brought no terrors along with it; that he had long expected the stroke; and that he was prepared to receive it whenever the great Author of his being should think fit. After a short illness of three days, he died on the 11th o. January 1752, and was interred on the 18th at Chelsea, in the same vault with his lady, the solemnity being attended with the greatest concourse of people, of all ranks and conditions, that had ever before been seen on the like occasion.

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[1] This garden was first established by the company in 1673; and having, after that period, been stocked by them with a great variety of plants, for the improvement of botany, Sir Hans, in order to encourage so serviceable an undertaking, granted to the company the inheritance of it, being part of his estate and manor of Chelsea, on condition that it should be for ever preserved as a physic garden. As a proof of its being so maintained, he obliged the company, in consideration of the said grant, to present yearly to the Royal Society, in one of their weekly meetings, fifty specimens of plants that had been grown in the garden the preceding year, and which were all to be specifically distinct from each other, until the number of two thousand should be completed. This number was completed in the year 1761. In 1733 the company erected a marble statue of Sir Hans, executed by Rysbrac, which is placed upon a pedestal in the centre of the garden, with a Latin inscription, expressing his donation, and the design and advantages of it.

Sir Hans being extremely solicitous lest his cabinet of curiosities, which he had taken so much pains to collect, should be again dissipated at his death, and being at the same time unwilling that so large a portion of his fortune should be lost to his children, bequeathed it to the public, on condition that L.20,000 should be made good by parliament to his family. The sum, though large in appearance, was scarcely more than the intrinsic value of the gold and silver medals, the ores and precious stones that were found in it; for in his last will he declares, that the first cost of the whole amounted at least to L.50,000. Besides his library, consisting of more than fifty thousand volumes, three hundred and forty-seven of which were illustrated with cuts finely engraven and coloured from nature, there were three thousand five hundred and sixty manuscripts, and an infinite number of rare and curious works of every kind. The parliament accepted the legacy, and fulfilled the conditions.

SLOBODSK-UKRAINE, a province of European Russia, which extends in north latitude from 48° 35′ to 51° 16′, and in east longitude from 34° 10′ to 38° 21′, comprehending 26,217 square miles. It is an elevated plain, over which few hills are to be seen. It contains but few forests, and the soil is generally dry, but by no means unfruitful. There are many small rivulets and rivers, which discharge their waters into either the Don or the Dnieper. The climate is considered healthy, though intensely hot in summer, and as severely cold in winter. The land varies in quality, but much of it is highly productive in corn. The inhabitants are of various races, some of them of Little Russian origin, others Cossacs, others from Great Russia, many called colonists, consisting chiefly of Germans or Poles, a few Kalmucks, and many Jews. The whole population is 718,500, the far greater part of whom adhere to the Greek church, but there are Arminians, Catholics, Lutherans, and a few Mahomedans and Pagans. The province is divided into twelve circles, and contains 15 cities, 547 parishes, with 1180 market-towns and villages. The capital is Charkow, or Kharkow, in latitude 49. 59. 20., and longitude 36. 10. E.

SLOT, in the sportsman's language, a term used to express the mark of the foot of a stag or other animal proper for the chace in the clay or earth, by which they are enabled to guess when the animal passed, and which way he went. The slot, or treading of the stag, is very nicely studied on this occasion. If the slot be large, deeply imprinted in the ground, and with an open cleft, and, added to these marks, there is a large space between mark and mark, it is certain that the stag is an old one. If there be observed the slots or treadings of two, the one long and the other round, and both of one size, the long slot is always that of the larger animal. There is also another way of knowing the old ones from the young ones by the treading; which is, that the hinder feet of the old ones never reach to their fore feet, whereas those of the young ones do.

SLOUGH, a market town of the county of Buckingham, in the hundred of Stoke. Though a town it is not a parish, one part being within the parish of Upton, and another part in the parish of Stoke Poggis. It is twenty miles from London and two from Eton, and is furnished with excellent inns, being on the great road to Bath and Bristol. It has a market on Thursday. It is chiefly remarkable from having been the residence of the celebrated astronomer Dr. Herschel, who constructed, in a garden near the road, his large and invaluable telescope, and made those discoveries in the heavens which have immortalised his name.

SLUICE, a frame of timber, stone, or other matter, serving to retain and raise the water of a river, and on occasion to let it pass.

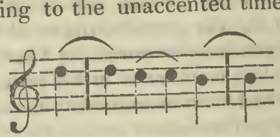
Such is the sluice of a mill, which stops and collects the water of a rivulet, to let it fall at length in greater plenty upon the mill-wheel; such also are those used as vents or drains to discharge water off land; and such are the sluices of Flanders, which serve to prevent the waters of the sea from overflowing the lower lands.

Sometimes there is a kind of canal inclosed between two gates or sluices, in artificial navigations, to save the water, and render the passage of boats equally easy and safe, upwards and downwards; as in the sluices of Briare in France, which are a kind of massive walls built parallel to each other, at the distance of twenty or twenty-four feet, closed with strong gates at each end, between which is a kind of canal or chamber, considerably longer than broad; in which a vessel being inclosed, the water is let out at the first gate, by which the water is raised fifteen or sixteen feet, and passed out of this canal into another much higher. By such means a boat is conveyed out of the Loire into the Seine, though the ground between them rises above one hundred and fifty feet higher than either of those rivers.

Sluices are made in different ways, according to the use for which they are intended. When they serve for navigation, they are shut with two gates, presenting an angle towards the stream; when they are made near the sea, two pair of gates are made, the one to keep the water out and the other in, as occasion requires. In this case, the gates towards the sea present an angle that way, and the others the contrary way; and the space inclosed by those gates is called the *chamber*. When sluices are made in the ditches of a fortress, to keep up the water in some parts, instead of gates, shutters are made so as to slide up and down in grooves; and when they are made to raise an inundation, they are then shut by means of square timbers let down in cullises, so as to lie close and firm.

The word *sluice* is formed of the French *escluse*, which Ménage derives from the Latin *exclusa*, which is found in the Salic law in the same sense. But this is to be restricted to the sluices of mills, for as to those serving to raise vessels, they were wholly unknown to the ancients.

SLUR, in *Musical Notation*, a curved line drawn over two or more notes, signifying, that these are to be performed in a smooth and connected manner *(legato.)* When the slur is applied to two notes of the same degree, this generally occurs in what is called a *syncopation*, *i. e.* where a note of the accented time of the measure is united with a note of the same name belonging to the unaccented time immediately preceding, thus:



SLUYS, a town of Dutch Flanders, opposite the island of Cadsand, with a good harbour, ten miles north of Bruges, containing 14,000 inhabitants. Long. 3. 25. E. Lat. 51. 19. N.

SLUZK, a city, the capital of a circle of the same name, in the province of Minsk in West Russia, 715 miles from St. Petersburg. It is situated on a river which gives it its name, is the best city in the province, contains two Catholic, two Greek, a Lutheran, and a Reformed church, and 1000 houses, with 5800 inhabitants, among whom are many Jews. There is a public school or college, where mathematics and natural philosophy are taught. Its chief employment is in agriculture. Lat. 53. 3. Long. 27. 22. E.

SMACK, a small vessel, commonly rigged as a sloop or hoy, used in the coasting or fishing trade, or as a tender in the king's service.

SMALAND, a province in the south of Sweden. See CALMAR.

SMALKALD, a town of Germany, in Franconia, and in the county of Henneberg; famous for the confederacy entered into by the German Protestants against the emperor, commonly called the *league of Smalkald*. The design of it was to defend their religion and liberties. It is seated on the river Werra, twenty-five miles south-west of Erford, and fifty north-west of Bamberg. Long. 10. 53. E. Lat. 50. 40. N. It is subject to the prince of Hesse-Cassel.

SMALL KEY, a small island in the Eastern Sea. Long. 247. 16. W. Lat. 10. 37. N.

SMALT, a kind of glass of a dark blue colour, which when levigated appears of a most beautiful colour; and if it could be made sufficiently fine, would be an excellent succedaneum for ultramarine, as not only resisting all kinds of weather, but even the most violent fires. It is prepared by melting one part of calcinated cobalt with two of flint powder, and one of potash. At the bottoms of the crucibles in which the smalt is manufactured, we generally find a regulus of a whitish colour inclined to red, and extremely brittle. This is melted afresh, and when cold, separated into two parts; that at the bottom is the cobaltic regulus, which is employed to make more of the smalt; the other is bismuth.

SMEATON, JOHN, an eminent civil engineer, was born on the 18th of June 1724, at Austhorpe, near Leeds, in a house built by his grandfather, and where his family have resided ever since.

The strength of his understanding and the originality of his genius appeared at an early age. His playthings were not the playthings of children, but the tools which men employ; and he appeared to have greater entertainment in seeing the men in the neighbourhood work, and asking them questions, than in any thing else. One day he was seen on the top of his father's barn, fixing up something like a windmill; another time, he attended some men fixing a pump at a neighbouring village, and observing them cut off a piece of bored pipe, he was so lucky as to procure it, and he actually made with it a working pump that raised water. These anecdotes referred to circumstances that happened while he was yet in petticoats, and most likely before he attained his sixth year.

About his fourteenth or fifteenth year, he constructed for himself an engine for turning, and made several presents to his friends of boxes in ivory or wood very neatly turned. He forged his iron and steel, and melted his metal; he had tools of every sort for working in wood, ivory, and metals. He made a lathe, by which he cut a perpetual screw in brass, a thing little known at that day, which was the invention of Mr. Henry Hindley of York, with whom Mr. Smeaton soon became acquainted, and they spent many a night at Mr. Hindley's house till day-light, conversing on those subjects.

Thus had Mr. Smeaton, by the strength of his genius and indefatigable industry, acquired, at the age of eighteen, an extensive set of tools, and the art of working in most of the mechanical trades, without the assistance of any master. A part of every day was generally occupied in forming some ingenious piece of mechanism.

Mr. Smeaton's father was an attorney, and desirous of bringing him up to the same profession. Mr. Smeaton therefore came up to London in 1742, and attended the courts in Westminster hall; but finding that the law did not suit the bent of his genius, he wrote a strong memorial on that subject to his father, whose good sense from that moment left the youth to pursue the bent of his genius in his own way.

In 1751, he began a course of experiments to try a machine of his invention to measure a ship's way at sea, and also made two voyages in company with Dr. Knight to try it, and a compass of his own invention and making, which was rendered magnetical by Dr. Knight's artificial magnets. The second voyage was made in the Fortune sloop of war, commanded at that time by Captain Alexander Campbell.

In 1753 he was elected member of the Royal Society. The number of papers published in their Transactions will show the universality of his genius and knowledge. In 1759 he was honoured by an unanimous vote with their gold medal for his paper entitled "An Experimental Inquiry concerning the Natural Powers of Water and Wind to turn Mills, and other Machines depending on a circular motion." This paper, he says, was the result of experiments made on working models in the years 1752 and 1753, but not communicated to the Society till 1759; before which time he had an opportunity of putting the effect of these experiments into real practice, in a variety of cases, and for various purposes, so as to assure the Society he had found them to answer.

In December 1755, the Eddystone lighthouse was burned down. Mr. Weston, the chief proprietor, and the others, being desirous of rebuilding it in the most substantial manner, inquired of the Earl of Macclesfield, then president of the Royal Society, whom he thought the most proper to rebuild it; and his lordship recommended Mr. Smeaton. He accordingly undertook the work, and he completed it in the summer of 1759. Of the preparation for this extraordinary work, of its commencement and progress, Mr. Smeaton has given an ample and interesting description in a splendid folio volume which was first published in 1791. The same volume contains the history of the different buildings which have been erected on the Eddystone rock.

Though Mr. Smeaton completed the building of the Eddystone lighthouse in 1759, yet it appears he did not soon get into full business as a civil engineer; but in 1764, while in Yorkshire, he offered himself a candidate to be one of the receivers of the Derwentwater estate, and on the 31st of December in that year, he was appointed at a full board of Greenwich hospital, in a manner highly flattering to himself, when other two persons, strongly recommended and powerfully supported, were candidates for the employment.

Mr. Smeaton having now got into full business as a civil engineer, performed many works of general utility. He made the Calder navigable; a work that required great skill and judgment, owing to the very impetuous floods in that river. He planned and attended the execution of the great canal in Scotland for conveying the trade of the country either to the Atlantic or German Ocean; and having brought it to the place originally intended, he declined a handsome yearly salary, in order that he might attend to the multiplicity of his other business.

The vast variety of mills which Mr. Smeaton constructed, so greatly to the satisfaction and advantage of the owners, will show the great use which he made of his experiments in 1752 and 1753; for he never trusted to theory in any case where he could have an opportunity to investigate it by experiment. He built a steam-engine at Austhorpe, and made experiments upon it, purposely to ascertain the power of Newcomen's steam-engine, which he improved and brought to a greater degree of perfection, both in its construction and powers, than it was before.

About the year 1785 Mr. Smeaton's health began to decline; and he then took the resolution of endeavouring to avoid all the business he could, so that he might have leisure to publish an account of his inventions and works, which was certainly the first wish of his heart; for he has often been heard to say, that "he thought he could not render so much service to his country as by doing that." He got only his account of the Eddystone lighthouse completed, and some preparations to his intended *Treatise on Mills;* for he could not resist the solicitations of his friends in various works; and Mr. Aubert, whom he greatly loved and respected, being chosen chairman of Ramsgate harbour, prevailed upon him to accept the place of engineer to that harbour. To their joint efforts the public is chiefly indebted for the improvements which have been made there, as fully appears in a report that Mr. Smeaton presented to the board of trustees in 1791, which they immediately published.

Mr. Smeaton being at Austhorpe, walking in his garden on the 16th of September 1792, was struck with palsy, and died the 28th of October.

SMELL, a word which in most languages has two meanings, signifying either that sensation of mind of which we are conscious, in consequence of certain impressions made on the nostrils, and conveyed to the brain by the olfactory nerves; or that unknown virtue, or quality in bodies, which is the cause of our sensations of smell.

SMELLIE, William, a learned and ingenious printer, was born at Edinburgh in the year 1740. His father, Alexander Smellie, who followed the occupation of a master-builder, is said to have been a classical scholar, and a writer of Latin verses. He belonged to the sect of reformed Presbyterians, more commonly described as Cameronians. He left two sons and three daughters. John, the elder son, followed his father's employment, and married a sister of the late James Ferrier, Esq. clerk of session. Two of his daughters were likewise married. Residing in the suburban street called the Pleasance, he sent his younger son to Duddingstone school, which is scarcely a mile distant. William Smellie was there initiated in the ordinary branches of education, including the Latin language; but he left school at the early age of twelve, and was destined to follow some mechanical employment. It was his father's original intention to bind him an apprentice to a staymaker, but some difference occurred as to the terms of the indenture; "and the young scholar was preserved from the mortifying drudgery of scraping whalebone, and stitching coats of armour to force the female form into every shape save that of natural elegance." On the first of October 1752, he was bound an apprentice, for six years and a half, to Hamilton, Balfour, and Neill, printers to the university.

To this occupation he applied himself with great assiduity, and he soon became conspicuous for the rapidity, as well as the correctness, with which he dispatched his work. With equal assiduity he devoted his evenings to the acquisition of knowledge. Two years before the expiration of his apprenticeship, his masters appointed him a corrector of the press, with a weekly allowance of ten shillings, which at that period was no despicable remuneration. His father was now dead, and two of his sisters were materially indebted to him for their support. During his apprenticeship, he was permitted to attend some of the academical lectures. The printing-office was within the precincts of the university buildings; "and he generally continued at work till he heard the bell ring for lecture, when he immediately laid down his composing-stick, shifted his coat, ran off with his note-book under his arm, and returned to his work immediately after lecture." The Edinburgh Philosophical Society having offered a silver medal for the most accurate edition of a Latin classic, Smellie set and corrected an edition of Terence, which obtained this prize for his employers. His edition, which bears the date of 1758, but was actually printed during the preceding year, has been described as immaculate; but of the literal accuracy of this description, we entertain some doubt. It is very elegantly printed, and is in all respects creditable to the Edinburgh press of that period. His apprenticeship was completed on the first of April 1759; and in the ensuing month of September, he agreed to transfer his services to the office of Murray and Cochrane. Here he was not only to perform the ordinary work of a corrector, but was likewise to collect articles for the Scots Magazine, and to make abstracts, extracts, or transcripts of such pieces as his employers should direct. He was moreover to lend his aid "in writing accounts, and, in cases of hurry in printing, in composing or case-work;" and in return for these various services, he was to receive a weekly salary of sixteen shillings.

It was one advantage of his new situation, that his employers allowed him three hours a-day for the prosecution of his academical studies; and thus, under peculiar circumstances, he was enabled to obtain a regular education. He not only studied the Latin, Greek, and Hebrew languages, but likewise mathematics, logic, rhetoric, moral, and natural philosophy. He besides attended all the medical courses, including the lectures on chemistry and botany. The Hebrew class he attended in the year 1758, with the immediate view of preparing himself to superintend the printing of Dr. Robertson's Hebrew Grammar. His course of study had thus been so regular and complete, that he was in a state of mature preparation for more than one of the learned professions. Some of his friends recommended the study of divinity; Dr. Buchan urged him to betake himself to the practice of physic; but the hazard of relinquishing a certain though small income for a very uncertain experiment, must have served to mancipate him to his original avocation. An early marriage fixed him more completely in the printing-office. His wife, Jane Robertson, was the daughter of an army-agent in London, who had once been opulent, but who finally left his family in indigent circumstances. Her mother was the cousin of Mrs. Oswald of Dunikier, and there were other family connexions described as genteel, but they do not appear to have rendered any service to Smellie or his children. The marriage took place in 1763, when he had only attained the twenty-third year of his age.

In the mean time, his love of learning suffered no abatement. In the year 1760 he had become a member of the Newtonian Society, a literary association chiefly composed of young men educated in the university. They held their weekly meetings in one of the class-rooms. At each meeting an essay was read by one of the members; and a subject, previously assigned, was discussed in due form. The essays were restricted to subjects of natural science, but the debates extended to a wider range. The list of members included various names which were afterwards conspicuously known; and among others, we find that of Robert Blair, the late president of the court of session. To this association likewise belonged Thomas Blacklock, Robert Hamilton, Alexander Adam, Henry Hunter, Samuel Charters, and William Buchan. After the interruption of their regular meetings as a society, some of the members continued for several years to hold a weekly meeting in a tavern, where they partook of a sober repast, and spent their evenings in literary and social conversation. With two very estimable members of this club, Dr. Hamilton of Aberdeen, and Dr. Charters of Wilton, Smellie always retained a friendly connexion. A new association, of which he acted as secretary, was formed in the year 1778, under the denomination of the Newtonian Club. Most of the other members were connected with the medical profession, and five of them either then were or afterwards became medical professors in the university. In the list of these associates we find the names of Dugald Stewart and James Gregory. No person was eligible unless he was a member of the Philosophical Society; and the meetings of the club were appointed to take place immediately after the close of each meeting of the society. The number of members was not to exceed twenty; and a single black ball was to exclude any candidate. The last of their regulations stands thus: "As this club consists entirely of philosophers, it would therefore be ridiculous to make any laws for its internal police."

For the different branches of natural history Smellie had evinced an early predilection. To the study of botany he devoted so much attention, that in 1765 his Dissertation on the Sexes of Plants gained the gold medal given by Dr. Hope. In this dissertation, which was inserted in the first edition of the Encyclopædia, he strenuously opposed the doctrines of Linnæus.[1] The substance of it was incorporated in his Philosophy of Natural History; and his opinions were then controverted by Dr. Rotheram, afterwards professor of natural philosophy at St. Andrews. Of his proficiency in these studies we find a more conspicuous proof. While he was attending the botanical class, the professor sprained his leg so severely that for a considerable interval he was unable to meet his students; and on this occasion he selected Smellie to continue the course of lectures. In a botanic garden, lectures cannot be servilely read from papers, either written by the lecturer himself, or supplied by others.

On the 25th of March 1765 he commenced business as a printer, in conjunction with two brothers named Robert and William Auld, the former of whom was a solicitor. His private resources were obviously scanty; and two of his friends, Dr. Robertson, professor of oriental languages, and Dr Hope, professor of botany, advanced to him the sum of seventy pounds, which we reckon equivalent to two hundred in our present currency. This copartnery was dissolved within the space of less than two years, by the retirement of Robert Auld; but a new company, consisting of Balfour, W. Auld, and Smellie, commenced business on the 22d of December 1766. John Balfour, who was likewise a bookseller, had been a partner in the house of Hamilton, Balfour, and Neill. The new house published the Journal, a newspaper supposed to have been unprofitable. Their connexion only continued till the month of November 1771; and the modified firm of Balfour and Smellie continued the business from the twelfth of that month. Beside his share of the profits, the junior partner was to receive ninety pounds a-year, and he was bound to conduct the entire business of the office. His average income amounted to about L.200. After an interval of more than two years, he easily obtained from Lord Kames the favour of his becoming surety to the Royal Bank for a cash-account to the extent of two or three hundred pounds. Their acquaintance had arisen from a series of anonymous strictures which he communicated to his lordship when the Elements of Criticism were passing through the press of Murray and Cochrane. The author requested the acquaintance of his nameless critic, and afterwards honoured him with various marks of his friendly attention. He incidentally mentions his supping with Lord Kames, in company with Hume and other guests. He was likewise a guest at the learned suppers of Lord Monboddo; and he reckoned Lord Hailes, as well as Lord Gardenstone, among the number of his friends and well-wishers.

Balfour and Smellie were appointed printers to the university. The chief advantage which attended this appointment was the profit of printing the dissertations written by candidates for medical degrees. Smellie likewise printed the theses written by candidates for admission to the Faculty of Advocates; and his knowledge of the Latin language was in both cases found very serviceable to the writers. He rendered material assistance to his friend Dr. Buchan, in the composition of a work which attained to very extensive popularity. This work, entitled "Domestic Medicine, or, a Treatise on the Cure and Prevention of Diseases," was published at Edinburgh in the year 1770. In the course of forty years, it is said to have passed through twenty editions, each consisting of 6000 copies, besides many pirated editions in Ireland and America, and some even in Britain. Of this treatise, Smellie was sometimes represented as the sole author; but it appears with sufficient evidence that the manuscript was placed in his hands, and that in preparing it for the press, he made many essential alterations in its form and style. It was so diffuse and redundant, that a single chapter, as originally written, would nearly have equalled the size of the entire book, as at first printed. These services were compensated with a bill for one hundred pounds.

Of Smellie's life, we have now arrived at an era which recommends him to the more particular regard of the writers and readers of the present work. The first edition of the Encyclopædia Britannica consisted of only three volumes, which began to be printed in the year 1771. The principal articles were written, compiled, or devised by him, and he prepared and superintended the entire publication. "As you have informed me," says a letter of Andrew Bell, the chief proprietor, "that there are fifteen capital sciences which you will undertake for, and write up the subdivisions and detached parts, conform[ably] to your plan, and likewise to prepare the whole work for the press, &c. &c., we hereby agree to allow you L.200 for your trouble." If his capital sciences had not exceeded the old number of seven, this remuneration could scarcely have been considered as extravagant. One of his original articles, contributed to this edition, was that on *Æther*, which attracted a considerable degree of attention, and gave no small offence to Dr. Cullen, whose theory was there exposed, though without any mention of his name. From internal evidence, he was convinced that the article must have been written by his colleague Dr. John Gregory. He at length ascertained the real author; and this discovery, says the late Dr. Gregory, "gave occasion to the complete alteration and softening of the article Æther in the second and all the subsequent editions of the Encyclopædia; so that nothing of it was allowed to remain that could give offence to Dr. Cullen."[2]

Of the second edition of this work Smellie was offered a share, apparently a third, conjoined with the charge of editorship. This offer he unfortunately declined, and thus lost the only golden opportunity that fortune ever presented to him. "At the death of Mr. Macfarquhar, printer, in April 1793, the whole work became the property of Mr. Bell. It is well known that Mr. Macfarquhar left a handsome fortune to his family, all or mostly derived from the profits of the Encyclopædia; and that Mr. Bell died in great affluence, besides possessing the entire property of that vast work; every shilling of which may be fairly stated as having grown from the labours of Mr. Smellie in the original fabrication of the work, which is confessedly superior, and all of which he and his family might have shared in equally with Mr. Bell and the other proprietor, if he had not been too fastidious in his notions, and perhaps too timid in his views of the risk which might have been incurred in the mercantile part of the speculation."[3] His chief objection is stated, not with much probability, to have arisen from a difference of opinion as to the general plan: "because the other persons concerned, it has been said upon the suggestion of a very distinguished nobleman of the highest rank and most princely fortune, insisted upon the introduction of a system of general biography; which Mr. Smellie objected to, as by no means consistent with the title." If this statement is accurate, we consider the nobleman as decidedly right, and Smellie as decidedly wrong; inasmuch as the historical and biographical part of the work has recommended it to many readers, who do not feel an equal degree of interest in the arts and sciences. The perfection of such a work is to render it agreeable as well as instructive to the greatest possible number of readers. The second edition, consisting of 1500 copies, began to be published in 1776. The third, extending to no fewer than 10,000 copies of eighteen volumes, commenced in 1786. By this edition, we are informed, the two proprietors "are said to have cleared a net profit of L.42,000, besides being each paid for their respective work in the conduct of the publication as tradesmen; Mr. Bell as engraver of all the plates, and Mr. Macfarquhar as sole printer."

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[1] Smellie's Philosophy of Natural History, vol. i. p. 245.

[2] Gregory's Additional Memorial to the Managers of the Royal Infirmary, p. 188.

[3] Kerr's Memoirs of the Life, Writings, and Correspondence of William Smellie, F.R.S. & F.A.S., vol. i. p. 363. Edinb. 1811, 2 vols. 8vo.

Smellie afterwards embarked in a speculation which did not prove so lucrative. This was "The Edinburgh Magazine and Review," of which the first number appeared in the month of October 1773. The editor was Dr. Stuart, whose temper and discretion were not equal to his talents and learning. Smellie was one of five partners, including the editor; and besides printing the work at the ordinary rates, he "was regularly to compile the last half-sheet of every number, to consist of foreign and domestic occurrences, or the news-department, and other articles; to keep the accounts of the concern; to answer all letters relative to the concern; and to review certain articles, as should be agreed upon between him and Dr. Stuart." The work only extended to five volumes, closing with the number for August 1776. It was conducted with so much ability, that it might have run a more prosperous career, if the personalities of the editor, displayed within so narrow a field, had not excited a degree of hostility with which it was hopeless to contend. But the history of this work will be resumed in our notice of Gilbert Stuart.

Of the Society of Antiquaries, instituted at Edinburgh in 1780, Smellie was an original member. In 1781 he was elected Superintendent of the Museum of Natural History, which they proposed adding to their antiquarian cabinet. He afterwards published an "Account of the Institution and Progress of the Society of the Antiquaries of Scotland." Edinb. 1782, 4to. To this account he added a second part in 1784. He was elected to the office of secretary in 1793. This new institution excited the jealousy of some other learned bodies. The senate of the university presented a memorial to the lord advocate, remonstrating against the grant of a royal charter to the Society of Antiquaries, on the allegation that Scotland was too limited a country for two literary Societies; and proposing, that instead of granting such a charter, the king should incorporate a society under the designation of the Royal Society of Scotland. They further suggested "that the Society of Antiquaries would intercept the communication of many specimens and objects of natural history, which would otherwise be deposited in the museum of the university, and of many documents tending to illustrate the history, antiquities, and laws of Scotland, from being deposited in the library of the Faculty of Advocates. They likewise noticed that the possession of a museum of natural history might enable and induce the Society of Antiquaries to institute a lectureship of natural history, in opposition to the professorship in the university." Nor did the curators of the Advocates Library remain inactive. They represented to the lord advocate that the grant of a charter to the Antiquaries "might prove injurious to that magnificent library, by intercepting ancient manuscripts and monuments illustrative of the history and antiquities of Scotland, which would be more useful when collected into one repository than in a state of division." To all these representations the Society returned an elaborate answer, in the form of a memorial addressed to the lord advocate; and the royal charter was finally ratified in the month of May 1783. It is scarcely necessary to add, that few or none of the multifarious evils which had thus been predicted, were found to result from the incorporation of this Society, which has proved almost as harmless as any institution in the kingdom. The Royal Society of Edinburgh soon afterwards obtained its charter; and as a member of the Philosophical Society, Smellie was incorporated on the 23d of June 1783.

At the request of the Society of Antiquaries, he had in 1781 digested the plan of a statistical account of all the parishes of Scotland. The circulation of this plan did not excite much industry; but, at no distant period, it was followed by an extensive and important work. As superintendent of the museum, he was authorized to deliver in their hall a course of lectures on natural history. "His object was to deliver lectures on the philosophy of natural history, which is a subject totally different from what a public professor is obliged to teach. A professor must instruct his students in the technical and elementary part of the science; but the private lecturer was to confine himself to general views of the economy of nature."[1] The professor of natural history, who certainly had reason to fear such a rival, was alarmed at what he considered as an encroachment on his province, and this plan of lectures was reluctantly abandoned. On the death of Dr. Ramsay in the year 1775, Smellie had offered himself as a candidate for the professorship; but his claims were disregarded, and it was bestowed upon Dr. Walker, at that time minister of Moffat, and afterwards of Colinton.

Smellie however continued to prosecute his favourite study, and he published "Natural History, general and particular, by the Count de Buffon: translated into English. Illustrated with above 200 copper-plates, and occasional notes and observations by the Translator." Edinb. 1781, 8 vols. 8vo. "Much the greater portion of this extensive work," says Mr. Kerr, "was executed in a small correcting room or closet connected with his printing-office, where he was continually liable to interruption, from the introduction of proof-sheets for correction, and revises for comparison, and to the almost perpetual calls of customers, authors, and idle acquaintances: yet such was his accuracy of self-possession, that, as usual with almost every thing he wrote, he gave it out page by page, as fast as written, to his compositors, and hardly ever found it necessary to alter a single word after the types were set up from his first uncorrected manuscript. Although, to have enabled him to execute this translation in the excellent manner in which it is done, Mr. Smellie must necessarily have possessed a very thorough knowledge of the French language, it appears that he had acquired this entirely by means of his own private study, and without the assistance of any teacher; for we have been assured by those who knew him very intimately, that he was quite unacquainted with the pronunciation of French." A second edition of his translation, in nine volumes, followed in the year 1785. Other three editions, all of them extensive, were afterwards published; so that the work may be considered as having been eminently successful. The translator's notes were allowed to have added no inconsiderable value to the text; and the chief fault imputed to him was the use of provincial idioms. He was honoured with the correspondence of Buffon, and likewise of Pennant.

The firm of Balfour and Smellie having been dissolved, that of Creech and Smellie began business on the 14th of September 1782, and continued it till the close of the year 1789. Creech, well-known as a bookseller, was in all cases difficult to bring to a settlement of accompts, when he had any reason to believe the balance to be on the wrong side. The affairs of this copartnery, being somewhat intricate, were submitted to arbitration, and a balance was ultimately found due to Smellie; but the decision was so long deferred, that it was not pronounced till some time after his death. After the termination of these different partnerships, he continued the business on his own account. Lord Kames died in the year 1782; and he was now indebted to the kindness of Lord Gardenstone, who became his surety to the banking-house of Sir W. Forbes and Co.

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[1] Smellie's Account of the Society of Antiquaries, part ii. p. 24.

His next publication was "An Address to the People of Scotland, on the Nature, Powers, and Privileges of Juries. By a Juryman." Edinb. 1784, 8vo. This tract is entitled to particular notice, because it contains a clear and judicious exposition of legal principles, very important in themselves, and at that period very little understood. "It is," he remarks, "a common notion that jurymen are judges of the *fact* only, and not of the *law*. This absurd, and often fatal prejudice is much more prevalent than might be expected, in a city like this, where general knowledge ought to be pretty widely diffused. It has perhaps been too much fostered by the injunctions of judges and magistrates. It is exceedingly natural that plain simple jurymen should look up with veneration to the high rank, and superior abilities of those men who are appointed by their sovereign to dispense justice over the nation. For this reason it is, that the English judges are so extremely solicitous not to inculcate their own opinions on the minds of jurymen, but to leave their determinations solely to the dictates of their own consciences. But from whatever source this prejudice may have derived its origin, I shall endeavour to shew that it has neither law nor common sense for its support." A further specimen may very satisfactorily be produced. "I know it to be the opinion of many jurymen, that after the court admits a *relevancy*, they are bound by their oaths to find the libel either *proved* or *not proved*. But these gentlemen should consider, that their business is to give a verdict of a very different kind. They are to judge both of the criminality of the culprit, and of his exculpatory evidence. The words *proved* or *not proved* should be for ever banished from the verdicts of juries. A relevancy may be found, when the jurymen, who hear the indictment impugned, are of an opposite opinion from the court. A crime may be libelled, when the facts related in the indictment, though completely proved, do not constitute the essence of the crime charged. Hence, whenever the minds of jurymen are convinced that a relevancy has been improperly found, their verdict, however the proof may stand, should be *Not guilty*. Indeed, the expressions, *Guilty* or *Not guilty* ought alone to be employed in verdicts." This tract excited a considerable degree of attention; and it was quoted with much approbation by Lord Erskine, in his famous speech in defence of Dr. Shipley, dean of St. Asaph. He published several other pamphlets, which chiefly related to local politics.

But the most elaborate of his works is "The Philosophy of Natural History." Edinb. 1790, 4to. This is an ingenious book, written in a very pleasing style, and it accordingly experienced a favourable reception. It was reprinted at Dublin and Philadelphia. Lichtenstein published a German translation, to which some notes were added by C. A. W. Zimmermann. For the original volume, Charles Elliot agreed to pay one thousand guineas, at six, twelve, and eighteen months, as well as a certain sum for every edition after the first. This enterprising bookseller died before the work was ready for publication; but the agreement was honourably fulfilled by his trustees, though the benefit accrued, not to the author himself, but to his family. "This," says Mr. Kerr, "was probably the largest sum that had ever been given, at least in Edinburgh, for the literary property of a single quarto volume, and evinced both the liberality of the bookseller, and the high estimation in which he very justly held the fame and talents of the author."

His plan however was not yet completed, and he immediately applied himself to the preparation of a second volume. He lived to bring it to a conclusion, though not to make any arrangement for its publication. During the last years of his life, his health appears to have been infirm and precarious. In June 1793, he stated to his friend Dr. Hutton, that he had for several months been distressed with a debility in his limbs, accompanied with a want of appetite; and to another medical friend, Dr. Gardiner, we find him stating very unfavourable symptoms in the course of the following year. After a long illness, he died on the 24th of June 1795, at the age of sixty-five. He left a widow, with four sons and four daughters; two sons and three daughters having died before their father. His eldest daughter was married to Mr. George Watson, an eminent portrait-painter in Edinburgh. Smellie had never been in affluent circumstances, but he left to his family the means of prosperity; and the printing business has been more successfully conducted by his son Mr. Alexander Smellie.

Of his Philosophy of Natural History, the second volume was published by this son in the year 1799. Another posthumous work speedily followed: "Literary and characteristical Lives of John Gregory, M.D., Henry Home, Lord Kames, David Hume, Esq., and Adam Smith, LL.D. To which are added a Dissertation on Public Spirit, and three Essays." Edinb. 1800, 8vo. His original plan comprehended the lives of other twenty-five men of literary eminence, with whom he was personally acquainted. One of these was his friend Dr. Stuart, with whose private history he was sufficiently familiar, and of which he could have supplied very curious, though perhaps not very edifying details. It is not however a subject of much regret that his plan was never completed. In the specimen with which we have thus been presented, there is too little biography, and too much discussion. This remark is more particularly applicable to the life of Dr. Gregory, which extends to 118 pages, but is almost entirely occupied with an account, not of the writer, but of his writings. The other lives are of less extent. In his account of Hume, he relates, without any symptom of disapprobation, the indecent levity with which he sported on the verge of another world; and in the same manner he likewise repeats the declaration of Dr. Smith as to the character of that philosopher, "I have always considered him, both in his lifetime and since his death, as approaching as nearly to the idea of a perfectly wise and virtuous man, as perhaps the nature of human frailty will permit." This ingenious printer may himself have been somewhat too anxious to be classed among philosophers.

Smellie appears to have been a man of excellent talents, and of extensive knowledge. His disposition was social, his habits were convivial, and he was distinguished by a sarcastic vein of wit and humour. According to the description of his biographer, he "was about the middle size, and had been in his youth well-looked and active; but when rather past the middle of life, he had acquired from almost constantly stooping at his desk to write or correct, a rather lounging gait and appearance; and from a long-continued series of difficulties in his affairs, and much disappointment in matters of affectionate moment, he had become careless and rather slovenly in his dress and appearance; wearing his hair long and bushy, his ordinary black and wide-made clothes ill brushed, and well sprinkled with snuff, and his usual old-fashioned cocked hat for the most part rusty." Burns describes him as "a man positively of the first abilities and greatest strength of mind, as well as one of the best hearts and keenest wits, that he had ever met with." And in the following lines, which allude to a club called the Crochallan Fencibles, he has exhibited a graphic delineation of Smellie:

To Crochallan came
The old cock'd hat, the brown surtout the same;
His bristling beard just rising in its might,
'Twas four long days and nights to shaving-night;
His uncomb'd grizzly locks, wild staring, thatch'd
A head for thought profound and clear unmatch'd;
And though his caustic wit was biting, rude,
His heart was warm, benevolent, and good. (x.)

SMELLING is the act by which we perceive smells, or become sensible of the presence of odorous bodies. The sensations of smell are excited by certain effluvia, which, in the open air, are always issuing from the surfaces of most bodies, and striking on the extremities of the olfactory nerves, give them a peculiar sort of impression, which is communicated to the brain. The particles which issue thus from bodies are extremely volatile, and produce sensation by a degree of contact, which, though insensible, is still more efficient than if it were more gross and palpable. It is by a similar species of insensible contact that the eyes and ears are affected by external objects; while, in the excitation of the sensations of touch and of taste, an actual and sensible contact of the object with the organ is necessary. The organs of smelling are the nostrils and olfactory nerves; the minute ramifications of the latter being distributed throughout the whole concavity of the former.

The effluvia from odorous bodies are constantly floating about in the atmosphere, and must of course be drawn into the nostrils along with the air in inspiration; "so that there is," as Dr. Smith observes, "a manifest appearance of design in placing the organ of smell in the inside of that canal through which the air is continually passing in inspiration and expiration." It has been affirmed by Boerhaave, that the matter in animals, vegetables, fossils, and the like, which chiefly affects the sense of smelling, is that attenuated substance, inherent in their oily parts, called *spirits;* because, when this is taken away from the most fragrant bodies, what remains has scarcely any smell at all; but this, he says, if poured on the most inodorous bodies, gives them a fragrancy.[1] We cannot however enter at present upon this inquiry.

The sense of smell has a close alliance with that of taste; and it seems probable from the proximity in the situation of their organs in all animals, that both are principally intended to guide them in the choice of their food; so that from this close connection, they are better enabled to choose what is good for them, and to reject what would be injurious. This is the opinion of Dr. Reid, as it was, in a very early period of the history of philosophy, that of Socrates and of Cicero.[2] Dr. Reid also remarks, that the sense of smell probably serves the same purpose in the natural state of man; but it is not always a sure guide for this purpose. The organs of smell differ, like those of the other senses, according to the destination of the animals to which they belong; and we know, that this sense is in man much less acute, than in many other animals. We see, that in the choice of their food, they are guided by the senses of smell and of taste, except when man has brought them into a sort of unnatural state by domestication. And this circumstance renders it probable, that both these senses were intended to serve the same purpose in the natural state of our species, although less calculated for this end than they were in the brutes, on account of the great superiority of their smelling organs. Besides, since it is probable that man, in the natural state, acts more by instinct than when civilized in society, so also it is reasonable to think, that he may possess some of the senses, this of smell for instance, in greater acuteness than we do. This indeed we are assured to be a fact; for we are told in the *Histoire des Antilles*, that there are negroes who, by the smell alone, can distinguish the footsteps of a Frenchman from those of a negro.

The sense of smell is much more obtuse in man than in some of the lower animals. Dogs we know possess a power of smelling, of which we can scarcely form a conception, and which it is happy for us we do not possess;[3] and birds of prey are said to possess this sense in still greater acuteness. But although this be more perfect, still the sense of smelling in man, who has other means of judging of his food, is such as to fit him for deriving enjoyment from a diversity of scents, particularly those of flowers and perfumes, to which dogs and other animals seem perfectly insensible. It has been said, we are aware, that some animals, the elephant for instance, are capable of this enjoyment;[4] but of this fact we cannot help being very doubtful.

There is a very great sympathy between the organs of smell and of taste; for any defect or disease of one is generally attended with some corresponding defect or disease of the other. There is also a greater similarity between the sensations of both these, than between those of any other two senses; and hence it is, that we can sometimes tell the taste of an object from its smell, and *vice versa.* Hence also the reason why we apply the same epithets to the names of both these classes of sensations; as a sweet smell or taste.

It deserves also to be remarked, that both these senses seem subservient to the preservation of the animal existence, rather than to any other purpose. They accordingly constitute an object of the natural history of man, rather than of intellectual or of moral philosophy. The other three senses, on the contrary, seem rather intended for, as they certainly are essential to, our intellectual improvement, and become, of course, a proper object of investigation in the sciences of moral philosophy, or metaphysics.

The advantages derived by man and the other animals from the sense of smelling are not confined to the assistance which it affords them in the choice of their food. Most bodies in nature, when exposed to the open air, are constantly sending forth emanations or effluvia of such extreme minuteness as to be perfectly invisible. These diffuse themselves through the air, and however noxious or salutary, would not be perceived without the sense of smelling, which, if not vitiated by unnatural habits, is not only a faithful monitor when danger is at hand, but conveys to us likewise the most exquisite pleasures. The fragrance of a rose, and of many other flowers, is not only pleasant, but gives a refreshing and delightful stimulus to the whole system, while the odours proceeding from hemlock, or any noxious vegetable, or other substance, are highly offensive to our nostrils. Hence we are naturally led to seek the one class of sensations, and to avoid the other.

In some species of animals the sense of smell seems to be connected with certain mental sympathies, as those of hearing and sight are in all that possess them in any high degree; for not only their sexual desires appear to be excited by means of it, but other instinctive passions, which, according to the usual system of nature, should be still more remote from its influence. Dogs, although wholly unacquainted with lions, will shudder at their roar; and an elephant that has never seen a tiger, will in the same manner show the strongest symptoms of horror and affright at the smell of it. "The late Lord Clive," says an ingenious writer, "exhibited a combat between two of these animals at Calcutta; but the scent of the tiger had such an effect upon the elephant, that nothing could either force or allure him to go along the road, where the cage in which the tiger was inclosed, had passed, until a gallon of arrack was given him. Upon this, his horror suddenly turning into fury, he broke down the paling to get at his enemy, and killed him without difficulty."

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[1] See also Sir William Drummond's Academical Questions, book i. chap. 9.

[2] "Ut gustus," says a learned physiologist, "cibi itineri, sic olfactus ostio viarum, quas aer subire debet, custos præponitur, moniturus ne quid noxii, via quæ semper patet, in corpus admittatur. Porro, ut gustus, sic quoque olfactus ad salutarem cibum invitat, a noxio aut corrupto, putrido imprimis vel rancido, deterret."

"When thou seest the mouth, through which animals take in whatever they desire, always placed near the nose and eyes, thinkest thou not, say Socrates to Aristodemus, that this is the work of a providence." (Xenophon's Memorabilia, book i. chap. 4.)

[3] "The excessive eagerness which dogs express on smelling their game, seems to be but little connected with the appetite for food, and wholly independent of any preconceived ideas of the objects of their pursuit being fit for it. Hence several kinds of them will not eat the game which they pursue with such wild impetuosity; and of which the scent seems to animate them to a degree of ecstacy far beyond what the desire of food can produce." (Knight on Taste.)

[4] There is an animal to which, naturalists say, perfume is so agreeable and so necessary, that nature has provided it with a little bag stored with an exquisite odour. "On pretend," says Buffon, "que la mangouste ouvre cette poche, pour se refraichir lorsqu' elle a trop chaud."

If riding along a road, near which a dead horse, or part of its carcass, happens to be lying, we know, that our horse although he sees it not, cannot be made to pass the place but with difficulty. Where blood has been shed, particularly that of their own species, oxen will assemble, and upon smelling it, roar and bellow, and show the most manifest signs of horror and distress; and yet these symptoms could not arise from any associated notions of danger or death, since they appear in such as never had any opportunities of acquiring them. They must therefore be instinctive like other instinctive antipathies and propensities. But although in their mutual intercourse, animals make much use of the sense of smell, still it does not seem to be further concerned in exciting their sexual desires, than in indicating their object.

Some of those splenetic philosophers, who are ready upon all occasions to quarrel with the constitution of nature, have taken the liberty of condemning their Maker, because it has pleased his unfathomable wisdom to bestow in some instances upon the brutes senses and instincts more perfect than he has given to man, without reflecting that he has given to man an ample equivalent; for it may be asked with the poet,

> Is not his reason all these powers in one?
> Is Heaven unkind to man and man alone?
> Shall be alone, whom rational we call,
> Be pleased with nothing if not blessed with all?

With respect to that unknown peculiarity of bodies, which is the cause of our sensations of smell, the opinions of philosophers have been very various. Until of late, the doctrine of Des Cartes and Locke on this subject was pretty generally received; but, since the publication of Dr. Reid's works, his opinion, which we deem the most correct and satisfactory, has become very popular. We will endeavour to abridge his account of this matter. For this purpose, let us suppose a person, who has grown up without the sense of smell, to be immediately endowed with the use of this organ, and placed near some flowers of an exquisite savour. When he examines what he feels in such a situation, he can find no resemblance between this new sensation, and any thing with which he is already acquainted. He finds himself unable to explain its nature, and cannot ascribe to it figure, extension, or any known property of matter. It is a simple affection, or feeling of mind, and, considered abstractedly, can have no necessary connection with the nerves, the nostrils, or effluvia, or with any thing material whatever. By the nature of his constitution he is however led to refer this peculiar sensation to the nostrils, as its organ; and when, from experience, and by means of touch, he learns that external objects have the power of exciting this sensation, he concludes, that there must exist in bodies some unknown cause by which it is excited. In the first part of this process he considers the feeling, or sensation, abstractedly. As such, it exists in the mind only; and cannot exist there but when the mind is conscious of it. His consciousness soon enables him to distinguish different sorts of smells, all of them very distinct from one another, but, conformably to the nature of all sensation, extremely simple. He concludes, that each of these must have a distinct cause; and finding, by experience, that this cause is an unknown something in bodies, he concludes, that it must be a property of matter, and, for want of another, gives it the name of smell. When he removes an odorous body from the organ, the sensation vanishes; when the body is again applied, the sensation is excited; and hence it is, that he is led naturally to connect the sensation with this unknown peculiarity of bodies by which it is produced. But since we see, that the sensation is, in a great degree, related to other objects besides its unknown cause, to the mind in which it exists, for instance, and to the organ which is its instrument, it may be asked why it becomes associated in the mind with its cause only? The reason seems pretty obvious. No single sensation, or class of sensations, is more connected with the mind, than any other of which it is susceptible. Nor is the connection subsisting between the organ and any of the sensations peculiar to it, greater than that which subsists between it and every other sensation of which it is the inlet. Hence the connection between the smell of an orange and the mind, or between it and the nostrils, is very general, and cannot, in the former instance, distinguish it from any other sensation of whatever kind, nor, in the latter, from any other particular smell. But the connection between this sensation and the orange is peculiar and permanent; and we accordingly find them always associated in the mind, just as we associate the notion of fire with the sensation of burning. The relation which a sensation of smell, or any sensation, bears to the mind, to an organ, or to the memory and conception of itself, is common to all sensations. The relation which any sensation bears to its own cause, suppose of the sensation of smell to a particular virtue or quality of bodies, is common to it with every other sensation, when considered with respect to its peculiar cause. And finally, a sensation of any kind bears the same sort of relation to the memory and conception of itself, that any other feeling or operation of mind bears to the conception and memory of that particular feeling or operation.

Whatever then be the nature of the minute particles of bodies by which our sensations of smell are excited, we cannot help considering their unknown cause as a virtue or quality of matter. Like all other modifications of material substance, it must be confessed, that this can have no resemblance to the sensations of mind. But we are not therefore to conclude with the followers of Des Cartes and Locke, that this secondary quality is a mere sensation; especially as we can readily conceive it existing where it is not smelled, or even after supposing the annihilation of every sentient being throughout the universe. The existence of the sensation we know to be momentary and fugitive; but in the existence of its cause we can, without difficulty or inconsistency, conceive a permanency independent of mind and of its sensations.

The doctrine which we have been illustrating has of late been called in question by a sceptical writer, who, it appears to us, has upon this occasion been entirely deficient in his accustomed acuteness. Dr. Reid's speculations seem so full, so clear and convincing, that we are at a loss to conceive how his meaning can be misunderstood; and yet the argument and objections of the writer to whom we allude, derive all their plausibility from a misinterpretation of Dr. Reid's meaning, and from a deviation from the established use of language. "An eminent metaphysician," says this author, "has declared that he has not the least difficulty in conceiving the air perfumed with aromatic odours in the deserts of Arabia; and he has decided, that the man who maintains smells to exist only in the mind must be mad, or must abuse language and disgrace philosophy. There are some authors, nevertheless, who differ widely on this subject from the learned metaphysician. Is it possible for a sensation to exist where there is no sentient? The authors to whom I allude think it impossible." And so, we may tell this learned author, does Dr. Reid, if he will take his word for it. Of the sensation of smell he remarks, "It

Smelling.

is indeed impossible, that it can be in any body; it is a sensation, and a sensation can be in a sentient thing only."[1] Again, "I can think of the smell of a rose when I do not smell it; and it is possible that when I think of it, there is no rose any where existing; but, when I smell it, I am necessarily determined to believe that the sensation really exists. This is common to all sensations, that, as they cannot exist but in being perceived, so they cannot be perceived but they must exist."[2] But, continues this acute metaphysician, "a smell is nothing else than a sensation. It is a feeling, which may be agreeable or disagreeable; which may, as some think, be excited by various combinations of elements; but which, since it is a feeling, cannot be those elements which are said to cause it, and cannot exist where there is no creature to perceive it. What is to be understood, in philosophical strictness, by the perfumes of the desert? We can excuse the poet when he makes the ocean smile,[3] the winds dance,[4] and the flowers respire;[5] or even were he to perfume the desert. But the philosopher is no such magician, and had better not wander through the regions of fancy in search of sensations where there is no sentient." And is it then true that the word smell means only a sensation? A sensation is no more than an effect; it is a transient modification of the mind, which the mind itself can never produce. It must then have some cause which is external to the mind. Now, it is to this cause, and not to the sensation, that the name smell is most frequently applied in all languages; and it is this cause which Dr. Reid supposes capable of existing in the deserts of Arabia, where there is no sentient being to perceive it. But let us hear himself. "We have considered smell as signifying a sensation, feeling, or impression upon the mind; and in this sense it can only be in a mind or sentient being; but it is evident that mankind give the name of smell much more frequently to something which they conceive to be external, and to be a quality of body; they understand by it something which does not at all infer a mind, and have not the least difficulty in conceiving the air perfumed with aromatic odours in the deserts of Arabia, or some uninhabited island where the human foot never trod."[6] "The faculty of smelling is something very different from the actual sensation of smelling; for the faculty may remain when we have no sensation. And the mind is no less different from the faculty, for it continues the same individual being when the faculty is lost. What is smell in the rose? It is a quality or virtue of the rose, or of something proceeding from it, which we perceive by the sense of smelling; and this is all we know of the matter. But what is smelling? It is an act of the mind, but is never imagined to be a quality of the mind. Again, the sensation of smelling is conceived to infer necessarily a mind or sentient being; but smell in the rose infers no such thing. We say, this body smells sweet, and that stinks; but we do not say, this mind smells sweet, and that stinks; therefore smell in the rose, and the sensation which it causes, are not conceived, even by the vulgar, to be things of the same kind, although they have the same name."[7]

There are some other remarks on Dr. Reid's opinion, in the work upon which we have been commenting, which we shall pass by; we may however notice the author's concluding argument. After mentioning some examples, he observes, "Now, in these instances, we see men and animals, that must have perception of smell, if I may be permitted to say so, altogether different from each other. Is not smell sensation when the spaniel finds sport in the field for his master; when the shark pursues through the ocean its expected victim; and when the camel conducts the thirsty wanderer to a fountain of fresh water, across the burning sands of the Arabian desert? If no animal had the sensation of smell, there would be no odour; for aroma and oils may be thought to be material compositions, but are neither agreeable nor disagreeable feelings." If men and animals differ in their perceptions of smell, and, no doubt, difference of organization will cause them to do so, the conclusion should not be, we think, that smell is merely sensation, but that there is actually something external which is the cause of their sensations, and about which they differ. A rose put to the nostrils of a man, and then to those of a dog, may excite very different sensations; but we cannot think that the peculiarity of the rose, which excites those different sensations, varies by thus changing the position of the rose. If at table one person mistakes mutton for beef, and another thinks that it is venison, the conclusion may be, that it is neither venison nor beef; but no man in his senses, can conclude that there is no meat at the table. But, "is not smell sensation when the spaniel finds sport in the field?" There is sensation no doubt; but we may be permitted to ask, what would become of the spaniel's sensation of smell and of his master's sport, were there no game in the field? What of the shark's sensation of smell and pursuit, were there no victim in the ocean? and what of the camel and the thirsty wanderer, were there no fountain of fresh water in the Arabian desert? "The smell of a rose signifies two things," says Dr. Reid; "first, a sensation which can have no existence but when it is perceived, and can only be in a sentient being or mind; secondly, it signifies some power, quality, or virtue in the rose, or in effluvia proceeding from it, which hath a permanent existence independent of the mind, and which, by the constitution of nature, produces the sensation in us. By the original constitution of our nature, we are both led to believe that there is a permanent cause of the sensation, and prompted to seek after it; and experience determines us to place it in the rose. The names of all smells, tastes, sounds, as well as heat and cold, have a like ambiguity in all languages; but it deserves our attention, that these names are but rarely, in common language, used to signify the sensations; for the most part, they signify the external qualities which are indicated by the sensations."[8] We have been induced thus to discuss this topic at some length, because we regretted to see Dr. Reid's opinion and reasoning misrepresented; and we shall now conclude, not as this modern Berkleian does, "that if no animal had the sensation of smell, there would be no odour," but, that if there were no odour or external cause of smell, no animal would have this sensation.

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SMELTING IRON by HOT-BLAST. Since the article on the MANUFACTURE OF IRON was published in the usual order of the progress of this work, certain changes have been introduced in the process of making iron, of so extensive and important a character, that we cannot consider them in any other light than as effecting an entire revolution in those branches of industry and of commerce connected with the manufacture and application of that most valuable of metals. The change has been comparatively unnoticed, extending itself during the last ten years, from the little spot in a remote part of this island whence it took its origin, and has now found its way over a great part of the old world, and been adopted extensively in the new. Wherever it has found its way, wealth and prosperity have attended it, poverty and sterility have fled before it; and there have been opened up vast stores of mineral wealth to assist in the advancement of civilization and industry, which our former impotence and want of skill had marked with the stigma of utter unproductiveness. It is therefore necessary that we give in this article, as supplementary to our former treatise, an account of the new process, now well known over the whole manufacturing world as the *hot-blast process* for smelting iron.

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[1] Reid's Inquiry, ch. ii. sect. 2.
[2] Reid's Inquiry, chap. ii. sect. 3.
[3] Milton.
[4] Cowley.
[5] Thomson.
[6] Inquiry, chap. ii. sect. 8
[7] Inquiry, chap. ii. sect. 9.
[8] Inquiry, ch. ii. sect. 9.

Smelting by hot-blast.

The hot-blast process was invented in Scotland by Mr. James Beaumont Neilson, a practical engineer at Glasgow, and was by him made the subject of a patent, dated September 1828, being entitled, an "improved application of air, to produce heat in fires, forges, and furnaces, where bellows and other blowing apparatus are required."

The invention of Mr. Neilson, like a great many other inventions, and indeed some of the most valuable, is characterized by extreme simplicity; and his invention so perfectly accords with all the known laws of physics, that we at once apply to it the well known exclamation of wonder, "how strange! that a thing so obvious should not have been done long before!" an exclamation in which we too often find ourselves doing an act of injustice to the very inventors to whom we lie under the weightiest obligations. Mr. Neilson's hot blast is as simple a contrivance as was the steam-engine condenser of his countryman, Mr. Watt, and indeed bears a very close analogy to its character as an invention. Before the time of Mr. Watt, steam was introduced into that part of the steam-engine where it performed its labour, and was then condensed into water in the same place where it had done its duty, thereby causing great waste of fuel and loss of power; and to remedy this defect, Watt introduced his new principle on which his fame rests; he used a *separate condenser*, that is, cooled the steam, and reconverted it into water, not in the cylinder, where it was detrimental, but in a separate vessel communicating with it. In like manner, Mr. Neilson's invention consists in separately heating that which was formerly done so as to be injurious to the process intended. Cold air was blown into a furnace designed to produce intense heat for the smelting of iron from ore, so that the cold blast of air itself required to be heated by the fuel in the furnace intended to smelt the iron, and so its temperature was cooled down by the very intensity of the blast required for the desired combustion. To remedy this defect, Mr. Neilson introduced his new principle of hot blast; and instead of allowing this blast of cold air to enter at once from the blowing machine or bellows into the furnace, to be heated there, he provided a *separate heating apparatus*, by which the air of the blast was to be heated by a separate furnace and fire, previously to its entrance into the smelting furnace. This is the whole invention. A hot blast of air, instead of a cold one, is thus introduced for the generation of heat. Could any thing be more simple, more natural, more appropriate, or more likely to prove effectual? This is the hot blast, which has already in this and other countries created many millions of valuable property out of what was formerly worthless, because unavailable by any of the processes formerly known.

Like most other inventions, the progress of this was at first very slow. Retarded by practical difficulties, which beset all new processes in their first use, by men who have every thing to learn,—stopped every now and then by the prejudices of custom and ignorance, which cling with inveterate tenacity to maxims of established practice, and repel equally the innovations which improve and those which merely alter without improvement,—opposed also by the change of interests which such a revolution must necessarily involve; the invention, tardy in its first steps, and feeble in its early efforts, was more than once at the point of being altogether abandoned. Like the invention of Watt, a great part of the interest in its possible remuneration was transferred by the inventor to strangers, whose combined efforts and influence it was necessary to obtain on the side of the innovation. To Mr. Dunlop of Clyde iron-works Mr. Neilson had to give up three-tenths of his patent rights; to Mr. Mackintosh three-tenths; and one-tenth to Mr. Wilson of Dundivan, retaining to himself only three-tenths of this valuable monopoly. But the transfer was judicious; it was necessary. Mr. Mackintosh is distinguished as a man of much practical science; Mr. Dunlop was one of the most sagacious iron-masters of his time; and Mr. Wilson was a man of tried practical talent. The co-operation of these gentlemen was essential to the speedy and successful trial of the novel though simple process.

Specification of the hot-blast patent.

The following is the specification of Mr. Neilson's patent: "I, James Beaumont Neilson, do hereby declare, that the nature of my said invention for the improved application of air to produce heat in fires, forges, and furnaces, where bellows or other blowing apparatus are required, and the manner in which the same is to be performed are particularly described and ascertained as follows: That is to say, a blast or current of air must be produced by bellows or other blowing apparatus in the ordinary way, to which mode of producing the blast or current of air this patent is not intended to extend. The blast or current of air so produced is to be passed *from the bellows or blowing apparatus into an air vessel or receptacle, made sufficiently strong to endure the blast, and through and from that vessel or receptacle, by means of a tube, pipe, or aperture into the fire, forge, or furnace.* The air vessel or receptacle must be air-tight, or nearly so, except the apertures for the admission and emission of the air; and at the commencement, and during the continuance of the blast, it must be kept *artificially heated to a considerable temperature.*

"It is better that the temperature be kept to a red heat, or nearly so; but so high a temperature is not absolutely necessary to produce a beneficial effect. The air-vessel or receptacle may be conveniently made of iron; but as the effect does not depend upon the nature of the material, other metals or convenient materials may be used. The size of the air vessel must depend upon the blast, and on the heat necessary to be produced. For an ordinary smith's fire or forge, an air vessel or receptacle, capable of containing 1200 cubic inches, will be of proper dimensions; and for a cupola of the usual size for cast-iron founders, an air-vessel capable of containing 10,000 cubic inches will be of a proper size. For fires, forges, or furnaces, upon a greater scale, such as blast-furnaces for smelting iron, and large cast-iron founders' cupolas, air-vessels of proportionably increased dimensions and numbers are to be employed. The form or shape of the vessel or receptacle is immaterial to the effect, and may be adapted to the local circumstances or situation. The air-vessel may generally be conveniently heated by a fire, distinct from the fire to be affected by the blast or current of air, and generally it will be better that the air-vessels and the fire by which it is heated should be inclosed in brick-work or masonry, through which the pipes or tubes connected with the air-vessel should pass. The manner of applying the heat to the air-vessel is, however, immaterial to the effect if it be kept at a proper temperature. In witness whereof, I, the said James Beaumont Neilson, have hereunto set my hand and seal, the 28th day of February, in the year of our Lord 1829."

Manner of using the hot-blast.

The only part of the process of smelting the iron which is at all affected by this novelty, is the transit of the air from the blowing machinery into the smelting furnace. The bellows, steam-engine, water-wheel, blowing cylinders, equalizing reservoirs, or other apparatus of whatever sort, for producing the current of air to blow the fire, are left unchanged, as we have already described and figured them in our article on IRON. The furnace may be left of its former shape and dimensions in every respect as used in the old process, and as we formerly described them; all that is required for the introduction of the new process, is to interpose between the smelting furnace and the blowing machinery an oven, heated by a separate fire, through which, in appropriately shaped vessels or pipes, the blast of air on its way to the furnace may be heated to a considerable temperature,—400°, 600°, or any temperature found most suitable to the purpose, and so blown upon the incandescent fuel in the furnace in a hot blast, as distinguished from the ordinary cold blast of atmospheric air.

The consequences of this hot blast system in an economic point of view, may be illustrated by the following experimental facts.

Advantages of the hot-blast system.

In a given furnace in Scotland, previous to the introduction of the new process, the following was the average result obtained:

20 tons of coal (coked),
with $3\frac{1}{2}$ tons of limestone,
smelted $4\frac{1}{2}$ tons of iron,
being $3\frac{1}{2}$ tons of fuel to each ton of iron.

In the same furnace, by the introduction of the new process, the result was as follows:

14 tons of coal (raw),
with $2\frac{1}{4}$ tons of lime,
smelted 8 tons of iron,
being $1\frac{3}{4}$ tons of fuel to each ton of iron.

Here, then, we see that, in the first place, one half of the fuel only is required; that coking, a very expensive process, is avoided, the coal being used raw, which was formerly impossible; and that only about one-third of the quantity of limestone is required to flux the iron, and all the cost of these materials, and all the labour employed in their transport, and in the process of melting, are clearly saved. But these were not the only benefits conferred on the iron-master. The same furnace, blowing apparatus, and establishment, that formerly produced fifty tons a-week, yielded under the hot blast more than double that quantity.

Peculiar advantage of the hot-blast in Scotland.

As it was in Scotland that these advantages were first obtained, so it is there that they are still possessed in the highest degree. Previously to the introduction of the hot blast, it had become an almost hopeless competition to produce iron there at so cheap a rate as the Welsh iron-masters could import it into Scotland. The hot blast at once turned the scale; and Scotland now transmits annually many thousand tons of iron to all the markets of England, and even into the very heart of the iron districts of the principality itself.

The cause of this difference between the advantage which Wales has derived from the hot-blast process, and that conferred on Scotland, is simply this: the coal fields of Wales are a rich, strong, and highly carbonaceous fuel, which loses not more than thirty to forty per cent. in the process of coking. The coal basin of Scotland in the iron district is, on the contrary, of a poor, earthy, light description, so as to lose from fifty to sixty per cent. in the process of coking, and giving, for every two tons of coal, not more, and frequently much less, than one ton of coked fuel fit for the cold-blast smelting-furnace. The expense and loss in the Scotish coal by this preparatory process of coking, was therefore excessive, when compared with the Welsh coal; and hence the adoption of this new plan, which did not require this preliminary process of coking, became a much greater boon to the Scotchman, in exact proportion to his former disadvantage.

Result in Staffordshire.

Great as these advantages have been found in Scotland, they have by no means been limited to the country of the inventor. In Staffordshire, in the wonderfully rich mineral basins of Dudley, and in Derbyshire, the invention was very early introduced, and most successfully practised. The following are the general results of the hot-blast system, as now practised in Staffordshire, in comparison with the old system:

By the cold blast,
8 tons of coal (coked),
with $1\frac{1}{10}$ ton of lime,
yielded 3 tons of iron,
being $2\frac{2}{3}$ tons of fuel to each ton of iron.
By the hot blast, in 1840,
$2\frac{1}{2}$ tons of coal (raw),
with $\frac{6}{10}$ths of a ton of limestone,
yield $2\frac{1}{2}$ tons of iron,
being 1 ton of fuel to each ton of iron.

Hot-blast admits the use of inferior materials.

The saving thus obtained in the article of fuel, is accompanied, it will be noticed, in every instance, with a corresponding saving in the limestone employed to flux the metal. But even here the whole amount of advantage does not meet the eye. It was formerly important to use the very best quality of coal that could be obtained,—light, bituminous, or earthy coal, being least fit for the purpose, and most unprofitable. Now, although it is still desirable to have a better rather than a worse fuel, the importance of this point is so greatly diminished, that almost all the inferior descriptions of poorer and more bituminous coal may be employed with economy and advantage. Limestone of the best quality was essential to the produce of good iron by the old method; by the new method, it is obvious, from inspection of the examples given, that the saving in limestone varies from a third to two-thirds of the quantity employed; but, in addition to this, it has become practicable to employ limestone of a very inferior quality, where better may be scarce, without sensible deterioration of the metal.

For the production of good iron, the hot-blast system has thus opened vast resources, which formerly could not be rendered available, in consequence of the inferior quality of some one of the raw materials which could be brought together in a given locality. In one place, abundant in excellent carbonate of lime and rich ore, it became impossible to realise the mineral wealth, on account of the inferior quality of the coal; while, in another, an abundant supply of good limestone, and of good coal, could not be used with advantage, from the poverty of the ore, which happened to be a clay stone, containing a small proportion of iron. Perhaps, also, a portion of sulphur mixed with the materials in such a quantity, as to ruin the iron. These all are counterbalanced by the hot blast, and every one of these impracticable cases is now exemplified in daily use.

But there is no sphere in which the hot blast has exerted a more beneficial influence in promoting the success of industry, and extending the resources of civilization, than in its application to those sterile districts of the mineral world, known as the region of the stone coal, blind coal, or anthracite formation. In the blind or stone coal strata, we have that most valuable of all combustibles, carbon, in a condition of high density and purity, amounting to as much as ninety or ninety-five per cent. of the stone coal, with a very small per centage of earthy or hydrogenous matter, yet so contracted, and, as it were, iron-bound, so hard and obdurate, that, instead of forming a good combustible, it seems to partake of the nature of that wonderful and brilliant substance, so hard of combustion as to have been reckoned one of the incombustibles until the glass of the accomplished analyst resolved the glittering brilliant into its primitive carbon. The anthracite seems, in fact, truly to deserve the name of the "black diamond," having been rendered, by its dense and close structure, nearly as incombustible. Although America, and many wide districts of Europe, abound with this rich carbon, it has failed to furnish, even in the hands of many accomplished chemists and mechanicians, an available fuel, either for the generation of steam, or for the ordinary wants of social life, and has resisted even the intense heat of the blast furnace. But even its consummate obstinacy has yielded to the power of the hot blast. In Wales, and in America, hot-blast iron of the very finest quality is now made from stone coal; and thus stores of the richest fuel which the world contains, appear only to have been reserved, by their wonderful obduracy, from the rapid destruction to which all other fuel has been so wastefully subjected, to supply the civilization and science of the nineteenth century with the means of rewarding and extending its astonishing discoveries. So kindly has Providence placed at the surface of the earth one mineral fuel to replace the forests which supplied the fires of our forefathers, and deposited another still richer, but more remote in the bowels of the earth, to await and to reward the industry and research of their children and our own. What geologist will henceforth call in question the abundance of that supply, which now seems to augment with the very means that are invented for increasing its consumption?

V e of th ot- bl in W h an- th te di ict,

The Welsh coal-field is perhaps the richest in the world. Rich with bitumen on one side, it gradually falls off by insensible gradations into a more purely carbonaceous, but still free-burning coal, and, passing through every intermediate gradation, is found at last in the state of a rich, resplendent refractory anthractous, or stony coal. This, mixed in the proportion of two to three, three to two, or half and half, smelts iron readily under the hot blast, and produces a rich powerful pig, possessing the qualities of a rich charcoal iron, and also capable of being converted into a most tenacious and malleable bar iron. In the anthracite district of Wales, new furnaces are rapidly rising into use; and Mr. Crane is distinguished by his extensive use of Mr. Neilson's hot-blast in that application of it.

ar in the ar racite di ict of A erica.

But it is probably in America that the hot-blast system will most extensively contribute to the development of mineral wealth. The anthracite is there the staple of fuel. It covers a vast extent of country, and constitutes the only substitute with which our transatlantic brethren can replace those forests that are so rapidly receding before the advances of civilization. Here the hot-blast is most successfully employed.

D ription of he hot- bl appa- ra .

We have thus given our readers the general specification of the hot-blast improvement; a specification so general as to include all possible forms of apparatus, applicable, not only to the smelting of iron, but to all cases of manufacture in which a blast is employed to produce heat, and which touches only the process of heating the air, without regard either to the mode of producing the blast, the mode of applying the blast, or the means of heating air; and the patent only provides for the carrying into effect the process of heating the air, that the blast shall be passed through a heated vessel or receptacle of any form or dimensions, such as a cast or malleable iron retort, kept to a dull red heat of some 1000° of temperature as the most desirable. It will readily be imagined that this apparatus, described in terms of so great generality, would assume various forms, according to the different views which the various practical men employed to construct the apparatus took of the most effective mode of heating the air. This is accordingly what occurred with the progress of time, and the increasing experience of those who used the apparatus; practical difficulties gradually diminished with the increased experience which was every day suggesting new and better expedients. It was also soon found that the advantage gained was increased in a rapid proportion with the degree of heat communicated to the air, so that the apparatus which gave at first some 300° of temperature to the air, and produced one measure of benefit, was soon superseded by a second form of apparatus giving 400°, and conferring still higher advantages; and this in its turn gave way to another and another, each giving a higher temperature to the air, and promising a higher degree of economy to the user. And thus at last a temperature between 600° and 700° was given to the air; a temperature higher than that of melting lead, which is indeed the criterion now generally applied to test the working heat of the blast.

P ess of im ve- me exhi bit in the Bu rly iro vorks.

We shall probably give our readers the clearest views of these general improvements, and of the progress which has generally taken place in carrying them into effect, by taking a single example. For this purpose we have selected the various modes of heating the air that have necessarily suggested themselves to, or been put in practice by the ingenious proprietors of the Butterly iron-works in Derbyshire, who were the first to introduce the hot-blast into that part of the country, and who have been among the most successful in carrying it into effect, and producing one of the most superior qualities of hot-blast iron.

Plate CCCCLXII. fig. 1, shows the construction of the earliest and simplest plan by which the inventors of hot-blast first brought it into use. An iron vessel *hhh* was formed of malleable plates, rivetted together like a common steam-boiler, something near three feet in diameter, and eight or ten feet long, cylindrical, and fitted at the ends to two pipes B*b*, communicating with the bellows, and S*s* with the smelting furnace. Below this large pipe or tube a fire is placed, which is fed from the door D, and the whole is enclosed in an oven of brickwork OOOO, leaving a clear space all round the pipe *hhh*, so that the flame and hot air rising up and enveloping the receptacle, should keep it so hot as to communicate through the sides of the vessel a higher temperature to the air rushing through it, on its way from the bellows, B, towards the smelting furnace S. And in order to communicate this temperature more uniformly and completely to all the air passing through the vessel *hhh*, lunular partitions *ppp* proceeding alternately from opposite sides of the tube on its interior surface, cause the stream of air to impinge first on one side, and then on the other side of the heated iron pipe, as shown in the figure. By this apparatus a moderate current of air has been heated to three or four hundred degrees.

First apparatus.

Fig. 2 shows the manner in which the method of heating the air was employed at first in the Butterly ironworks. In the oven O O are placed the two cast-iron retorts *hh*, about thirty-two inches in diameter, and nine feet long, being of metal an inch and an eighth part in thickness. They are laid parallel to each other; one of them is at one end connected with the pipe B *b* from the blowing apparatus, and this conducts the air from its other extremity through a curved junction pipe JJ, into the second receptacle *hh*; where, on its way becoming hot, it passes through the hot-air pipe S *s*, from the heating furnace or oven, and is blown by the orifice T through the twyre T into the hearth of the smelting furnace at F. In this, as is usual, more than one blast, as at T', was blown into the same smelting furnace. The fire *dd*, is placed at one corner of the oven on the bars *rr*, and is fed from the door D, and the smoke and flame rising up and surrounding h^1h^1, pass through a partition by the flue *f*, and fill the second compartment of the oven, clear spaces being left quite round the retorts on every side for the communication of the heat; only at the points *k* and *k*, they are supported by contact on the brick pillars *kk*. Finally, the products of combustion pass through a flue *f* into the short chimney C. In this way the cold air from the blast pipe B*b* passing into the vessel h^2 h^2, is partially heated, and is conducted into a second chamber, which, being placed immediately over the fire, is much more intensely hot, and from this second chamber at once discharged into the smelting furnace.

Its effects.

This apparatus was first tried in November 1830. The air was only heated to 240°. Yet so admirable is the process, that it was attended with the following effect:

With cold blast there were previously used at Butterly,
$5\frac{1}{2}$ tons coal (coked),
to 1 ton of iron.
By the new apparatus there were required
only 3 tons coal (raw),
to 1 ton of iron.

So admirable an effect as this was not to be neglected on account of the practical difficulties attending it, which indeed only served as an inducement to further exertion; and in about a year after the following improved apparatus, with an increased number of tubular vessels, having increased dimensions of length, was successfully introduced.

Second apparatus.

Fig. 3. In the transverse section h^1 h^2 h^3, are three pipes of cast-iron $1\frac{1}{2}$ inch thick, being about 17 feet long, and about 22 inches in diameter. They are similarly denoted in the ground plan, and in the longitudinal section by the letters $h^1h^2h^3$. The cold air pipe from the blowing apparatus B, enters the heating oven at *b* and traverses the pipe h^1 h^1 to the opposite end of the furnace: here a

Smelting by hot-blast.

bent pipe $h^1 h^2$ conveys the air into a second longitudinal pipe $h^2 h^2$, by which the stream of air returns back to the end of the oven at which it entered, and is conducted by a second bent pipe $h^2 h^3$ into the third tubular vessel $h^3 h^3$ in which it is for the last time exposed to the heated metal, and passes off from the heating oven into the smelting furnace, by the hot air pipe S, whence, as formerly, it is discharged through the twyre into the hearth of the furnace. The fuel is placed through the door D upon the fire of the oven on the bars *r*, and by means of a number of small pigeon holes *ccc*, *ccc*, *ccc*, is spread over the whole length of the pipes with some measure of uniformity, whereas, if allowed to act directly on the retorts, it would irregularly and less effectually heat their surface. The manner of protecting the retorts from the direct action of the fire, is well shown in the transverse section: a brick arch *aaa* is thrown over the fire, and the flame is only permitted to ascend through the aforesaid openings *cc*, *cc*. It will be noticed that the retorts are every where clear of the building and of each other, that they are wholly enclosed by the oven O O O; and it will also be seen in the transverse section, and in the longitudinal section, that the products of combustion are carried off by a descending flue *ff*, regulated by a damper *e e*, into the short vertical chimney C. This damper is very useful in retarding the draught of air, so as to leave the products of combustion a longer time in contact with the heaters.

Its effects.

This apparatus is more effective and more durable than the last. It raised the heat of the air as high as 400° to 500°, being 200° higher than the former plan, as indeed we should expect from the greater number and length of the vessels, and the greater surface in contact with the air. The result, compared with the last, is as follows:

By the former plan with air at 240°,
3 tons of coal were required
to melt 1 ton of iron.
By the improved plan, with air at 400° to 500°,
$2\frac{13}{20}$ tons of coal were required
to melt 1 ton of iron.

The reader will not fail to be struck with the fact, that a much greater gain was obtained by the original ruder plan of using the air, when compared with the old system of hot-blast, than was afterwards got from the introduction of the improved apparatus over the former one. The higher temperature does not appear to have conferred an advantage at all proportionable to the increased temperature.

Third apparatus.

Fig. 4 is a very superior and durable heating apparatus, which continues in efficient use to the present time. Its form is well adapted to prevent all the evils of expansion and contraction; and it is our opinion that by multiplying the vessels, a more effective apparatus might be made than any now in use. Its form is very ingenious, and its functions may be easily learned by studying the figure, in which the letters describe the same parts with those of the previous figures. B is the pipe coming from the blowing apparatus to the heating furnace O O O O; S is the hot air pipe, proceeding from the heating oven to the smelting furnace; $h^1 h^1 h^1$ is a large retort into which the air is at first carried, and from the further end of which a malleable iron tube $i^1 i^1$, concentric with the retort, carries it back again to that end where it first entered, and through a bent pipe I I conducts it along by a second interior tube $i^2 i^2$ to the further end of the second heater $h^2 h^2 h^2$, along the hot surface of which it returns in the manner shown by the arrows to the base of the second retort: now, this second retort communicates at the base with a third $h^3 h^3$, and after traversing its heated surface to the end, is brought back by a tube concentric with the axis to the base of the retort. This process might be continued with great advantage, and make one of the best series of heating vessels. The fire is covered by arches *aaa*, with small apertures *ccc*, as in the former case, to prevent the vessels from being injured by the local action of the intense fires.

Smelt by h blast.

Its effec

This apparatus raised the temperature to between 500° and 600°, and produced a further saving in coals. By the former plan $2\frac{13}{20}$ tons of coal were required to smelt one ton of iron. By this improved apparatus, $2\frac{10}{20}$ tons of coal melted a ton of iron.

Fourth fifth ap paratus.

Figs. 5 and 6 are the general forms of apparatus now most extensively used. Fig. 5 is a form first given to the apparatus, we believe, by Mr. Dixon at Calder, and hence generally called the Calder pipes. Similar pipes were also early introduced at Gartsherrie, and at Wedensbury; and are very generally approved of from their extensive heating surface, although they are liable to the inconvenience of cracking, from unequal expansion. The form, as erected at Butterly, consists of two parallel horizontal pipes L L called technically "the lying pipes," one forming a communication immediately with the cold-blast pipe B, and the other with the hot-blast pipe S. Into sockets formed in the lying pipe, are inserted a series of smaller pipes springing up at right angles with the one lying pipe, and after forming an arch, returning down to the second lying pipe, being inserted in like manner into sockets in it. The air, therefore, on entering the first lying pipe, is forced through these transverse heating pipes, or "A pipes" as they are called from their figure, and thus exposed to the heat of a very extensive surface, is delivered into the hot-air pipe. Sometimes, as at Gartsherrie and many other works, there are several times as many pipes as in this example, and the air is made to cross and recross the fire several times.

The figures of the transverse pipes are as various as the taste of the parties who use them. Sometimes they rise up and form a large semicircular arch over the fire, which is placed in the centre; sometimes a double tier of such arches is employed. Sometimes they cross the fire in the form of a pointed arch variously acuminate. Then again by some, the pipes are carried up four, six, eight, or ten feet, like columns, united at the top by a semicircular arch.

The cross section of the heating pipe is as various as the form into which the pipe itself is made to bend. A circular pipe was used at first, then a flattened elliptical one for the purpose of exposing more surface in proportion to volume; next a pipe, flat at one part, and semicircular on the other, was introduced; next a pipe of a cardioïd or heart-like section was employed. At Butterly Mr. Terrop used a circular pipe cast with a solid core, to keep the air near the hot surface, as shown in the figure; and finally, he employed the rectangular section as shown in our figure 6th. All of these appear to answer their purpose of heating the air sufficiently well, and all of them cause trouble and expense by cracking now and then.

The result of all these forms is to produce a hot-blast of more than 600° temperature, and at Butterly, figs. 5 and 6 yield as follows: $2\frac{1}{3}$ tons of coal melt one ton of iron. It is found, however, at Butterly, that pigs, for the forge, require about three cwt. less of coal than this average quantity, and that No. 1 iron requires about three cwt. more than this, as we should expect.

The Scotch use less coal than the Butterly Company, principally on this account, that the former use calcined ore, of which thirty-two cwt. with seven cwt. of lime, makes a ton of iron, while at Butterly, the quantity used for a ton of iron is $2\frac{3}{4}$ tons, with a ton of lime, being $3\frac{3}{4}$ tons of materials in one case, and less than two tons in the other.

Ratio of the cess.

The explanation of the principles from which hot-blast derives its efficacy as the means of producing elevated temperature, is very easy and plain to any one acquainted with the elementary principles of chemistry and mechanics. All that we think it necessary to add on this subject, we shall state in the words of Mr. Babbage and Dr. Ure.

Mr. I bage's planat

> "The increased effect," says Babbage, "produced by thus heating the air is by no means an obvious result; and an analysis of its action will lead to some curious views repecting tbe future application of machinery for blowing furnaces.
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> "Every cubic foot of atmospheric air, driven into a furnace, con-

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sists of two gases;[1] about one-fifth being oxygen, and four-fifths azote. According to the present state of chemical knowledge, the oxygen alone is effective in producing heat; and the operation of blowing a furnace may be thus analyzed.

"1. The air is forced into the furnace in a condensed state, and, immediately expanding, abstracts heat from the surrounding bodies.

"2. Being itself of moderate temperature, it would, even without expansion, still require heat to raise it to the temperature of the hot substances to which it is to be applied.

"3. On coming into contact with the ignited substances in the furnace, the oxygen unites with them, parting at the same moment with a large portion of its latent heat, and forming compounds which have less specific heat than their separate constituents. Some of these pass up the chimney in a gaseous state, whilst others remain in the form of melted slags, floating on the surface of the iron, which is fused by the heat thus set at liberty.

"4. The effects of the azote are precisely similar to the first and second of those above described; it seems to form no combinations, and contributes nothing, in any stage, to augment the heat.

"The plan, therefore, of heating the air before driving it into the furnace, saves obviously the whole of that heat which the fuel must have supplied in raising it from the temperature of the external air up to that of 600° Fahrenheit; thus rendering the fire more intense, and the glassy slags more fusible, and perhaps also more effectually decomposing the iron ore. The same quantity of fuel, applied at once to the furnace, would only prolong the duration of its heat, not augment its intensity.

"The circumstance of so large a portion of the air[2] driven into furnaces being not merely useless, but acting really as a cooling, instead of a heating, cause, added to so great a waste of mechanical power in condensing it, amounting, in fact, to four-fifths of the whole, clearly shews the defects of the present method, and the want of some better mode of exciting combustion on a large scale."

The reader will find it interesting to compare this account with the following by Dr. Ure.

Dr. res'
exp -
tion

"Wherever a forced stream of air is employed for combustion, the resulting temperature must evidently be impaired by the coldness of the air injected upon the fuel. The heat developed in combustion is distributed into three portions; one is communicated to the remaining fuel, another is communicated to the azote of the atmosphere, and to the volatile products of combustion, and a third to the iron and fluxes, or other surrounding matter to be afterwards dissipated by wider diffusion. This inevitable distribution takes place in such a way, that there is a nearly equal temperature over the whole extent of a fire-place, in which an equal degree of combustion exists.

"We thus perceive that if the air and the coal be very cold, the portions of heat absorbed by them might be very considerable, and sufficient to prevent the resulting temperature from rising to a proper pitch; but if they were very hot they would absorb less caloric, and would leave more to elevate the common temperature. Let us suppose two furnaces charged with burning fuel, into one of which cold air is blown, and into the other hot air, in the same quantity. In the same time, nearly equal quantities of fuel will be consumed with a nearly equal production of heat; but notwithstanding of this, there will not be the same degree of heat in the two furnaces, for the one which receives the hot air will be hotter by all the excess of heat in its air above that of the other, since the former air adds to the heat while the latter abstracts from it. Nor are we to imagine that by injecting a little more cold air into the one furnace, we can raise its temperature to that of the other. With more air indeed we should burn more coals in the same time, and we should produce a greater quantity of heat, but this heat being diffused proportionally among more considerable masses of matter, would not produce a greater temperature; we should have a larger space heated, but not a greater intensity of heat in the same space.

"Thus, according to the physical principles of the production and distribution of heat, fires fed with hot air should, with the same fuel, rise to a higher pitch of temperature than fires fed with common cold air. This consequence is independent of the masses, being as true for a small stove which burns only an ounce of charcoal in a minute, as for a furnace which burns a hundred weight; but the excess of temperature produced by hot air cannot be the same in small fires as in great; because the waste of heat is usually less the more fuel is burned.

Smelting by hot-blast.

"This principle may be rendered still more evident by a numerical illustration. Let us take, for example, a blast furnace, into which 600 cubic feet of air are blown per minute; suppose it to contain no ore but merely coal or coke, and that it has been burning long enough to have arrived at the equilibrium of temperature, and let us see what excess of temperature it would have if blown with air of 300° C. (572° F.) instead of being blown with air at 0° C.

"Six hundred cubic feet of air under the mean temperature and pressure, weigh a little more than 45 pounds avoirdupoise; they contain 10·4 pounds of oxygen, which would burn very nearly 4 pounds of carbon, and disengage 16,000 times as much heat as would raise by one degree cent. the temperature of two pounds of water. These 16,000 portions of heat, produced every minute, will replace 16,000 other portions of heat, dissipated by the sides of the furnace and employed in heating the gases, which escape from its mouth. This must take place in order to establish the assumed equilibrium of caloric.

"If the 45 pounds of air be heated beforehand up to 300° C., they will contain about the eighth part of the heat of the 16,000 disengaged by the combustion, and there will be therefore in the same space one-eighth of heat more, which will be ready to operate upon any bodies within its range, and to heat them one-eighth more. Thus the blast of 300° C. gives a temperature which is nine-eighths of the blast at zero C., or at even the ordinary atmospheric temperature; and as we may reckon at from 2200° to 2700° F. (from 1200° to 1500° C.) the temperature of blast furnaces worked in the common way, we perceive that the hot-air blast produces an increase of temperature equal to from 270° to 360° F.

"Now in order to appreciate the immense effects which this excess of temperature may produce in metallurgic operations, we must consider that often only a few degrees more temperature are required to modify the state of a fusible body, or to determine the play of affinities dormant at lower degrees of heat. Water is solid at 1° under 32° F.; it is liquid at 1° above. Every fusible body has a determinate melting point, a very few degrees above which it is quite fluid, though it may be pasty below it. The same observation applies to ordinary chemical affinities; charcoal, for example, which reduces the greater part of metallic oxides, begins to do so only at a determinate pitch of temperature, under which it is inoperative, but a few degrees above, it is in general lively and complete. It is unnecessary, in this article, to enter into any more details to show the influence of a few degrees of heat, more or less, in a furnace, upon chemical operations, or merely upon physical changes of state.

"These consequences might have been deduced long ago, and industry might thus have been enriched with a new application of science; but philosophers have been and still are too much estranged from the study of the useful arts, and content themselves too much with the minutiæ of the laboratory or theoretic abstractions. Within the space of seven years, the use of the hot-blast has been so much extended in Great Britain, as to have enabled many proprietors of iron-works to add 50 per cent. to their weekly production of metal, to diminish the weekly expenses of smelting by 50 per cent., and, in many cases, to produce a better sort of cast-iron from indifferent materials."

The following table is from a report of M. Dufresnoy, made to the director-general of mines in France in 1834.

Cost of iron by hot-blast.

Cost price of a ton of pig-iron at the Clyde Iron-Works.

Materials used.	In 1829, with cold air.					In 1833, with hot air.				
	ton.	cwt.	*L.*	*s.*	*d.*	ton.	cwt.	*L.*	*s.*	*d.*
Coal for fusion, at 5s. per ton,........	6	13	1	13	3	2	0	0	10	0
— for blowing machine, at 1s. 8d. per ton,.........	2	0	0	3	6	0	11	0	0	11
— for the heating apparatus,.........	...		...			0	8	0	0	8
Calcined ore, at 12s. per ton,[3]............	1	15	1	1	0	1	18	1	2	9
Limestone, at 7s.......		10	0	3	6	...		0	3	6
Labour, at 10s..........	...		0	10	0	...		0	10	0
General charges, interests of capital, 6s.	...		0	6	0	...		0	6	0
Total......			L.3	17	3			L.2	13	10

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[1] The accurate proportions are, by measure, oxygen 21, azote 79.

[2] A similar reasoning may be applied to lamps. An argand burner, whether used for consuming oil or gas, admits almost an unlimited quantity of air. It would deserve inquiry, whether a smaller quantity might not produce greater light; and, possibly, a different supply furnish more heat with the same expenditure of fuel.

[3] This mineral is very rich: the average produce of the iron mines of the Glasgow coal basin is 44 per cent. after calcination; in this state it costs from 8s. 6d. to 9s. per ton. The cost of the mineral will, therefore, be very nearly as stated in the table.

Smelting by hot-blast.

Since that period the cost has been rendered much lower, and those who have made good arrangements for mineral property, can manufacture iron at a cost of little more than L.2 per. ton.

Chemical constitution of hot-blast iron.

At the request of the British Association, Dr. Thomson of Glasgow examined the chemical constitution of hot-blast iron, and he gives the following as the result of his inquiry:

"(1.) The specific gravity of hot-blast iron is greater than that of cold-blast.

"The following are the specific gravities of eight specimens of cold blast iron:

1st. Muirkirk	6·410
2nd. Ditto	6·435
3rd. Ditto	6·493
4th. Ditto	6·579
5th. Ditto	6·775
6th. From pyrites	6·9444
7th. From Carron	6·9888
8th. Clyde Iron Works	7·0028

"The specific gravity of the Muirkirk iron is considerably less than of that smelted at Carron and the Clyde Iron-Works; the mean of the eight specimens is 6·7034.

"It has been hitherto supposed that the difference between cast-iron and malleable iron consists in the presence of carbon in the former, and its absence from the latter; in other words, that cast iron is a carburet of iron. But in all the specimens of cast iron which we analysed we constantly found several other ingredients besides iron and carbon. Manganese is pretty generally present in minute quantity, though in one specimen it amounted to no less a quantity than 7 per cent.; its average amount is 2 per cent. *Silicon* is never wanting, though its amount is exceedingly variable, the average quantity is about 1⅕ per cent.; some specimens contained 3⅕ per cent. of it, while others contain less than a half per cent. Aluminum is very rarely altogether absent, though its amount is more variable than that of silicon. Its average amount is 2 per cent.; sometimes it exceeds 4½ per cent., and sometimes it is not quite $\frac{1}{5000}$th part of the weight of the iron.

"Calcium and magnesium are sometimes present, but very rarely, and the quantity does not much exceed ⅕th per cent. In a specimen of cast iron which I got from Mr. Neilson, and which he had smelted from pyrites, there was a trace of copper, showing that the pyrites employed was not quite free from copper; and in a specimen from the Clyde Iron-Works there was a trace of sulphur. The following table exhibits the composition of six different specimens of cast iron, No. 1, analyzed in my laboratory, either by myself or by Mr. John Tennent.

	Muirkirk.	Muirkirk.	Muirkirk.	Pyrites.	Carron.	Clyde.	Mean.
Iron,	90·98	90·29	91·38	89·442	94·010	90·824	91·154
Copper,	...	...	...	0·288	...	...	
Manganese,	...	7.14	2·00	...	0·626	2·458	2·037
Sulphur,	...	...	...	...	...	0·045	
Carbon,	7·40	1·706	4·88	3·600	3·086	2·458	3·855
Silica,	0·46	0·830	1·10	3·220	1·006	0·450	1·177
Aluminum,	0·48	0·016	...	3·776	1·032	4·602	1·651
Calcium,	...	0·018	0·20	...	...	...	
Magnesium,	...	...	...	...	...	0·340	

"The constant constituents of cold-blast cast-iron, No. 1, are iron, manganese, carbon, silicon, and aluminum. The occasional constituents are copper, sulphur, calcium, and magnesium. These occur so rarely, and in such minute quantity, that we may overlook them altogether.

"The constant constituents occur in the following mean atomic proportions:

22	atoms iron,	= 77·00
½	atom manganese,	= 1·75
4·36	atoms carbon,	= 3·27
1	atom silicon,	= 1·00
1⅛	aluminum,	= 1·40—84·42

"2. I examined only one specimen of cast-iron, No. 2. It was an old specimen, said to have come from Sweden, but I have no evidence of the correctness of this statement. Its specific gravity was 7·1633 higher than any specimens of cold-blast iron, No. 1. Its constituents were,

Iron,	93·594
Manganese,	0·708
Carbon,	3·080
Silicon,	1·262
Aluminum,	0·732
Sulphur,	0·038—99·414

"The presence of sulphur in this specimen leads to the suspicion that it is not a Swedish specimen; for as the Swedish ore is magnetic iron, and the fuel charcoal, the presence of sulphur in the iron is very unlikely.[1]

"In this specimen, the atoms of iron and manganese are to those of carbon, silicon, and aluminum, in the proportion of 4½ to one, instead of 3½ to one, as in cast-iron No. 1.

"The atoms of carbon, silicon, and aluminum, approach the proportions of 7, 2, and 1, so that in cast-iron, No, 2, judging from one specimen, there is a greater proportion of carbon, compared with the silicon and aluminum, than in cast-iron, No. 1.

"Mr. Tennent analyzed a specimen of hot blast-iron, No. 2, from Gartsherry. Its specific gravity was 6·9156, and its constituents,

		Atoms.	
Iron,	90·542	25·86	3·72
Manganese,	2·764	0·78	
Carbon,	3·094	4·05	1·
Silicon,	0·680	0·68	
Aluminum,	2·894	2·31	
Sulphur,	0·023	0·011	
	99·997		

So that it resembles cast-iron, No. 1, in the proportion of its constituents. The carbon is almost the same as in cold-blast iron, No, 2, but the proportion of aluminum is four times as great, while the silicon is little more than half as much. The atomic ratios are, carbon, 4·; silicon, 0·67; aluminum, 2·28.

"3. Five specimens of hot-blast cast iron, No. 1, were analyzed. Two of these were from Carron, and three from the Clyde Iron-Works, where the hot-blast originally began; and where, of course, it has been longest in use. The specific gravity of these specimens was found to be as follows:

1st. From Clyde Works	7·0028
2d. From Carron,	7·0721
3d. From Carron,	7·0721
4th. From Clyde Works,	7·1022
Mean,	7·0623

"It appears from this, that the hot-blast increases the specific gravity of cast-iron by about $\frac{1}{22}$nd part. It approaches nearer the specific gravity of cast iron No. 2, smelted by cold air, than to that of No. 1.

"The following table exhibits the constituents of these four specimens.

	Clyde.	Carron.	Carron.	Clyde.	Clyde.
Iron,	97·096	95·422	96·09	94·966	94·345
Manganese,	0·332	0·336	0·41	0·160	3·120
Carbon,	2·460	2·400	2·48	1·560	1·416
Silicon,	0·280	1·820	1·49	1·322	0·520
Aluminum,	0·385	0·488	0·26	1·374	0·599
Magnesium,	...	...	...	0·792	...
	100·55	100·466	100·73	100·174	100·

The mean of these analyses gives us,

		Atoms.	
Iron,	95·584 or	27·31	6·5
Manganese,	0·871 or	0·249	
Carbon,	2·099 or	2·79	1·
Silicon,	1·086 or	1·086	
Aluminum,	0·422 or	0·337	
	101·285		

Or, in the proportion of 6½ atoms of iron and manganese to 1 atom of carbon, silicon, and aluminum. In the cold-blast cast-iron we have,

	Iron.	Carbon. &c.
In No. 1,	3½ atoms	1 atom.
In No. 2,	4½	1 —
In hot-blast,	6½	1 —

"Thus it appears, that when iron is smelted by the hot-blast its specific gravity is increased, and it contains a greater proportion of iron, and a smaller proportion of carbon, silicon, and aluminum, than when smelted by the cold-blast.

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[1] I have been told by Mr. Mushet that the Swedes add sulphur to their iron No. 2.

At the request of the British Association, Mr. Eaton Hodgkinson examined the mechanical properties of hot and cold-blast iron. The following are his general results.

Carron Iron, No. 2.

	Cold-Blast.	Hot-Blast.	Ratio representing Cold Blast by 1000.
Tensile strength in lbs. per square inch..............	16683 (2)	13505 (3)	1000 : 809
Compressive ditto in lbs. per inch from castings torn asunder....	106375 (3)	108540 (2)	1000 : 1020
Do. from prisms of various forms	100631 (4)	100738 (2)	1000 : 1001 Mean 997
Do. from cylinders	125403 (13)	121685 (13)	1000 : 970
Transverse strength from all the experiments	.... (11)	.... (13)	1000 : 991
Power to resist impact	.... (9)	.... (9)	1000 : 1005
Transverse strength of bars one inch square in ibs............	476 (3)	463 (3)	1000 : 973
Ultimate deflection of do. in in.	1·313 (3)	1·337 (3)	1000 : 1018
Modulus of elasticity in lbs. per square inch.....	17270500 (2)	16085000 (2)	1000 : 931
Specific gravity......	7066	7046	1000 : 997

Devon Iron, No. 3.

	Cold-Blast.	Hot-Blast.	Ratio representing Cold Blast by 1000.
Tensile strength.....	....	21907 (1)	
Compressive ditto	....	145435 (4)	
Transverse ditto from the experiments generally	.... (5)	.... (5)	1000 : 1417
Power to resist impact	.... (4)	.... (4)	1000 : 2786
Transverse strength of bars one inch square	448 (2)	537 (2)	1000 : 1199
Ultimate deflection ditto........	·79 (2)	1·09 (2)	1000 : 1380
Modulus of elasticity ditto.......	22907700 (2)	22473650 (2)	1000 : 981
Specific gravity......	7295 (4)	7229 (2)	1000 : 991

Buffery Iron, No. 1.

	Cold-Blast.	Hot-Blast.	Ratio representing Cold Blast by 1000.
Tensile strength......	17466 (1)	13434 (1)	1000 : 769
Compressive ditto...	93366 (4)	86397 (4)	1000 : 925
Transverse ditto....	.... (5)	.... (5)	1000 : 931
Power to resist impact	.... (2)	.... (2)	1000 : 963
Transverse strength of bars one inch square	463 (3)	436 (3)	1000 : 942
Ultimate deflection do..........	1·55 (3)	1·64 (3)	1000 : 1058
Modulus of elasticity ditto......	15381200 (2)	13730500 (2)	1000 : 893
Specific gravity......	7079	6998	1000 : 989

Coed-Talon Iron, No. 2.

	Cold-Blast.	Hot-Blast.	Ratio representing Cold Blast by 1000.
Tensile strength.....	18855 (2)	16676 (2)	1000 : 884
Compressive ditto...	81770 (4)	82739 (4)	1000 : 1012
Specific gravity.....	6955 (4)	6968 (3)	1000 : 1002

Carron Iron, No. 3.

	Cold-Blast.	Hot-Blast.	Ratio representing Cold Blast by 1000.
Tensile strength	14200 (2)	17755 (2)	1000 : 1250
Compressive ditto...	115442 (4)	133440 (3)	1000 : 1156
Specific gravity......	7135 (1)	7056 (1)	1000 : 989

"Of the three columns of numbers in the table above, the first is the strength or other quality in the cold-blast iron; the second is that in the hot-blast; and the third is the ratio of these quantities.

"The results in this table contain nearly the whole information relative to the question of hot and cold-blast-iron that the preceding research affords; and before adverting to them, it may be mentioned, that it is usual for the makers of cast-iron to divide it, when taken from the furnace, into three classes, called Nos. 1, 2, 3, differing from each other in the appearance and qualities of the material. No. 1 contains the softest and richest irons, those which have the largest crystals; No. 3, the hardest and densest irons, those with the least crystals; and No. 2, irons intermediate between the former two descriptions. Beginning with the No. 1 iron, of which we have a specimen from the Buffery Iron-Works, a few miles from Birmingham, we find the cold-blast iron somewhat surpassing the hot-blast in all the following particulars; direct tensile strength, compressive strength, transverse strength, power to resist impact, modulus of elasticity or stiffness, specific gravity; whilst the only numerical advantage possessed by the hot-blast iron is, that it bends a little more than the cold-blast before it breaks.

"In the irons of the quality No. 2, the case seems in some degree different; in these the advantages of the rival kinds seem to be more nearly balanced. They are still, however, rather in favour of the cold blast.

"Referring to the No. 2 iron, from the Carron Works in Scotland, we find the tensile, compressive, and transverse strengths, together with the modulus of elasticity and specific gravity, all higher in the cold-blast iron than the hot-blast, whilst the ultimate deflection and power of sustaining impact are greater in the hot-blast. The cold-blast iron is the better, but the difference is very small.

"In the iron No. 2, from the Coed-Talon Works in North Wales, the tensile strength is greater in the cold-blast than in the hot; but the resistance to compression is higher in the latter than the former, and that is the case with the specific gravity.

"So far as my experiments have proceeded, the irons of No. 1 have been deteriorated by the hot-blast; those of No. 2 appear also to have been slightly injured by it; while the irons of No. 3 seem to have benefited by its mollifying powers. The Carron iron No. 3, hot-blast, resists both tension and compression with considerably more energy than that made with the cold-blast; and the No. 3 hot-blast iron from the Devon Works, in Scotland, is one of the strongest cast-irons I have seen, whilst that made with the cold-blast is comparatively weak, though its specific gravity is very high, and higher than in the hot. The extreme hardness of the cold-blast Devon iron above prevented many experiments that would otherwise have been made upon it, no tools being hard enough to form the specimens. The difference of strength in the Devon irons is peculiarly striking.

"From the evidence here brought forward, it is rendered exceedingly probable that the introduction of a heated blast into the manufacture of cast-iron has injured the softer irons, whilst it has frequently mollified and improved those of a harder nature; and considering the small deterioration that the irons of the quality No. 2 have sustained, and the apparent benefit to those of No. 3, together with the great saving effected by the heated blast, there seems good reason for the process becoming as general as it has done." (C. A.)

SMITH, Sir Thomas, was born at Walden in Essex, in the year 1512. At fourteen he was sent to Queen's College, Cambridge, where he distinguished himself so much, that he was made Henry the Eighth's scholar, together with John Cheke. He was chosen a fellow of his college in 1531, and appointed two years afterwards to read the public Greek lecture. The common mode of reading Greek at that time was very faulty, the same sound being given to the letters and diphthongs, ι, η, υ, ει, οι, υι. Smith and Cheke had been for some time sensible that this pronunciation was wrong; and after a good deal of consultation and research, they agreed to introduce that mode of reading which prevails at present. Smith was lecturing on Aristotle *De*

Republica, in Greek. At first he dropped a word or two at intervals in the new pronunciation, and sometimes he would stop as if he had committed a mistake, and correct himself. No notice was taken of this for two or three days; but as he repeated it more frequently, his audience began to wonder at the unusual sounds, and at last some of his friends mentioned to him what they had remarked. He owned that something was in agitation, but that it was not yet sufficiently digested to be made public. They entreated him earnestly to discover his project, He did so, and in a short time great numbers resorted to him for information. The new pronunciation was adopted with enthusiasm, and soon became universal at Cambridge. It was afterwards opposed by Bishop Gardiner the chancellor; but its superiority to the old mode was so visible, that in a few years it spread over all England.

In 1539 he travelled into foreign countries, and studied for some time in the universities of France and Italy. At Padua he took the degree of LL.D. On his return, he was admitted *ad eundem* at Cambridge, and was appointed regius professor of the civil law. He was useful in promoting the reformation of religion as well as of learning. Having gone into the family of the duke of Somerset the protector, during the minority of Edward the Sixth, he was employed by that nobleman in public affairs; and in 1548 he was made secretary of state, and received the honour of knighthood. While Somerset continued in office, he was sent as ambassador, first to Brussels, and afterwards to France. Upon the accession of Mary, he lost all his places, but was fortunate enough to preserve the friendship of Gardiner and Bonner. He was exempted from persecution, and was allowed, probably by their influence, a pension of L.100. During Elizabeth's reign he was employed in public affairs, and was thrice sent to France in the capacity of an ambassador. He died in the year 1577.

Sir Thomas Smith was a man of excellent talents, united with solid and variegated learning. He obtained a respectable place among the scholars of the age, by the publication of his epistle to the bishop of Winchester, "De recta et emendata Linguae Graecae Pronuntiatione." Lutetiae, 1568, 4to. The same volume includes his dialogue, "De recta et emendata Linguae Anglicanae Scriptione." But the work by which he is best known in modern times, is entitled "*De Republiea Anglorum:* the Maner of Gouernment or Policie of the Realme of England." Lond. 1583, 4to. Of this treatise, which was translated into Latin, there are many editions.

SMITH, EDMUND, an English poet, the only son of Mr. Neale, an eminent merchant, by a daughter of Baron Lechmere, was born in 1668. By his father's death, he was left young to the care of Mr. Smith, who had married his father's sister, and who treated him with so much tenderness, that at the death of his generous guardian, he assumed his name. His writings are not many, and these are scattered in miscellanies and collections. His celebrated tragedy of Phædra and Hippolytus was acted in 1707; and being introduced at a time when the Italian opera so much engrossed the attention of the polite world, gave Mr. Addison, who wrote the prologue, an opportunity to rally the vitiated taste of the public. Notwithstanding the esteem in which it has always been held, it is perhaps rather to be considered as a fine poem than as a good play. This tragedy, with a poem to the memory of Mr. John Philips, three or four odes, with a Latin oration spoken at Oxford, *In laudem Thomæ Bodleii*, were published as his works by his friend Mr. Oldisworth. Mr. Smith died in 1710.

SMITH, ADAM, was born at Kirkcaldy, on the 5th of June 1723. His father, who held the situation of comptroller of customs in that town, died a few months before his birth; so that the charge of his early education devolved wholly on his mother, the daughter of Mr. Douglas of Strathenry, in the county of Fife. His constitution during infancy is said to have been extremely infirm and delicate, and required all the anxious attention of his mother, who treated him with the greatest indulgence. This did not, however, produce any unfavourable effect on his temper or dispositions; and he repaid the fond solicitude of his parent by every attention that filial gratitude and affection could dictate, during the long period of sixty years. When only three years of age, he was stolen from Strathenry, to which place he had been carried by his mother, by a party of gipsys. Fortunately, however, for the best interests of mankind, he was speedily recovered by the exertions of his uncle.

He received the first rudiments of his education in the grammar school of Kirkcaldy. The weakness of his constitution prevented him from indulging in the amusements common to boys of his age. But Mr. Stewart states, that he was even then distinguished by his passion for books, and by the extraordinary powers of his memory; that he was much beloved by his school-fellows, many of whom subsequently attained to great eminence, for his friendly and generous disposition; and that even then he was remarkable for those habits which remained with him through life, of speaking to himself when alone, and of mental absence in company. He continued at Kirkcaldy until 1737, when he was sent to the University of Glasgow, where he remained for three years. He then entered Balliol College, Oxford, as an exhibitor on Snell's foundation; and he continued for seven years to prosecute his studies at that celebrated seminary.

Mr. Stewart mentions, on the authority of Dr. Maclaine of the Hague, that mathematics and natural philosophy formed young Smith's favourite pursuits while at Glasgow. But subsequently to his removal to Oxford he seems to have entirely abandoned them, and to have principally devoted the time not consumed in the routine duty of the University to the study of polite literature, and of those moral and political sciences of which he was destined afterwards to become so great a master. Smith does not seem to have felt any very peculiar respect for his English *alma mater*. The severe remarks in the *Wealth of Nations* on the system of education followed in Oxford and Cambridge, had evidently been suggested by his own observation.

While he resided at Oxford, something had occurred to excite the suspicions of his superiors with respect to the nature of his private pursuits; and the heads of his college, having entered his apartment without his being aware, unluckily found him engaged reading Hume's *Treatise of Human Nature*. The objectionable work was, of course, seized; the young philosopher being at the same time severely reprimanded.

Subsequently to his return from Oxford in 1747, he continued to reside for nearly two years at Kirkcaldy with his mother. He had been sent to Oxford that he might be qualified for entering the church of England. The ecclesiastical profession was not, however, agreeable to his taste; and in opposition to the advice of his friends, he returned to Scotland, resolved to devote himself exclusively to literary pursuits. In the latter part of the year 1748, he fixed his residence in Edinburgh, where, in consequence of the encouragement and persuasion of Lord Kames, and some of his other friends, he was prevailed upon to deliver, during that and the two following years, a course of lectures on rhetoric and polite literature. The lectures were attended by a respectable auditory, composed chiefly of students of law and theology; and he had the honour to reckon among his pupils Mr. Wedderburne, afterwards Lord Loughborough, Mr. William Johnstone, afterwards Sir William Pulteney, and Dr. Blair; with all of whom he subsequently continued on the most intimate terms. It was also at this period that he laid the foundation of that friendship with David Hume, which lasted, without the slightest interruption, till the death of the latter.

No part of these lectures was ever published; but it would appear from the statement of Dr. Blair, who commenced his course of Lectures on rhetoric in 1758, ten years after Dr. Smith's first course, that they had been reduced into a systematic form. In a note to his eighteenth lecture, Dr. Blair mentions that he had borrowed several of the ideas respecting the general characters of style, particularly the plain and simple, and the characters of those English authors who are classed under them, from a manuscript treatise of Dr. Smith on Rhetoric, of which the author had shewn him a part.

In consequence of his increasing celebrity, Dr. Smith was elected, in 1751, professor of logic in the University of Glasgow; and the year following he was elevated to the chair of moral philosophy in the same University, vacant by the death of Mr. Craigie, the immediate successor of the celebrated Dr. Hutcheson, under whom Dr. Smith had formerly studied. He continued to hold this situation for thirteen years; and, as the studies and inquiries in which his academical duties daily engaged him, were the most agreeable to his taste, it is not surprising that he should have considered the period of his residence at Glasgow as the happiest portion of his life. At the same time, it seems reasonable to conclude that his professional pursuits must have had a great effect in maturing his speculations in morals and politics, and, consequently, in determining him to undertake those great works which have immortalized his name, and largely benefited the whole human race.

Mr. Millar, the distinguished author of the *Historical View of the English Government*, and professor of law in the University of Glasgow, had the advantage of hearing Dr. Smith's course of lectures on moral philosophy; of which he has given the following account: "There was no situation in which the abilities of Dr. Smith appeared to greater advantage than as a professor. In delivering his lectures, he trusted almost entirely to extemporary elocution. His manner, though not graceful, was plain and unaffected; and, as he seemed to be always interested in the subject, he never failed to interest his hearers. Each discourse consisted commonly of several distinct propositions, which he successively endeavoured to prove and illustrate. These propositions, when announced in general terms, had, from their extent, not unfrequently something of the air of a paradox. In his attempts to explain them, he often appeared, at first, not to be always interested in the subject, and spoke with some hesitation. As he advanced, however, the matter seemed to crowd upon him, his manner became warm and animated, and his expression easy and fluent. In points susceptible of controversy, you could easily discern, that he secretly conceived an opposition to his opinions, and that he was led upon this account to support them with greater energy and vehemence. By the fulness and variety of his illustrations, the subject gradually swelled in his hands, and acquired a dimension which, without a tedious repetition of the same views, was calculated to seize the attention of his audience, and to afford them pleasure, as well as instruction, in following the same object through all the diversity of shades and aspects in which it was presented, and afterwards in tracing it backwards to that original proposition or general truth from which this beautiful train of speculation had proceeded.

"His reputation as a professor was accordingly raised very high, and a multitude of students from a great distance resorted to the University, merely upon his account. Those branches of science which he taught became fashionable at this place, and his opinions were the chief topic of discussion in clubs and literary societies. Even the small peculiarities in his pronunciation or manner of speaking became frequently the objects of imitation."

It is understood that Dr. Smith made his debût as an author by contributing, anonymously, two articles to a publication entitled the *Edinburgh Review*, commenced in 1755, of which only two numbers were published. The first of these articles is a review of Dr. Johnson's Dictionary, and displays considerable acuteness; the second is in the form of a letter to the editor, and contains some general observations on the literature of the different European countries. It is chiefly remarkable as evincing the attention paid by the author to continental literature, at a period when it was comparatively neglected in this country.

In 1759 Smith published his *Theory of Moral Sentiments.* He had been engaged for a very considerable period in the composition of this work, which is throughout elaborated with the greatest care. The fundamental principle maintained by the author is, that *sympathy* forms the real foundation of morals; that we do not immediately approve or disapprove of any given action, when we have become acquainted with the intention of the agent and the consequences of what he has done, but that we previously enter, by means of that sympathetic affection which is natural to us, into the feelings of the agent and those to whom the action relates; that, having considered all the motives, and passions by which the agent was actuated, we pronounce, with respect to the *propriety* or *impropriety* of the action, according as we sympathize or not with him; while we pronounce, with respect to the *merit* or *demerit* of the action, according as we sympathize with the gratitude or resentment of those who were its objects; and that we necessarily judge of our own conduct by comparing it with such maxims and rules as we have deduced from observations previously made on the conduct of others.

Several, and, as it is now generally admitted, some unanswerable, objections have been urged against this most ingenious theory. But, whatever difference of opinion may exist with respect to the truth of the principle it involves, the *Theory of Moral Sentiments* has been universally allowed to abound in the most admirable disquisitions, in a faithful and skilful delineation of character, and in the soundest and most elevated maxims for the practical regulation of human life. The style various, but always eloquent, is worthy of the subject; and while it serves, by the beauty and richness of its colouring, to relieve the dryness of some of the more abstract discussions, it gives additional force to the powerful recommendations of generous, upright, and disinterested conduct to be found in every part of the work.

Dr. Brown, who has criticised this theory with his usual acuteness, and has shewn that though sympathy may diffuse moral sentiments, it can never originate them, bears, notwithstanding, the strongest testimony to the transcendent merits of Dr. Smith's work. "The *Theory of Moral Sentiments*," he observes, "is, without all question, one of the most interesting works, perhaps I should have said the most interesting work, in moral science. It is valuable, however, as I before remarked, not for the leading doctrine, of which we have seen the fallacy, but for the minor theories which are adduced in illustration of it; for the refined analysis which it exhibits in many of its details; and for an eloquence which, adapting itself to all the temporary varieties of its subject, familiar, with a sort of majestic grace, and simple even in its magnificence, can play amid the little decencies and proprieties of common life, or rise to all the dignity of that sublime and celestial virtue, which it seems to bring from heaven indeed, but to bring down gently and humbly, to the bosom of man."[1]

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[1] Brown's Lectures, vol. iv. p. 132. edit. 1824.

Having published the substance of so important a part of his lectures, Smith was enabled to make considerable retrenchments from the ethical parts of his course, and to give a proportionally greater extension to the disquisitions on Jurisprudence and Political Economy. He had long been in the habit of embodying in his lectures the results of his studies and investigations with respect to both these departments of political science, and particularly the latter; and it appears from a statement which he drew up in 1755, in order to vindicate his claims to certain political and literary opinions, that he had been in the habit of teaching, from the time he obtained a chair in the University of Glasgow, and even when at Edinburgh, the same enlarged and liberal doctrines with respect to the freedom of industry, and the impolicy and injurious influence of artificial restraints and regulations, which he afterwards so fully established in the *Wealth of Nations*. His residence in a large commercial city, like Glasgow, gave him considerable advantage in the prosecution of his favourite studies, by affording means of easily obtaining that correct practical information, on many points, which cannot be learned from books, and by enabling him to compare his theoretical doctrines with the experimental conclusions of his mercantile friends. Notwithstanding the disinclination so common among men of business, to listen to speculative opinions, and the opposition of his leading principles to the old maxims of trade, he was able, before he quitted his situation in the University, to rank some very eminent merchants among his proselytes.

The publication of the *Theory of Moral Sentiments* brought a great accession of reputation to the author; and placed him, in the estimation of all who were qualified to form an opinion on such a subject, in the first rank of moralists, and of able and eloquent writers. In 1762 the Senate of the University of Glasgow unanimously conferred on him the degree of Doctor of Laws; in testimony, as it is expressed in the minutes of the meeting, of their respect for his universally acknowledged talents, and of the advantage that had resulted to the University from the ability with which he had for many years expounded the principles of jurisprudence. But the most important effect of his increasing celebrity, in so far at least as respected himself, was his receiving in 1763 an invitation from Mr. Charles Townsend, who had married the Duchess of Buccleugh, to attend her Grace's son, the young Duke, on his travels; and the advantageous terms that were offered, combined with the strong desire which he entertained of visiting the Continent, induced him to accept the offer, and to resign his chair at Glasgow. "With the connexion which he was led to form in consequence of this change in his situation," says Mr. Stewart, "he had reason to be satisfied in an uncommon degree, and he always spoke of it with pleasure and gratitude. To the public it was not, perhaps, a change equally fortunate; as it interrupted that studious leisure for which nature seems to have destined him, and in which alone he could have hoped to accomplish those literary projects which had flattered the ambition of his youthful genius."

Dr. Smith set out for France in company with his noble pupil in March 1764. They remained only a very few days at Paris on their first visit to that capital, but proceeded to Toulouse, where they resided for about eighteen months. The society of Toulouse, a considerable city, and at that time the seat of a parliament, must have been a good deal superior to that of most country towns; and Dr. Smith would, no doubt, avail himself of it, and of the leisure he then enjoyed, to perfect and extend his knowledge of the literature, internal policy, and state of France. He has told us that he was not disposed to place much confidence in the facts and reasonings of political arithmeticians; and it is evident from his rarely stating facts on the authority of others, and from the references he occasionally makes to circumstances connected with Toulouse, Geneva, and other places which he visited, that he was chiefly indebted to his own observation and inquiries for the accurate and extensive information he is universally acknowledged to have possessed with respect to the institutions, habits, and condition of the French people.

After leaving Toulouse, Dr. Smith and his pupil proceeded to Geneva, where they resided two months. They returned to Paris at Christmas, 1765, and remained in that city for nearly twelve months. During the whole of this period, Dr. Smith lived on the most friendly footing with the best society in Paris. Turgot, afterwards comptroller general of Finance, D'Alembert, Helvetius, Marmontel, the Abbé Morellet,[1] the Duc de la Rochefoucault, and Madame Riccoboni, were of the number of his acquaintances; and some of them he continued ever after to reckon among his friends. He was also on familiar terms with M. Quesnay, founder of the sect of the Economists; and there is every reason to think that he derived considerable advantage from his intercourse with that able and excellent person, than whom none was better qualified to strike out original and ingenious views. So sensible, indeed, was Dr. Smith of his great and various merits as a man and a philosopher, that he intended, had he not been prevented by Quesnay's death, to have left a lasting testimony of the estimation in which he held him, by dedicating to him the *Wealth of Nations*.

In October 1766, the Duke of Buccleugh and Dr. Smith returned to London. The latter soon after removed to his old residence at Kirkcaldy; where he continued to reside, with very little interruption, for about ten years, habitually occupied in study, and in the elaboration of his great work. The *Inquiry into the Nature and Causes of the Wealth of Nations* appeared in 1776; an æra that will be for ever memorable in the history of political philosophy. Of this invaluable work, it is sufficient to observe, that, notwithstanding the defects that have been discovered in some of its principles, and the objections that have been made, and, perhaps, with justice, to its arrangement, it will ever remain one of the noblest monuments of profound sagacity, great and varied learning, sound judgment, and persevering research, directed to the best, because the most useful, purposes. There can be no question with respect to the claim of Dr. Smith to be considered as the real founder of the modern system of Political Economy. Though he has not left a perfect work, he has left one which contains a greater number of useful truths than have ever been given to the world by any other individual; and he has pointed out and smoothed the route, by following which subsequent philosophers have been able to perfect much that he left incomplete, to rectify the mistakes into which he fell, and to make many new and important discoveries. Whether indeed we refer to the soundness of its leading doctrines, the liberality and universal applicability of its practical conclusions, or the powerful and beneficial influence which it has had on the progress of economical science, and on the policy and conduct of nations, the *Wealth of Nations* must be placed in

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[1] The paragraph which follows is extracted from the Mémoires of the Abbé Morellet published in 1821. "J'avais connu Smith dans un voyage qu'il avait fait en France, vers 1762; il parlait fort mal notre langue; mais sa *Théorie des Sentimens Moraux*, publiée en 1759, m'avait donné und grande idée de sa sagacité et de sa profondeur. Et véritablement je le regarde encore aujourd'hui comme une des hommes qui a fait les observations et les analyses les plus complètes dans toutes les questions qu'il a traitées. M. Turgot, qui animait ainsi que moi la métaphysique, estimait beaucoup son talent. Nous le vîmes plusieurs fois; il fut présenté chez Helvétius: nous parlâmes théorie commerciale, banque, crédit public, et de plusieurs points du grand ouvrage qu'il méditait. Il me fit présent d'un fort joli portefeuille anglais de poche, qui était à son usage, et dont je me suis servi vingt ans." Tom. i. p. 237.

the foremost rank of those works that have helped to liberalize, enlighten, and enrich mankind.

Dr. Smith survived the publication of the *Wealth of Nations* fifteen years. He had the satisfaction to see it translated into all the languages of Europe; to hear his opinions quoted in the House of Commons; to be consulted by the minister; and to observe that the principles which he had expounded were beginning to produce a material change in the public opinion, and in the councils of this and other countries; and he must have enjoyed the full conviction that the progress of events would ensure their ultimate triumph, by showing that they were productive of signal advantage, not only to the general mass of mankind, but to the inhabitants of every country which should have good sense enough to adopt them.

Mr. Hume died very soon after the publication of the *Wealth of Nations*. Dr. Smith, with whom he had long lived on the most intimate terms, was most assiduous in his attentions to his illustrious friend during his illness; and he gave a brief account of the circumstances connected with his death, together with a sketch of his character, in a letter addressed to Mr. Strahan of London, which was soon after published as a supplement to Mr. Hume's autobiography. The unqualified eulogium pronounced in this letter on Mr. Hume's character excited the indignation of those who took offence at his religious opinions. Dr. Horne, bishop of Norwich, in an anonymous letter, attacked Dr. Smith on this ground; and very naturally ascribed to him the same sceptical opinions that had been entertained by his deceased friend. But he took no notice of this attack; and wisely declined entering upon a controversy that could have led to no useful result.

Dr. Smith resided principally in London during the two years immediately subsequent to the publication of the *Wealth of Nations;* caressed by the most distinguished persons in the metropolis, who were justly proud of his acquaintance, and who, though they could not always subscribe to the justice of his remarks, were equally delighted with the goodness of his heart, the simplicity of his manners, the vigour of his understanding, and the variety of his attainments. In 1788 he was appointed, through the unsolicited application of his old pupil and friend, the Duke of Buccleugh, a commissioner of customs for Scotland. In consequence of this appointment he removed to Edinburgh, where he continued afterwards to reside, possessed of an income more than equal to his wants, and in the enjoyment of the society of his earliest and most esteemed friends. His mother, then in extreme old age, and his cousin, Miss Douglas, accompanied him to Edinburgh, the latter superintending the domestic arrangements and economy of his family. But though his appointment to the customs reflects high credit on the nobleman by whose intervention it was procured, it may be doubted whether it was worthy of the country or of Dr. Smith. The philosopher who had produced a work in which the true sources of national wealth and prosperity were, for the first time, fully explored and laid open, deserved a different and a higher reward.

In 1787 Dr. Smith was elected Lord Rector of the University of Glasgow; on which occasion he addressed a letter to that learned body, which strikingly evinces the high sense he felt of this honour, and his affectionate regard for those from which it emanated. "No preferment," says he, "could have given me so much real satisfaction. No man can owe greater obligations to a society than I do to the University of Glasgow. They educated me; they sent me to Oxford. Soon after my return to Scotland, they elected me one of their own members; and afterwards preferred me to another office, to which the abilities and virtues of the never to be forgotten Dr. Hutcheson had given a superior degree of illustration. The period of thirteen years, which I spent as a member of that society, I remember as by far the most useful, and therefore as by far the happiest and most honourable, period of my life; and now, after three and twenty years' absence, to be remembered in so very agreeable a manner by my old friends and protectors, gives me a heartfelt joy which I cannot easily express to you."

His constitution, which had at no time been robust, began early to give way; and his decline was accelerated by the grief and vexation he felt on account of the death of his mother, to whom he had been most tenderly attached, in 1784, and of Miss Douglas, in 1788. He survived the latter only about two years, having died in July 1790. His last illness, which was occasioned by a chronic obstruction of the bowels, was both tedious and painful: but he bore it with the greatest fortitude and resignation: his cheerfulness never forsook him; and he had all the consolation that could be derived from the affectionate sympathy and attention of his friends.

His conduct in private life did not belie the generous principles inculcated in his works. He was in the habit of allotting a considerable part of his income to offices of secret charity. Mr. Stewart mentions that he had been made acquainted with some very affecting instances of his beneficence. "They were all," he observes, "on a scale much beyond what might have been expected from his fortune; and were accompanied with circumstances equally honourable to the delicacy of his feelings and the liberality of his heart."

Dr. Smith collected an exceedingly valuable and well-selected, though not a very extensive, library. He was very particular, not only with respect to the books themselves, but also with respect to the condition of the copies admitted into his collection. "The first time," says Mr. Smellie, "I happened to be in his library, observing me looking at the books with some degree of curiosity and perhaps surprise, for most of the volumes were elegantly and some of them superbly bound, 'You must have remarked,' said he, 'that *I am a beau in nothing but my books.*'"[1] His library is still in the possession of Lord Reston's widow.

Notwithstanding the apparent flow and artlessness of his style, and his great experience in composition, Dr. Smith stated, not long before his death, that he continued to compose as slowly, and with as great difficulty, as at first. He did not write with his own hand, but generally walked up and down his apartment, dictating to an amanuensis.[2]

Dr. Smith had been long resolved that none of his manuscripts, except those which he himself judged fit for publication, should ever see the light; and a few days before his death he carried this resolution into effect, by having all his papers committed to the flames, with the exception of the fragments of some essays, intended to illustrate the principles that lead and direct philosophical inquiries, which he left to the discretion of his friends to publish or not as they thought proper. The contents of the manuscripts that were destroyed are not exactly known; but they certainly contained the course of lectures on rhetoric delivered at Edinburgh in 1748, and the lectures on jurisprudence and natural religion, which formed a most important part of the course of moral philosophy delivered at Glasgow. The loss of the latter must ever be a subject of deep regret. We are ignorant of the motives which induced Dr. Smith to destroy them; but Mr. Stewart supposes that it was not so much on account of any apprehended injury to his literary reputation from the publication of such unfinished works, as from an anxiety lest the progress of truth should be retarded by the statement of doctrines of which the principles were not fully developed.

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[1] Smellie's Lives, p. 296.

[2] Mr. Stewart states that all Hume's works were written with his own hand; and that the last volumes of his history were printed from the original copy, with only a few marginal corrections.

The following observations on the private character and habits of Dr. Smith proceed from the pen of Mr. Stewart, who knew him well, and who was the last survivor of that galaxy of illustrious men who shed, during the last century, so imperishable a glory over the literature of Scotland. "The more delicate and characteristical features of his mind," Mr. Stewart observes, "it is perhaps impossible to trace. That there were many peculiarities, both in his manners and in his intellectual habits, was manifest to the most superficial observer; but although, to those who knew him, these peculiarities detracted nothing from the respect which his abilities commanded; and although, to his intimate friends, they added an inexpressible charm to his conversation, while they displayed, in the most interesting light, the artless simplicity of his heart; yet it would require a very skilful pencil to present them to the public eye. He was certainly not fitted for the general commerce of the world, or for the business of active life. The comprehensive speculations with which he had been occupied from his youth, and the variety of materials which his own invention continually supplied to his thoughts, rendered him habitually inattentive to familiar objects, and to common occurrences; and he frequently exhibited instances of absence, which had scarcely been surpassed by the fancy of La Bruyere. Even in company he was apt to be engrossed with his studies; and appeared at times, by the motion of his lips, as well as by his looks and gestures, to be in the fervour of composition. I have often, however, been struck, at the distance of years, with his accurate memory of the most trifling particulars; and am inclined to believe, from this and some other circumstances, that he possessed a power, not perhaps uncommon among absent men, of recollecting, in consequence of subsequent efforts of reflection, many occurrences which, at the time when they happened, did not seem to have sensibly attracted his notice.

"To the defect now mentioned, it was probably owing, in part, that he did not fall in easily with the common dialogue of conversation, and that he was somewhat apt to convey his own ideas in the form of a lecture. When he did so, however, it never proceeded from a wish to engross the discourse, or to gratify his vanity. His own inclination disposed him so strongly to enjoy in silence the gaiety of those around him, that his friends were often led to concert little schemes, in order to engage him in the discussions most likely to interest him. Nor do I think I shall be accused of going too far when I say, that he was scarcely ever known to start a new topic himself, or to appear unprepared upon those topics that were introduced by others. Indeed, his conversation was never more amusing than when he gave a loose to his genius upon the very few branches of knowledge of which he only possessed the outlines.

"The opinions he formed of men, upon a slight acquaintance, were frequently erroneous; but the tendency of his nature inclined him much more to blind partiality than to ill-founded prejudice. The enlarged views of human affairs, on which his mind habitually dwelt, left him neither time nor inclination to study, in detail, the uninteresting peculiarities of ordinary characters; and accordingly, though intimately acquainted with the capacities of the intellect, and the workings of the heart, and accustomed, in his theories, to mark, with the most delicate hand, the nicest shades, both of genius and of the passions; yet, in judging of individuals, it sometimes happened that his estimates were, in a surprising degree, wide of the truth.

"In his external form and appearance there was nothing uncommon. When perfectly at ease, and when warmed with conversation, his gestures were animated, and not ungraceful; and, in the society of those he loved, his features were often brightened with a smile of inexpressible benignity. In the company of strangers, his tendency to absence, and perhaps still more his consciousness of this tendency, rendered his manner somewhat embarrassed;—an effect which was probably not a little heightened by those speculative ideas of propriety, which his recluse habits tended at once to perfect in his conception, and to diminish his power of realizing."

The following is a list of the published works of Dr. Smith.

1. Two articles in the *Edinburgh Review* for 1755, being, (1) a Review of Johnson's *English Dictionary*, and (2) *A Letter to the Editors*.

2. *The Theory of Moral Sentiments*. The first edition of this work was published in 8vo, early in 1759. The sixth edition was published a short time before the author's death. It contains several additions, most of which were executed during his last illness.

3. *Considerations concerning the first Formation of Languages, and the different Genius of Original and Compounded Languages*. This essay was originally subjoined to the first edition of the *Moral Sentiments*. It is an ingenious and pretty successful attempt to explain the formation and progress of language, by means of that species of investigation to which Dugald Stewart has given the appropriate name of *Theoretical* or *Conjectural History;* and which consists in endeavouring to trace the progress and vicissitudes of any art or science, partly from such historical facts as have reference to it, and, where facts are wanting, from inferences derived from considering what would be the most natural and probable conduct of mankind under the circumstances supposed.

4. *An Inquiry into the Nature and Causes of the Wealth of Nations*. The first edition was published at London in 1776, in two volumes 4to. The fourth edition, which was the last revised by the author, appeared in three volumes 8vo, in 1786.

5. *Essays on Philosophical Subjects*. Lond. 1795, 4to. These are the fragments which he exempted from the general destruction of his manuscripts, and which were published by his friends, Dr. Black and Dr. Hutton. In an advertisement prefixed to the publication, the editors state that, when the papers which Dr. Smith had left in their hands were examined, "the greater number appeared to be parts of a plan he once had formed for giving a connected history of the liberal sciences and elegant arts." "It is long," they add, "since he found it necessary to abandon that plan as far too extensive; and these parts of it lay beside him neglected until his death. The reader will find in them that happy connection, that full and accurate expression, and that clear illustration, which are conspicuous in the rest of his works; and though it is difficult to add much to the great fame he so justly acquired by his other writings, these will be read with satisfaction and pleasure." The papers in question comprise, I. fragments of a great work *On the Principles which lead and direct Philosophical Inquiries, illustrated* (1) *by the History of Astronomy;* (2) *by the History of the Ancient Physics;* and (3) *by the History of the Ancient Logics and Metaphysics*. II. An essay entitled, *Of the Nature of that Imitation which takes place in what are called the imitative Arts*. III. A short tract, *Of the Affinity between certain English and Italian Verses*. IV. A disquisition, *Of the External Senses*.

Of the historical dissertations, the first only, on the *History of Astronomy*, seems to be nearly complete. They are all written on the plan of the dissertation on the *Formation of Languages*, being partly theoretical and partly founded on fact. In the essay on the *History of Astronomy*, after premising some acute and ingenious speculations with respect to the effects of unexpectedness and surprise, and of wonder and novelty, the author proceeds to give a brief, masterly, outline of the different astronomical systems, from the earliest ages down to that of Newton. The fragments that remain of the other two historical essays are much less complete, and do not possess the interest of the former. The short essay, *Of the Affinity between certain English and Italian Verses*, is curious rather than valuable. It affords a striking illustration of the variety and extent of Dr. Smith's literary pursuits. The disquisition with respect to the *External Senses* is of considerable extent. It embraces some ingenious discussions, and is a valuable contribution to the science of which it treats.

The *Wealth of Nations* has passed through many editions, some of which have been accompanied with notes and illustrations; but the best that has yet appeared, is that which was edited by Mr. M'Culloch, with notes and dissertations, embodying the views of later economists, and adapting the work to the present state of that science of which it has so eminently contributed to advance the progress.

SMITHERY, a smith's shop; also the art of a smith, by which iron is wrought into any shape by means of fire, hammering, and filing.

SMITING-LINE, in a ship, is a small rope fastened to the mizen-yard-arm, below at the deck, and is always furled up with the mizen-sail, even to the upper end of the yard, and thence it comes down to the poop. Its use is to loosen the mizen-sail without striking down the yard, which is easily done, because the mizen-sail is furled up only with rope-yarns; and therefore when this rope is pulled hard, it breaks all the rope-yarns, and so the sail falls down of itself. The sailor's phrase is, *smite the mizen*, that is, haul by this rope that the sail may fall down.

SMOAKY CAPE, on the east coast of New Holland. Long. 153. 42. Lat. 30. 55. S.

SMOKE, a dense elastic vapour arising from burning bodies. As this vapour is extremely disagreeable, and often prejudicial to health, several contrivances have been devised for the purpose of enabling us to enjoy the benefit of a fire without being annoyed by smoke; hence the use of chimneys, which, when properly constructed, carry it off entirely, but when improperly constructed, allow a part of it to escape into the room.

Chimneys operate in carrying off smoke by the rarity of the gaseous fluids which escape from the fire, and which, owing to their being expanded, are lighter than the adjoining air, and are therefore pressed up by it, carrying the smoke along with them. So long, then, as the gaseous products of the fire are lighter than the air, they ascend, while at the same time cold air must rush in from below to supply their place, which air, being heated in its turn, consumed, and mixed with the smoke, must also rise. The more, therefore, that the air in the chimney can be kept warm, so much the better; not only will the draught become greater, but there will also be less chance of any of the smoke being thrown back. The worse the power of the material of which the chimney is constructed for transmitting heat, the longer will the air within it be kept warm, and therefore the chimney will work better; hence the superior efficacy of bricks.

It is evident from what has been said, that there is a certain height to which chimneys may be carried, beyond which any farther lengthening, instead of being beneficial, will prove injurious; because, when the air within the chimney and without become of the same weight, which must be at a particular height in each, then if that chimney be made higher, the air within does not escape, or escapes slowly; air must therefore enter in slowly from below, and consequently the draught must be diminished. There are many circumstances which prevent chimneys from working well, or in other words, which make them return a part of the smoke into the room.

The causes of the smoking of chimneys may be reduced to nine, differing from each other, and therefore requiring different remedies.

1. *Smoky chimneys in a new house are such frequently from mere want of air.* The workmanship of the rooms being all good, and just out of the workman's hands, the joints of the boards of the flooring, and of the panels of wainscotting, are all true and tight; the more so as the walls, perhaps not yet thoroughly dry, preserve a dampness in the air of the room which keeps the wood-work swelled and close. The doors and the sashes too, being worked with truth, shut with exactness, so that the room is as tight as a snuff-box, no passage being left open for air to enter except the key-hole, and even that is sometimes covered by a little dropping shutter. Now if smoke cannot rise but as connected with rarefied air, and a column of such air, suppose it filling the funnel, cannot rise unless other air be admitted to supply its place; and if therefore no current of air enter the opening of the chimney, there is nothing to prevent the smoke from being diffused in the room. If the motion upwards of the air in a chimney that is freely supplied be observed by the rising of the smoke or a feather in it, and it be considered that in the time such feather takes in rising from the fire to the top of the chimney, a column of air equal to the content of the funnel must be discharged, and an equal quantity supplied from the room below, it will appear absolutely impossible that this operation should go on if the tight room is kept shut; for were there any force capable of drawing constantly so much air out of it, it must soon be exhausted like the receiver of an air-pump, and no animal could live in it. Those therefore who stop every crevice in a room to prevent the admission of fresh air, and yet would have their chimney carry up the smoke, require inconsistencies, and expect impossibilities. Yet under this situation it is not uncommon to see the owner of a new house in despair, and ready to sell it for much less than it cost; conceiving it uninhabitable because not a chimney in any one of its rooms will carry off the smoke unless a door or window be left open. Much expense has also been incurred to alter and amend new chimneys which had really no fault. In one house particularly which Dr. Franklin knew that belonged to a nobleman in Westminster, that expense amounted to no less than L.300, after his house had been, as he thought, finished, and all charges paid. And after all, several of the alterations were ineffectual, for want of understanding the true principles.

Remedies. When you find on trial that opening the door or a window enables the chimney to carry up all the smoke, you may be sure that want of air from without is the cause of its smoking. "I say from *without*," adds Dr. Franklin, "to guard you against a common mistake of those who may tell you the room is large, contains abundance of air sufficient to supply any chimney, and therefore it cannot be that the chimney wants air. These reasoners are ignorant that the largeness of a room, if tight, is in this case of small importance, since it cannot part with a chimneyfull of its air without occasioning so much vacuum; which it requires a great force to effect, and could not be borne if effected."

It appearing plainly then, that some of the outward air must be admitted, the question will be, how much is absolutely necessary? for you would avoid admitting more, as being contrary to one of your intentions in having a fire, namely, that of warming your room. To discover this quantity, shut the door gradually while a middling fire is burning, till you find that before it is quite shut the smoke begins to come out into the room; then open it a little till you perceive the smoke comes out no longer. There hold the door, and observe the width of the open crevice between the edge of the door and the rabbet into which it should shut.

Suppose the distance to be half an inch, and the door eight feet high; you thence find that your room requires an entrance for air equal in area to ninety-six half inches, or forty-eight square inches, or a passage of six inches by eight. This, however, is a large supposition, there being few chimneys that, having a moderate opening and a tolerable height of funnel, will not be satisfied with such a crevice of a quarter of an inch. Dr. Franklin found a square of six by six, or thirty-six square inches, to be a pretty good medium that will serve for most chimneys. High funnels with small and low openings may indeed be supplied through a less space; because, for reasons that will hereafter appear, the force of levity, if one may so speak, being greater in such funnels, the cool air enters the room with greater velocity, and consequently more enters in the same time. This, however, has its limits; for experience shews, that no increased velocity so occasioned has made the admission of air through the key-hole equal in quantity to that through an open door, though through the door the current moves slowly, and through the key-hole with great rapidity.

It remains then to be considered how and where this necessary quantity of air from without is to be admitted so as to be least inconvenient; for if at the door, left so much open, the air thence proceeds directly to the chimney, and in its way comes cold to your back and heels as you sit before your fire. If you keep the door shut, and raise a little the sash of your window, you feel a similar inconvenience. Various have been the contrivances to avoid this, such as bringing in fresh air through pipes in the jams of the chimney, which pointing upwards should blow the smoke up the funnel; opening passages in the funnel above, to admit air for the same purpose. But these produce an effect contrary to that intended; for as it is the constant current of air passing from the room through the opening of the chimney into the funnel which prevents the smoke from coming out into the room, if you supply the funnel by other means or in other ways with the air which it requires, and especially if that air be cold, you diminish the force of that current, and the smoke in its efforts to enter the room finds less resistance.

The required air must then indispensably be admitted into the room, to supply what goes off through the opening of the chimney. M. Gauger, a very ingenious and intelligent French writer on the subject, proposes with judgment to admit it above the opening of the chimney; and to prevent inconvenience from its coldness, he directs that it may be so made, that it shall pass in its entrance through winding cavities made behind the iron back and sides of the fire-place, and under the iron hearth-plate; in which cavities it will be warmed, and even heated, so as to contribute much, instead of cooling, to the warming of the room. This invention is excellent in itself, and may be used with advantage in building new houses, because the chimneys may then be so disposed as to admit conveniently the cold air to enter such passages. But in houses built without such views, the chimneys are often so situated as not to afford that convenience without great and expensive alterations. Easy and cheap methods, though not quite so perfect in themselves, are of more general utility; and such are the following.

In all rooms where there is a fire, the body of air warmed and rarefied before the chimney is continually changing place, and making room for other air that is to be warmed in its turn. Part of it enters and goes up the chimney, and the rest rises and takes place near the ceiling. If the room be lofty, that warm air remains above our heads as long as it continues warm, and we are little benefited by it, because it does not descend till it is cooler. Few can imagine the difference of climate between the upper and lower parts of such a room, who have not tried it by the thermometer, or by going up a ladder till their heads are near the ceiling. It is then among this warm air that the requisite quantity of outward air is best admitted, with which being mixed, its coldness is abated, and its inconvenience diminished so as to become scarcely observable. This may be easily done by drawing down about an inch the upper sash of a window; or, if not moveable, by cutting such a crevice through its frame; in both which cases it will be well to place a thin shelf of the length to conceal the opening, and sloping upwards, to direct the entering air horizontally along and under the ceiling. In some houses the air may be admitted by such a crevice made in the wainscot, cornice, or plastering, near the ceiling and over the opening of the chimney. This, if practicable, is to be chosen, because the entering cold air will there meet with the warmest rising air from before the fire, and be soonest tempered by the mixture. The same kind of shelf should also be placed here. Another way, and not a very difficult one, is to take out an upper pane of glass in one of your sashes, set it in a tin frame, giving it two springing angular sides, and then replacing it, with hinges below, on which it may be turned to open more or less above. It will then have the appearance of an internal sky-light. By drawing this pane in, more or less, you may admit what air you find necessary. Its position will naturally throw that air up and along the ceiling. In England some have of late years cut a round hole about five inches diameter in a pane of the sash, and placed against it a circular plate of tin hung on an axis, and cut into vanes; which, being separately bent a little obliquely, are acted upon by the entering air, so as to force the plate continually round like the vanes of a windmill. This admits the outward air, and by the continual whirling of the vanes, does in some degree disperse it. The noise only is a little inconvenient.

2. A second cause of the smoking of chimneys is, *their openings in the room being too large*: that is, too wide, too high, or both. Architects in general have no other ideas of proportion in the opening of a chimney than what relate to symmetry and beauty respecting the dimensions of the room; while its true proportion respecting its function and utility depends on quite other principles; and they might as properly proportion the step in a staircase to the height of the storey, instead of the natural elevation of men's legs in mounting. The proportion then to be regarded, is what relates to the height of the funnel. For as the funnels in the different storeys of a house are necessarily of different heights or lengths, that from the lowest floor being the highest or longest, and those of the other floors shorter and shorter, till we come to those in the garrets, which are of course the shortest; and the force of draft being, as already said, in proportion to the height of funnel filled with rarefied air, and a current of air from the room into the chimney, sufficient to fill the opening, being necessary to oppose and prevent the smoke from coming out into the room; it follows, that the openings of the longest funnels may be larger, and that those of the shorter funnels should be smaller. For if there be a larger opening to a chimney that does not draw strongly, the funnel may happen to be furnished with the air which it demands by a partial current entering on one side of the opening, and leaving the other side free of any opposing current, may permit the smoke to issue there into the room. Much, too, of the force of draft in a funnel depends on the degree of rarefaction in the air it contains, and that depends on the nearness to the fire of its passage in entering the funnel. If it can enter far from the fire on each side, or far above the fire, in a wide or high opening, it receives little heat in passing by the fire, and the contents of the funnel are by those means less different in levity from the surrounding atmosphere, and its force in drawing consequently weaker. Hence, if too large an opening be given to chimneys in upper rooms, those rooms will be smoky. On the other hand, if too small openings be given to chimneys in the lower rooms,

the entering air operating too directly and violently on the fire, and afterwards strengthening the draft as it ascends the funnel, will consume the fuel too rapidly.

Remedy. As different circumstances frequently mix themselves in these matters, it is difficult to give precise dimensions for the openings of all chimneys. Our fathers made them generally much too large. We have lessened them; but still they are often of greater dimensions than they should be, the human eye not being easily reconciled to sudden and great changes. If you suspect that your chimney smokes from the too great dimensions of its opening, contract it by placing moveable boards, so as to lower and narrow it gradually, till you find the smoke no longer issues into the room. The proportion so found will be that which is proper for that chimney, and you may employ the bricklayer or mason to reduce it accordingly. However, as in building new houses something must be sometimes hazarded, Dr. Franklin proposes to make the openings in the lower rooms about thirty inches square, and eighteen deep, and those in the upper only eighteen inches square, and not quite so deep; the intermediate ones diminishing in proportion as the height of the funnel is diminished. In the larger openings, billets of two feet long, or half the common length of cordwood, may be burned conveniently; and for the smaller, such wood may be sawed into thirds. Where coals are the fuel, the grates will be proportioned to the openings. The same depth is nearly necessary to all, the funnels being all made of a size proper to admit a chimney-sweeper. If in large and elegant rooms custom or fancy should require the appearance of a larger chimney, it may be formed of expensive marginal decorations, in marble, or in any thing else. But in time, perhaps, that which is fittest in the nature of things may come to be thought handsomest.

3. Another cause of smoky chimneys is *too short a funnel.* This necessarily happens in some cases, as where a chimney is required in a low building; for, if the funnel be raised high above the roof, in order to strengthen its draft, it is then in danger of being blown down, and crushing the roof in its fall.

Remedies. Contract the opening of the chimney, so as to oblige all the entering air to pass through or very near the fire; whereby it will be more heated and rarefied, the funnel itself be more warmed, and its contents have more of what may be called the force of levity, so as to rise strongly and maintain a good draft at the opening.

Or you may in some cases, to advantage, raise additional storeys over the low building, which will support a high funnel. If the low building be used as a kitchen, and a contraction of the opening therefore inconvenient, a large one being necessary, at least when there are great dinners, for the free management of so many cooking utensils; in such cases the best expedient perhaps would be to build two more funnels joining to the first, and having three moderate openings, one to each funnel, instead of one large one. When there is occasion to use but one, the other two may be kept shut by sliding plates, hereafter to be described; and two or all of them may be used together when wanted. This will indeed be an expense, but not an useless one, since your cooks will work with more comfort, see better than in a smoky kitchen what they are about, your victuals will be cleaner dressed, and not taste of smoke, as is often the case; and to render the effect more certain, a stack of three funnels may be safely built higher above the roof than a single funnel.

The case of too short a funnel is more general than would be imagined, and often found where one would not expect. For it is not uncommon, in ill-contrived buildings, instead of having a funnel for each room or fire-place, to bend and turn the funnel of an upper room, so as to make it enter the side of another funnel that comes from below. By these means the upper room funnel is made short of course, since its length can only be reckoned from the place where it enters the lower room funnel; and that funnel is also shortened by all the distance between the entrance of the second funnel and the top of the stack; for all that part being readily supplied with air through the second funnel, adds no strength to the draft, especially as that air is cold when there is no fire in the second chimney. The only easy remedy here is, to keep the opening of that funnel shut in which there is no fire.

4. Another very common cause of the smoking of chimneys is, *their overpowering one another.* For instance, if there be two chimneys in one large room, and you make fires in both of them, with doors and windows close shut, you will find that the greater and stronger fire shall overpower the weaker, from the funnel of which it will draw down air to supply its own demand; which air descending in the weaker funnel, will drive down its smoke, and force it into the room. If, instead of being in one room, the two chimneys are in two different rooms, communicating by a door, the case is the same whenever that door is open. In a very tight house, a kitchen chimney on the lowest floor, when it had a great fire in it, has been known to overpower any other chimney in the house, and draw air and smoke into its room as often as the door communicating with the staircase was opened.

Remedy. Take care that every room have the means of supplying itself from without with the air which its chimney may require, so that no one of them may be obliged to borrow from another, nor under the necessity of lending. A variety of these means has been already described.

5. Another cause of smoking is, *when the tops of chimneys are commanded by higher buildings, or by a hill,* so that the wind blowing over such eminences falls like water over a dam, sometimes almost perpendicularly on the tops of the chimneys that lie in its way, and beats down the smoke contained in them.

Remedy. That commonly applied in this case is a turncap made of tin or plate iron, covering the chimney above and on three sides, open on one side, turning on a spindle; and which, being guided or governed by a vane, always presents its back to the current. This may be generally effectual, though not certain, as there may be cases in which it will not succeed. Raising your funnels, if practicable, so as their tops may be higher, or at least equal, with the commanding eminence, is more to be depended on. But the turning-cap, being easier and cheaper, should first be tied. "If obliged to build in such a situation, I would choose," says Dr. Franklin, "to place my doors on the side next the hill, and the backs of my chimneys on the farthest side; for then the column of air falling over the eminence, and of course pressing on that below, and forcing it to enter the doors on that side, would tend to balance the pressure down the chimneys, and leave the funnels more free in the exercise of their functions."

6. There is another case which is the reverse of that last mentioned. It is where the commanding eminence is farther from the wind than the chimney commanded.

Remedy. There is but one remedy, which is to raise such a funnel higher than the roof, supporting it if necessary by iron bars. For a turncap in this case has no effect, the dammed-up air pressing down through it in whatever position the wind may have placed its opening.

Dr. Franklin mentions a city in which many houses are rendered smoky by this operation. For their kitchens being built behind, and connected by a passage with the houses, and the tops of the kitchen chimneys lower than the tops of the houses, the whole side of a street when the wind blows against its back, forms such a dam as above described; and the wind so obstructed forces down those kitchen chimneys, especially when they have but weak fires in them, to pass through the passage and house into the street. Kitchen-chimneys so formed and situated have another inconvenience. In summer, if you open your upper-room windows for air, a light breeze blowing over your kitchen chimney towards the house, though not strong enough to force down its smoke as aforesaid, is sufficient to waft it into your windows, and fill the rooms with it, which, besides the disagreeableness, damages your furniture.

7. Chimneys, otherwise drawing well, are sometimes made to smoke by *the improper and inconvenient situation of a door*. When the door and chimney are on the same side of the room, if the door being in the corner is made to open against the wall, which is common, as being there, when open, more out of the way, it follows, that when the door is only opened in part, a current of air rushing in passes along the wall into and across the opening of the chimney, and flirts some of the smoke out into the room. This happens more certainly when the door is shutting, for then the force of the current is augmented, and becomes very inconvenient to those who, warming themselves by the fire, happen to sit in its way.

The *remedies* are obvious and easy. Either put an intervening screen, from the wall round great part of the fire-place; or, which is perhaps preferable, shift the hinges of your door, so that it may open the other way, and when open, throw the air along the other wall.

8. A room that has no fire in its chimney is sometimes filled with *smoke which is received at the top of its funnel and descends into the room*. Funnels without fires have an effect according to their degree of coldness or warmth on the air that happens to be contained in them. The surrounding atmosphere is frequently changing its temperature; but stacks of funnels covered from winds and sun by the house that contains them, retain a more equal temperature. If, after a warm season, the outward air suddenly grows cold, the empty warm funnels begin to draw strongly upwards; that is, they rarefy the air contained in them, which of course rises, cooler air enters below to supply its place, is rarefied in its turn, and rises; and this operation continues till the funnel grows cooler, or the outward air warmer, or both, when the motion ceases. On the other hand, if after a cold season the outward air suddenly grows warm, and of course lighter, the air contained in the cool funnels, being heavier, descends into the room; and the warmer air which enters their tops being cooled in its turn, and made heavier, continues to descend; and this operation goes on till the funnels are warmed by the passing of warm air through them, or the air itself grows cooler. When the temperature of the air and of the funnels is nearly equal, the difference of warmth in the air between day and night is sufficient to produce these currents. The air will begin to ascend the funnels as the cool of the evening comes on, and this current will continue till perhaps nine or ten o'clock next morning, when it begins to hesitate; and as the heat of the day approaches, it sets downwards, and continues so till towards evening, when it again hesitates for some time, and then goes upwards constantly during the night, as before mentioned. Now when smoke issuing from the tops of neighbouring funnels passes over the tops of funnels which are at the time drawing downwards, as they often are in the middle part of the day, such smoke is of necessity drawn into these funnels, and descends with the air into the chamber.

The remedy is to have a sliding plate that will perfectly shut the offending funnel. Dr. Franklin has thus described it. "The opening of the chimney is contracted by brick-work faced with marble slabs to about two feet between the jams, and the breast brought down to within about three feet of the hearth. An iron frame is placed just under the breast, and extending quite to the back of the chimney, so that a plate of the same metal may slide horizontally backwards and forwards in the grooves on each side of the frame. This plate is just so large as to fill the whole space, and shut the chimney entirely when thrust quite in, which is convenient when there is no fire. Draw it out, so as to leave between its further edge and the back a space of about two inches; this space is sufficient for the smoke to pass; and so large a part of the funnel being stopped by the rest of the plate, the passage of warm air out of the room, up the chimney, is obstructed and retarded; and by those means much cold air is prevented from coming in through crevices, to supply its place. This effect is made manifest three ways. 1. When the fire burns briskly in cold weather, the howling or whistling noise made by the wind, as it enters the room through the crevices, when the chimney is open as usual, ceases as soon as the plate is slid in to its proper distance. 2. Opening the door of the room about half an inch, and holding your hand against the opening, near the top of the door, you feel the cold air coming in against your hand, but weakly, if the plate be in. Let another person suddenly draw it out, so as to let the air of the room go up the chimney, with its usual freedom where chimneys are open, and you immediately feel the cold air rushing in strongly. 3. If something be set against the door, just sufficient, when the plate is in, to keep the door nearly shut, by resisting the pressure of the air that would force it open; then, when the plate is drawn out, the door will be forced open by the increased pressure of the outward cold air endeavouring to get in to supply the place of the warm air that now passes out of the room to go up the chimney. In our common open chimneys, half the fuel is wasted, and its effect lost; the air it has warmed being immediately drawn off."

9. Chimneys which generally draw well, do nevertheless sometimes give smoke into the rooms, *it being driven down by strong winds passing over the tops of their funnels*, though not descending from any commanding eminence. This case is most frequent where the funnel is short, and the opening turned from the wind. It is the more grievous, when it happens to be a cold wind that produces the effect, because when you most want your fire you are sometimes obliged to extinguish it. To understand this, it may be considered that the rising light air, to obtain a free issue from the funnel, must push out of its way or oblige the air that is over it to rise. In a time of calm or of little wind this is done visibly; for we see the smoke that is brought up by that air rise in a column above the chimney. But when a violent current of air, that is, a strong wind, passes over the top of a chimney, its particles have received so much force which keeps them in a horizontal direction, and follow each other so rapidly, that the rising light air has not strength sufficient to oblige them to quit that direction and move upwards to permit its issue.

Remedies. In Venice, the custom is to open or widen the top of the flue, rounding it in the true form of a funnel. In other places the contrary is practised; the tops of the flues being narrowed inwards, so as to form a slit for the issue of the smoke, as long as the breadth of the funnel, and only four inches wide. This seems to have been contrived on a supposition that the entry of the wind would thereby be obstructed; and perhaps it might have been imagined, that the whole force of the rising warm air being condensed, as it were, in the narrow opening, would thereby be strengthened, so as to overcome the resistance of wind. This, however, did not always succeed; for when the wind was at north-east and blew fresh, the smoke was forced down by fits into the room where Dr. Franklin commonly sat, so as to oblige him to shift the fire into another. The position of the slit of this funnel was indeed north-east and south-west. Perhaps if it had lain across the wind, the effect might have been different. But on this we can give no certainty. It seems a matter proper to be referred to experiment. Possibly a turncap might have been serviceable, but it was not tried.

With all the science, however, that a man shall suppose himself possessed of in this article, he may sometimes meet with cases that shall puzzle him. "I once lodged," says Dr. Franklin, "in a house at London, which in a little room had a single chimney and funnel. The opening was very small, yet it did not keep in the smoke, and all attempts to have a fire in this room were fruitless. I could not imagine the reason, till at length observing that the chamber over it, which had no fireplace in it, was always filled with smoke when a fire was kindled below, and that the smoke came through the cracks and crevices of the wainscoat, I had the wainscoat taken down, and discovered that the funnel which went up behind it had a crack many feet in length, and wide enough to admit my arm; a breach very dangerous with regard to fire, and occasioned probably by an apparent irregular settling of one side of the house. The air entering this breach freely, destroyed the drawing force of the funnel. The remedy would have been, filling up the breach, or rather rebuilding the funnel; but the landlord rather chose to stop up the chimney.

"Another puzzling case I met with at a friend's country-house near London. His best room had a chimney in which, he told me, he never could have a fire, for all the smoke came out into the room. I flattered myself I could easily find the cause and prescribe the cure. I opened the door, and perceived it was not want of air. I made a temporary contraction of the opening of the chimney, and found that it was not its being too large that caused the smoke to issue. I went out and looked up at the top of the chimney: Its funnel was joined in the same stack with others, some of them shorter, that drew very well, and I saw nothing to prevent its doing the same. In fine, after every other examination I could think of, I was obliged to own the insufficiency of my skill. But my friend, who made no pretension to such kind of knowledge, afterwards discovered the cause himself. He got to the top of the funnel by a ladder, and looking down found it filled with twigs and straw cemented by earth and lined with feathers. It seems the house, after being built, had stood empty some years before he occupied it; and he concluded that some large birds had taken the advantage of its retired situation to make their nests there. The rubbish, considerable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave satisfaction."

Chimneys whose funnels go up in the north wall of a house, and are exposed to the north winds, are not so apt to draw well as those in a south wall; because, when rendered cold by those winds, they draw downwards. Chimneys enclosed in the body of a house are better than those whose funnels are exposed in cold walls. Chimneys in stacks are apt to draw better than separate funnels, because the funnels that have constant fires in them warm the others in some degree that have none.

Smoke-consuming. In manufacturing towns, where a great deal of fuel is used, it is of the utmost consequence to prevent, if possible, the production of smoke, so as not only to get quit of a great source of annoyance, but also to prevent the injury which it occasions to buildings; indeed to prevent the deterioration of property which in general occurs. Hence the clauses in acts of Parliament and in many police bills, compelling proprietors of steam engines, &c., to consume their smoke, if practicable; as also the numerous attempts which have been made to accomplish this object. Of course, if it could be done without an extra expenditure of fuel, so much the better; if with a saving of fuel, then the advantages to be gained are immense.

Numerous methods have been recommended, and many patents have been secured for accomplishing this desirable object. The principle of most of them depends on causing the smoke, immediately when given off from the coal, when fresh put on the fire, to pass over the half-burned or charred fuel, and thus be consumed.

Smoke is merely carbonaceous matter evolved from fuel; for when the whole of the inflammable gaseous product is not brought into contact with air at a proper degree of heat, it is not burned, and therefore escapes in the state of smoke. Now it is evident, that if that smoke or carbonaceous particles, as it flows over the burning fuel, be supplied with air, it also will be burned, provided they are brought together at a high temperature; but this is not done in the usual way of combustion, because the air passing up from the ash pit through the fuel, is almost entirely deprived of its oxygen before it reaches the upper part of the furnace. In addition to the air, therefore, which is requisite for the combustion of the fuel, air must also be admitted *above the fire* for the consumption of the smoke.

The most common method in practice for consuming smoke is, instead of throwing the fuel back into the furnace, to place it always on the dead plate or charring plate at the mouth, gradually pushing it on upon the bars, as it is charred, or deprived of its bituminous principle, and again supplying more on the dead plate, which is in general inclined, so as to allow the fuel placed on it to fall, and come into contact with that on the bars. For the success of this process, air must be admitted into the furnace, above the fuel, so as to mix with the flame and smoke; but this is attended with disadvantage, for being cold, it not only acts injuriously, as in lessening the production of steam, but by bringing down the temperature, prevents the action on the smoke itself, which is consequently not all destroyed. Hence the practice of heating the air to be thus admitted. When this is done by an additional fire, though the smoke may to a certain extent be consumed, yet it is attended with expense; but this is obviated in a great measure by the introduction of tubes into the flues or chimney, one end communicating with the atmosphere, the other terminating in the furnace, over the fuel, by which the air that passes through them derives a part of that heat which is otherwise carried up the vent.

This method of preventing smoke has not been attended with the success at first expected from it, as is proved by its not having come into general use. Perhaps one source of failure is the difficulty of getting the firemen to supply the coal carefully on the front of the furnace; and hence it has been recommended to employ hoppers, by which the coal is always thrown on the dead-plate; but even when these are used, the consumption of smoke is not complete. As to the heating of the air, by passing it through tubes in the chimney or vent, one great objection to them is the powerful influence they have over the draught. It is well known, that when cold air is allowed to rush into the chimney, the draught is instantly diminished. Now these tubes must operate in the same way; for though the air does not mingle with that in the vent, yet by withdrawing heat from it, it must reduce its temperature, and thus prevent it from being forced up.

By far the most effectual method of consuming smoke is that lately recommended and patented by Ivison. It consists in throwing steam into the fore-part of the furnace, *above the fuel*, by means of a fan-shaped distributor, in the front of which are small apertures, varying in size and number, according to the width of the furnace and the pressure of the steam. In general they are from five to eight or ten in number, and about an eighth or a twelfth of an inch in diameter. The quantity of steam thus admitted is very trifling; and by its passage through the flame and smoke given off from the coals on the charring-plate, it instantly causes the disappearance of the smoke, and accordingly none whatever escapes from the chimney-top, except just when fresh coal is thrown in, and then it is barely perceptible, and only for a few seconds.

When applied to furnaces with boilers, steam is easily procured, by taking from the top of the boiler a small tube, which is carried into the furnace, and connected with the distributor, and by means of a stop-cock the supply is regulated. In cases where there is no boiler, a very small one must be erected, which can be placed on some part of the furnace, and will thus give off steam without any extra expenditure of fuel.

The most remarkable circumstance attending the use of this patent process, is the almost total absence of draught through the ash-pit, consequently little or no air passes up through the fire, while there is a rush of air *over the surface of the fuel*. Hence the necessity of allowing air to flow in by the door of the furnace, or, which is better, by means of tubes placed in the chimney or flues, by which it is heated previous to its entrance; because, as before stated, the admission of cold air must have a prejudicial effect. It is evident from this, that the combustion must proceed almost entirely by air supplied on the surface. Indeed, when properly applied, the supply of air through the ash-pit is almost reduced to nothing; and accordingly the fire can be kept in good condition, even though the ash-pit is closed in front.

In addition to the consumption of smoke, the application of steam in this way is attended with another advantage; the saving of fuel, which is certainly a great recommendation in its favour. Different statements have been given of the amount of saving effected; but if we can place reliance in the reports given by the patentee, it seems to be considerable.

Watt, from his numerous experiments, concluded, that for each pound of coal (English caking) consumed, rather more than eight pounds of water could be evaporated, thus requiring about eight pounds of coal for the cubic foot of water. Since his time, however, improvements in the construction of furnaces have been introduced, which have increased the amount of evaporation.

Mr. Watt's maximum result with Wallsend caking coal, conducted with the greatest care, was 8.9 pound of water to the pound of coal. The lowest was 5.93, the mean 7.4.

Mr. Parkes of Warwick states the ordinary result with one pound of caking coal to be 7.5 pounds, evaporated from 212°, but by his improved method in the furnaces of other persons, it was 8.7, while by a similar mode with his own furnace, it was 10.32 pounds.

With one of the Cornish boilers, coated and covered with the greatest care, and in all other respects rendered as perfect as possible, the result was 11.8 pounds, and a similar result was more recently obtained by Henwood.

The following is a tabular view of the results of Watt and others, shewing the quantity of water evaporated, and the quantity of fuel required for the horse-power of an engine:

EXPERIMENTS.	lbs. water to 1 lb. of English coal.	lbs. English coal to cubic foot water, or horse-power per hour.	Cubic feet of water to 84 lb. English coal.	Cubic feet water to 112 lb. English coal.
Watt's average,..	7.4	8.4	10.	13.33
United Mines Loam (Ed. Phil Jour., July 1839),...	9.58	6.23	12.93	17.24
Parkes of Warwick's method,........................	10.32	6.03	13.9	18.5
Huel Towan (Ed. Phil. Jour., July 1839),..........	10.55	5.9	14.23	18.97
Mr. Henwood's experiment,..........................	11.87	5.32	15.8	21.

By the use of the Ivison patent, when properly applied, the amount of evaporation becomes much greater, as has been certified by repeated trials, by scientific men of eminence, as the following table shews. The experiments were conducted with Scotish coal; and considering the heat given out by it, as compared to English caking coal, to be as three to four, the results will shew the amount of evaporation, or, which is the same thing, the quantity of fuel, used in comparison with what is given in the preceding table.

EXPERIMENTS.	lbs. water to 1 lb. of *Scotish* coal.	lbs. water to 1 lb. of English coal.	lbs. English coal to cubic foot water, or horse-power per hour.	Cubic feet of water to 84 lb. English coal.	Cubic feet water to 112 lb. English coal.
Average of 8 experiments, certified April 13, 1839,....................	11.41	15.21	4.09	20.5	27.4
Average of 3 experiments, certified May 10, 1839,....................	13.94	18.58	3·35	25.	33.46
Average of 12 workings, certified July 1839,........................	13.25	17.66	3.52	23.91	31.78
Maximum result of do.,..............	14.72	19.62	3.12	26.47	35.3
Average of the four preceding lines,.	13.43	17.96	3.46	24.02	32.3

From the above tables it appears, that the greatest quantity of water evaporated by the pound of English coal is 11.37; the maximum result by Ivison's process is, using Scotish coal, 14.72; the average 13.43; which, if we consider the English to the Scotish as four to three, gives 17.9, or equal to only about 3.46 of English coal to the cubic foot of water or horse power of an engine, certainly by far the largest and most economical result on record.

That this mode of consuming smoke is accompanied with saving of fuel, is also proved by comparative trials made with and without the use of steam, on the same furnace, as is shewn by the following table:

Workings with the Patent.			
Date.	Time.	Period of day.	Pounds of Coal used.
Sept. 25, 1838.	5 h. 15 m.	P.M.	560
— 26, —	5 – 15 –	A.M.	449
— 27, —	5 – 15 –	A.M.	612
Average,.................558			

Workings without the Patent.			
Date.	Time.	Period of day.	Pounds of Coal used.
Sept. 25, 1838.	5 h. 15 m.	A.M.	812
— 26, —	5 – 15 –	P.M.	812
— 27, —	5 – 15 –	P.M.	812
Average,.................812			

For the same time, then, and for the same amount of work done, the consumpt of fuel, as shewn by the above table, is in the ratio of 812 to 540, or as 100 to 66, thus indicating a saving of about 33 per cent.

By the admission of steam into the furnace in this way of consuming smoke, the draught is prodigiously increased; hence the absolute necessity, when applied to furnaces having tall chimneys, of resorting to means to counteract it. It is remarkable that the damper in common use has comparatively little or no effect. The means found to answer best are the admission of cold air into the chimney, by apertures, which can be varied in size, according to circumstances; or when this is found not to be sufficient, to have covers to the ash-pit, by which the draught up through the bars may be prevented; for it is only when the draught is properly checked, and a due quantity of air admitted above the fuel, that none flows into the ash-pit. In furnaces to be erected for the purpose, the draught can be sufficiently checked, by making the chimney much narrower and shorter than those now in use. In fact, were it not for the necessity of having a vent to carry off the gaseous products, the chimney might be dispensed with, as the steam of itself creates sufficient draught to carry in air for the combustion. Hence one very great advantage, in addition to the many others, to be derived from this mode; as, independently of economy in fuel, there must be an immense saving in the outlay in constructing furnaces; the application of the steam-tube with its distributor costing very little.

Different opinions are entertained with regard to the *rationale* of this process. Some suppose that the steam merely acts mechanically, by carrying along with it a sufficient quantity of air to maintain the combustion; and that that air flowing *over* the fuel, not only carries on its consumption there, but, acting on the smoke, causes its combustion also, by which of course there is an additional supply of heat. Besides, as the upper part of the furnace is free from smoke, the radiation from the fire must have a more powerful effect on the bottom of the boiler, and those parts of it exposed in the flues being also free from soot, will more easily transmit the heat. If, however, we place reliance on the results of the trials stated above, and the names of the scientific gentlemen by whom they were conducted is a proof of their accuracy, it is difficult to conceive how so large a result should be obtained, were there no further action than the consumption of the fuel. It is generally admitted, that were the whole of the heat from coal undergoing combustion rendered available, about fourteen pounds of water would be evaporated on an average by each pound of coal. But this cannot be done, because part of the heat must necessarily pass off by the chimney; but even with this waste, the quantity of water evaporated by Scotish coal was in some trials beyond fourteen pounds. This has given rise to the idea, that the steam, in addition to its mechanical action of carrying air into the upper part of the furnace, acts also chemically, that in fact it is decomposed and consumed. It has been long known, that when steam is passed through tubes stuffed with incandescent carbon, it is decomposed, and resolved into gaseous products. In a paper published by Dr. Fyfe in the *Edinburgh Phil. Journal*, 1837, it is shewn, that these gaseous products are not carbonic acid and carburetted hydrogen, as at one time supposed, but carbonic oxid and pure hydrogen. Now a similar decomposition may be effected on the steam in the Ivison process; for when it is brought into contact with the carbonaceous matter of the smoke, as given off at a high temperature from the coal on the charring-plate, it may be decomposed, and give, by its action on the smoke, carbonic oxid and hydrogen; and these being freely supplied with air, will be burned, and by their combustion give out an additional supply of heat, and it is well known that the heat given forth by hydrogen is very great. If this explanation be the correct one, (and it is strengthened by the fact, that when the coal is thrown far back in the furnace, so as to be beyond the influence of the steam, it is not consumed), then the smoke is not burned by the direct action of the air, but by first getting oxygen from the steam, so as to form carbonic oxid, and which oxid then receives oxygen from the atmosphere. An additional quantity of oxygen is thus required; and hence most probably the additional amount of heat evolved by the process.

Smoke-Silver. Lands were held in some places by the payment of the sum of sixpence yearly to the sheriff, called *smoke-silver* (Par. 4. Edw. VI.) Smoke-silver and smoke-penny are to be paid to the ministers of divers parishes as a *modus* in lieu of tithe-wood; and in some manors formerly belonging to religious houses, there is still paid, as appended to the said manors, the ancient Peter-pence, by the name of *Smoke money*. (Twisd. *Hist. Vindicat.* 77.)

SMOLENSKO, a circle or government of the eastern side of the Russian empire. It was formerly a part of Lithuania, and being gained by Russia in 1654, was then called White Russia. It is 10,980 square miles in extent, and contains 1,031,860 inhabitants, who are a mixture of Russians, Poles, and Jews. The city from which the province takes its name, stands in a valley, watered by the river Dnieper, which runs from east to west, and which is navigable for barges. The city, which has been rebuilt since the war, is now said to contain 15,000 inhabitants. For this population there are upwards of twenty churches. It has a cathedral for both Catholic and Greek Christians, an ecclesiastical seminary, and a gymnasium or high grammar school. It is a frontier and fortified town, and is remarkable for the great battle fought under the walls of the city, on the 16th of August 1812.

SMOLLETT, Tobias, whose writings have conferred distinguished honour upon the literature of his country, was descended from a family of considerable antiquity and opulence in the county of Dunbarton. His grandfather, Sir James Smollett of Bonhill, married a daughter of Sir Aulay Macaulay of Ardincaple, and by that lady had four sons, of whom Archibald, the youngest, was the father of the novelist. Archibald, who had been bred to no profession, died at an early age, leaving his family, consisting of a widow and three children, one of whom was an infant daughter, solely dependent on the bounty of his father. Smollett was born in 1721, in the old mansion-house of Dulquhurn, now a ruin. It is situated near the village of Renton, in the parish of Cardross. He was baptized Tobias George. The valley of the Leven, in which Smollett first saw the light, is surpassed by no other spot in our island, either for the grandeur of its scenery, or for the venerable associations with which it is connected. Nor was the ground which had been dignified by the tread of Wallace, Bruce, Napier, and Buchanan, dishonoured by the steps of Smollett.

From the grammar-school of Dunbarton, in which he had imbibed the rudiments of classical learning, Smollett was transferred to the University of Glasgow, where he prosecuted his more advanced studies with application and success. He was afterwards bound an apprentice to Mr. John Gordon, an eminent medical practitioner in that city. His elder brother James had adopted the profession of arms, an example which he was ambitious of following; but the old knight probably illustrated the advantages of the study of physic by reasoning which it would have been vain to controvert. When the young student had attained his eighteenth year, his grandfather died, without having made any adequate provision for the children of his youngest son. For this omission, his descendant furnished him with a niche in *Roderick Random*, more conspicuous than desirable.

The term of his apprenticeship having expired in his nineteenth year, and being now thrown upon his own resources, Smollett proceeded to London, where he attracted the notice of Lord Lyttelton. He had carried with him his tragedy of *The Regicide*, a juvenile performance of uncommon merit, but indifferently adapted to the purpose of representation. The various efforts which he ineffectually used to bring his play upon the stage, are detailed with indignant prolixity in the preface to that production, which he sent to the press some years afterwards, with a view of heaping confusion upon the lukewarm patronage of Lyttelton, and upon the shuffling evasions of Garrick. The patron and the manager were visited with many other tokens of his displeasure; but he lived to repent of the severe retribution which he had exacted for trivial wrongs, and made honourable mention of both in his History of England.

Thwarted in his expectations of earning fame and profit as a writer for the stage, Smollett was glad to accept the situation of surgeon's mate on board the Cumberland. That vessel, an eighty-gun ship, belonged to the armament which was bound to the West Indies, to join the fleet under the command of Admiral Vernon. Of the disastrous expedition against Carthagena, Smollett inserted an animated narrative in *Roderick Random*, and afterwards published a more detailed account in the *Compendium of Voyages*. When the discomfited squadrons returned to Jamaica, he quitted the service in disgust, and fixed his residence on the island. With Miss Lascelles, a fascinating West Indian, he there formed an acquaintance, which afterwards ripened into a matrimonial union. In 1746 he returned to London, which then resounded with acclamations occasioned by the victory at Culloden. With these were mingled some expressions of indignation at the atrocities inflicted by the royal army upon the helpless families of the insurgents. The voice of Smollett swelled the weaker cry, and he produced his pathetic ode, *The Tears of Scotland.* During the same year was published, *Advice, a Satire*. His next literary effort was *Alceste, an Opera*, which he wrote at the suggestion of Mr. Rich of Covent Garden Theatre. In consequence of some dispute with that patentee, the piece was withdrawn, and has never appeared in print. In 1747 he published *Reproof*, a second part of his former satirical production. The versification of these poems is sufficiently harmonious, and they abound with impetuous invective; but the rage of the satirist is without dignity, and rabid, without being infectious to readers of the present day. About this period he married Miss Lascelles, who was possessed of a small estate in the island of Jamaica; a precarious species of property, from which her husband appears to have derived little or no ultimate benefit.

In the year 1748, appeared *The Adventures of Roderick Random*. Fielding had already evinced himself a noble follower of Cervantes, and Smollett now stood forth, a no less worthy disciple of Le Sage. It must be owned that in this, and in all the other novels of Smollett, humour frequently appears in very loose attire. These scenes, however, like sheet-lightning, are alarming, but perfectly innocuous. The solemn depravity of Rousseau is more dangerous than the ludicrous indecorum of Smollett. In 1749, *The Regicide* was published by subscription. During the same year Smollett took the degree of M.D., in what University has not been ascertained. In 1750 he went to Paris, where he is supposed to have occupied himself in composing *The Adventures of Peregrine Pickle*, which were published in 1751. This admirable novel is disfigured by the introduction of an impertinent episode, in which are detailed, with unrelenting minuteness, the tedious intrigues of Lady Vane; who is said to have rewarded Smollett handsomely for the drudgery of compiling that durable record of her infamy. To compensate for this blemish, and for some rash sallies of humour, *Peregrine Pickle* is an absolute mine of character and adventure. The entertainment prepared by the learned physician, in the manner of the ancients, is perhaps the most irresistible piece of pleasantry that was ever devised by a ludicrous fancy. In his heroes and heroines, Smollett is not happy. For Random we have no respect; for Pickle we have no esteem; and Narcissa and Emilia are only the objects of appetite. Since the days of Tom Bowling and the Commodore, we have seen many sailors in print, who display an accurate and profound knowledge of technical *minutiae;* but their humour, if they have any, will not pass muster ashore, the medium through which it is conveyed being to uninstructed ears a mere succession of unintelligible gibberish. And these modern tars have all a striking family likeness to each other, with the exception of some sentimental rope-haulers of the American school, who are evidently monsters of the imagination. But each of Smollett's seamen, though drawn to the life, exhibits the strongest idiosyncrasy of character, and converses in a dialect which can be readily understood by those who have never seen a ship.[1]

The next production of Smollett's pen was "An Essay on the External Use of Water, in a letter to Dr. ——; with particular remarks upon the present method of using the Mineral Waters at Bath, in Somersetshire; and a plan for rendering them more safe, agreeable, and efficacious." 1752, 4to. At the period of this publication, Smollett resided at Bath, where he solicited professional employment; but the reputation of the satirist effectually marred the prospects of the physician. Despairing of success in his profession, Dr. Smollett now hired a house at Chelsea, where he entirely devoted himself to literary pursuits. The first fruits of his retirement were, *The Adventures of Ferdinand Count Fathom*, which appeared in 1753. The author's object in this production is, to set up the principal character "as a beacon for the benefit of the inexperienced and unwary." This personage is as much below, as one of Richardson's heroes is above, the standard of general nature. Few men are so virtuous or depraved as to have much sympathy with either; and it may very reasonably be questioned, whether any one was ever allured to virtue by viewing the unattainable perfections of Grandison, or deterred from vice by contemplating the superlative villany of Fathom. Besides, a picture of insipid excellence is at least harmless; but there is a moral insanity about some men, which leads them not only to delight in, but sometimes to emulate the achievements of fictitious desperadoes. The most striking passage in this novel, is the adventure in the forest, which creates terror as strong as the convulsions of laughter which reward the exploits of Trunnion and his myrmidons.

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[1] The incident of Tom Pipes's concealing in his shoe his master's letter to Emilia, it is curious to trace to the following passage in Ovid's Art of Love; which has not escaped the laborious research of Hugo, *De prima Scribendi Origine*, p. 154.

Cum possit solea chartas celare ligatas,
Et vincto blandas sub pede ferre notas.

But although master of the passions of others, Smollett's own were under very indifferent control. A wretch, called Peter Gordon, whom he had maintained for a series of years, and in support of whose credit he had been prevailed upon to indorse notes, suddenly withdrew into the verge of the court, where, by means of insulting letters and messages, he provoked his benefactor to chastise him in such manner as to furnish grounds for an action of damages. The Hon. Alexander Hume Campbell, who was counsel for the plaintiff, having opened the proceedings with much gratuitous insolence towards the defendant and his witnesses, Smollett addressed a letter to that barrister, couched in very indignant and sarcastic terms, which afterwards found its way into the fifth volume of the European Magazine. This infamous prosecution terminated in the discomfiture of Gordon, but the issue of Smollett's dispute with Campbell is involved in obscurity. In the beginning of the year 1755, Smollett published his translation of Don Quixote, which was executed amid the anxiety of pecuniary embarrassment, and for which he had been paid by advance. This version is infinitely more spirited and elegant than that of his immediate predecessor Jarvis. But if Smollett has surpassed Motteux in maintaining the solemn fatuity of the knight, he is less happy in rendering the proverbial humour of the squire; for the corresponding phrases in English had already been appropriated, and he was reduced to the necessity of alteration, when there was no room for improvement. After the publication of Don Quixote, Smollett paid a visit to his native country. Upon his return to England, he undertook the superintendence of the Critical Review. The editorship of that journal involved him in a thousand vexatious disputes with persons who were utterly unworthy of being promoted to the rank of his antagonists. A contemptuous critique on the Rosciad, of which he was entirely innocent, provoked the spleen of Churchill, whose brief career was a perpetual crusade against genius and virtue, and whose coarse and rancorous effusions are now consigned to merited oblivion; for posterity has not realized the hopes of an undying name, so confidently expressed by the reverend bard, who proposed to annihilate the reputation of Pope, and who launched his slight javelins at the massy buckler of Johnson.

In 1757, Smollett published a popular compilation, entitled *A Compendium of Authentic and Entertaining Voyages.* 7 vols. 12mo. During the same year was performed and printed *The Reprisal*, a comedy in two acts. The characters in this piece are strongly marked, and the dialogue is extremely spirited, but the situations are conceived with little dramatic artifice; a species of knowledge which often enables the humble retainer of a playhouse to concoct a drama, which shall be admirably well adapted for the stage, and yet prove not more entertaining in the closet than a book of arithmetic. In the same year was published the "Complete History of England, deduced from the Descent of Julius Cæsar to the Treaty of Aix-la-Chapelle, 1748, containing the transactions of one thousand three hundred and three years." 4 vols. 4to. This surprising effort of industry and genius, is said to have been begun and completed in the course of fourteen months. If not the most accurate and philosophical of historians, Smollett yields to few in the unaffected elegance of his style, and in the graceful animation of his narrative. He had been bred a Whig, and whatever were the motives that led to the political tergiversation which is manifested in this work, it would be uncharitable to suppose that they were those of self-interest; a consideration which does not seem to have influenced any one action of his life.

In 1759, an article appeared in the Critical Review, animadverting in strong terms upon the conduct of Admiral Knowles, who had written a pamphlet to vindicate himself from the popular odium which attached to his character, in consequence of his share in a secret expedition to the French coast, which was planned and miscarried in 1757.[1] The admiral having commenced a prosecution against the printer, of which the avowed object was to induce the writer to declare himself, and give him satisfaction of another kind, Smollett, in this dilemma, solicited the good offices of his friend Wilkes, whose rhetoric made no impression on the incensed commander. At this juncture, Smollett stepped boldly forth, and proclaimed himself the author of the obnoxious article, offering the aggrieved party any satisfaction that he might desire. Upon this declaration, the magnanimous flag-officer immediately withdrew his action against the printer, and entered a fresh suit against the reviewer. The result of the action was, that Smollett was fined one hundred pounds, and sentenced to three months imprisonment in the King's Bench.

To cheer the gloom of his confinement, this indefatigable writer employed himself in composing *The Adventures of Sir Launcelot Greaves*, which first appeared in the *British Magazine* for 1760 and 1761, and was published in a separate form in 1762. The eye of criticism has always looked coldly upon this performance. Although it is one of those works, of which the execution must be admitted to surpass the conception, the story of the modern Don Quixote is no such incredible figment as it has been pronounced. Sir Launcelot Greaves is represented as a person of diseased understanding; and who shall set bounds to the vagaries of insanity? Nor does Captain Crowe appear to act out of character, in becoming a candidate for the honours of chivalry. For that original is in a state of happy ignorance concerning all terrestrial affairs; and the profession of a knight-errant appears to his unsophisticated understanding to be as lawful a calling as that of a tide-waiter; and it is one which is not at all discordant with the headlong courage and extravagant generosity of a British seaman.

To the modern part of Universal History, which was begun in 1759, and completed in 1764, Smollett contributed the histories of France, Italy, and Germany. In 1761 had appeared the first number of his *Continuation of the History of England*, which he finished in 1765; the narrative comprehending the transactions down to that period.

Upon the accession of George III., Smollett appeared in the character of a political partisan, and drew his pen in defence of the administration of Lord Bute, in a weekly paper, entitled *The Briton.* But being speedily tired of protecting from obloquy a minister who was indifferent to public opinion, he retired from the strife, leaving his antagonist, *The North Briton*, master of the field. This contest terminated an intimacy of long standing between Smollett and Wilkes. Notwithstanding his inferiority in talents, that demagogue had some decided advantages over his opponent. Wilkes was a cool political pugilist, who gathered courage from the applauses of the mob; while Smollett was greeted with a general burst of popular execration, which worked him into a phrensy that deprived him of his strength.

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[1] The offensive words were, "He is an admiral without conduct, an engineer without knowledge, an officer without resolution, and a man without veracity." Knowles was one of the heroes of Carthagena, at which memorable expedition he commanded the Weymouth, of 60 guns.

Smollett's name stands in the title-page of a translation of the works of Voltaire, and also in that of a compilation, entitled *The Present State of all Nations.* These works, to which he contributed sparingly, were published in 1763. In that year he sustained an irreparable loss in the death of his only child, a daughter named Elizabeth, who had attained the fifteenth year of her age. This calamity threw an impenetrable gloom over the brief remainder of his life. In the hope of dissipating his own grief and that of his wife, by change of scene, he passed over into France; in which country, and in Italy, he resided for two years. In 1766, he published his *Travels through France and Italy.* This production displays his usual acuteness of observation, and felicity of expression, but he appears to have contemplated every object through the distorted medium of disease and lacerated feelings. Sterne, who had met the bereaved father abroad, took an opportunity of exulting over the infirmities of rival genius in his Sentimental Journey.

In 1766, Smollett visited Scotland for the last time. At this period, he was a martyr to asthma and rheumatic pains, and afflicted with a virulent ulcer on his arm. In the following year, while residing at Bath, he enjoyed a short interval of convalescence, during which he wrote *The Adventures of an Atom.* In this political romance, he has blended, with greater dexterity than judgment, the reckless jollity of Rabelais with the withering sarcasm of Swift. With much wit and humour, this production betrays great physical indelicacy, a latent ferocity of sentiment, and an unqualified abhorrence of the lower order of the community, which is far from edifying. It may here be remarked, that the learning which is scattered through the fictitious narratives of Smollett, would, with proper management, make a most imposing show in works of much graver pretensions. Neither does he ever, like Fielding, hover on the verge of pedantry; nor resort to the disingenuous artifice of dazzling unlettered eyes with borrowed erudition, like Sterne, who had cool effrontery enough to express his sovereign contempt of literary larceny, in the unacknowledged words of Burton.[1]

After the publication of this romance, Smollett's complaints returned with increased violence, and his medical friends declared that his only chance of life lay in a more salubrious climate. To the great he never applied in vain, for he never applied at all. His friends however made some fruitless efforts to interest the ministry in his behalf. But from Smollett was sternly withheld that bounty which has often, before and since, been lavished with a prodigal hand upon the most worthless and foolish of mankind. With a constitution worn to the dregs in the service of literature, and with a purse which had been emptied in the lap of indigence, Smollett proceeded to Italy in 1770.

The last, and perhaps the best of all his works, was *The Expedition of Humphrey Clinker*, published in 1771. Each character in the galaxy of originals which are there pourtrayed, may submit without apprehension to Ben Jonson's test of humour:

> When some one peculiar quality
> Doth so possess a man, that it doth draw
> All his affects, his spirits, and his powers,
> In their conflictions, all to run one way,
> This may be truly said to be a humour.

Having bequeathed this legacy to the public, Smollett died at Monte Nero, a village in the neighbourhood of Leghorn, on the 21st of October 1771, in the fifty-first year of his age. A monument was erected to his memory by his widow, and a cenotaph on the banks of the Leven by his cousin, Mr. Smollett of Bonhill.

To a handsome person, and an address at once dignified and engaging, Smollett added colloquial powers of the highest order. His irascible passions were strong, but his social affections were not less so. If it is remembered that his personal and political prejudices were intense, let it not be forgotten that zealous friendship and ardent patriotism were among the number. He was improvident, for his hand was only closed to the necessities of others when he had nothing to bestow. He was a man of undaunted resolution, and lofty independence of mind. He was vindictive, but not implacable, and melted at the first appearance of contrition in those who had injured him. He was jealous of his fame, his sole possession, but he envied that of no other man, whether deserved or otherwise. Of Smollett, as an author, it may be truly said, that of the many different kinds of composition which he has attempted, there is none to which he has not communicated peculiar graces; nor can we hesitate for a moment in adding his name to the scanty list of those who have extended the limits of intellectual enjoyment.[2]

SMOOTH ISLAND, on the east coast of Van Diemen's Land, in Norfolk Bay, about three-quarters of a mile long.

SMUGGLERS, persons who import or export prohibited goods without paying the duties appointed by the law. When we consider the nature, and still more the history of mankind, we must allow that the enacting of severe penal laws is not the way to prevent crimes. It is indeed much to be wished that there were no such thing as a political crime; for the generality of men, but especially the poorer classes, not discerning the propriety or utility of such laws, consider them as oppressive and tyrannical, and never hesitate to violate them when they can do it with impunity. Instead therefore of punishing smugglers, it would be much better to remove the temptation. But the high duties which have been imposed upon the importation of many different sorts of foreign goods, in order to discourage their consumption in Great Britain, have in many cases served only to encourage smuggling; and in all cases have reduced the revenue of the customs below what more moderate duties would have afforded. The saying of Dr. Swift, that in the arithmetic of the customs two and two, instead of making four, make sometimes only one, holds perfectly true with regard to such heavy duties, which never could have been imposed, had not the mercantile system taught us, in many cases, to employ taxation as an instrument, not of revenue, but of monopoly.

The bounties which are sometimes given upon the exportation of home produce and manufactures, and the drawbacks which are paid upon the re-exportation of the greater part of foreign goods, have given occasion to many frauds, and to a species of smuggling more destructive of the public revenue than any other. In order to obtain the bounty or drawback, the goods, it is well known, are sometimes shipped and sent to sea, but soon afterwards clandestinely relanded in some other part of the country.

Heavy duties being imposed upon almost all goods imported, our merchant importers smuggle as much, and make entry of as little as they can. Our merchant exporters, on the contrary, make entry of more than they export; sometimes out of vanity, and to pass for great dealers in goods which pay no duty; and sometimes to gain a bounty or a drawback. Our exports, in consequence of these different frauds, appear upon the custom-house books greatly to overbalance our imports; to the unspeakable comfort of those politicians who measure the national prosperity by what they call the balance of trade.

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[1] See Scott's Biographical Memoirs of eminent Novelists, vol. i. p. 294.

[2] For more circumstantial details of the life of Smollett, the reader is referred to the narratives of Dr. Anderson and Dr. Moore.

SMYRNA, a large commercial city of Asia Minor, situated at the head of a long and winding gulph on the western coast of the Grecian Archipelago, and, with the exception of Constantinople, the most important sea-port of the Turkish empire. It has an imposing appearance from the sea; and its bay, besides numerous small craft, is frequented by ships from the chief ports of Europe. The present town is about four miles in circuit, and extends about a mile along the water. The bay is so completely landlocked, that nothing is seen from the town but the projecting points that enclose it. The interior of the city is not so inviting as its aspect from without. The streets are narrow, dirty, and ill-paved, and the houses are for the most part unseemly wooden edifices; but though their external appearance is rather gloomy, the situation of those built along the water is delightful, as they have all gardens attached to them, at the foot of which are summer-houses overlooking the sea. Of late years Smyrna has been greatly improved, and well-built hotels and excellent lodging-houses now invite the traveller to a city where, we are assured, not only the "decencies of house-keeping and house-furnishing, but the comforts and luxuries of life flow in abundantly from London and from Paris." The houses of painted wood, which were so unworthy of its ancient fame, are rapidly giving way to palaces of stone, which are rising in all directions; and in the course of a few years Smyrna will really be an elegant city, with every indication of prosperity and opulence. The bazaars, though well provided with goods, are by no means splendid in their structure. There are two very fine caravanseras, enclosing square courts, which, being covered with cupolas, make a handsome appearance. The shops are also arched over, and are very fine. The principal buildings are the mosques, the baths, the inns, and the market-place. Some of the mosques are very noble edifices; and likewise the inns, as already remarked. At the east end of the city is a large hill, about three quarters of a mile in circumference, on which the castle was built. The edifice appears to have been the work of the Genoese, and to have been by no means magnificent. Along its circumference, however, may still be traced the remains of a very thick and strong wall, apparently that of the ancient castle, and corresponding in its appearance with another which appears to have surrounded the whole city. Behind the city is an extensive plain, most luxuriant and highly cultivated, and crowned with numerous olive-trees; it is watered by a small river, from fifty to a hundred yards broad, which contains little water, unless when artificially confined. Of the former magnificence of this ancient city, scarcely any traces are now to be seen. The reason of this is stated by Pococke to be, that the ancient structures have been demolished to furnish materials for modern ones; and a more recent traveller, Arundel, assigns much the same reason. The present does not occupy the site of the ancient city. The latter was situated on the hills, to the south of the present town; but the earthquakes to which it is subject, and by which it was more than once nearly destroyed, together with the greater convenience of trade, occasioned its removal to the plain below, and to the lower declivities of the mountains; and accordingly it is observed by Mr. Arundel, that "few of the Ionian cities have furnished more relics of antiquity, or of greater merit, than Smyrna. But the convenience of transporting them, with the number of investigations, have exhausted the ruins; it is therefore not at all wonderful, that of the stoas and temples, the very ruins have vanished; and it is now extremely difficult to determine the sites of any of the ancient buildings, with the exception of the stadium, the theatre, and the temple of Jupiter Acræus, which was within the Acropolis." Of the stadium here mentioned, the ground-plan only remains, stript of its marble seats and decorations; and only the foundations can be seen of the splendid theatre, built on the slope of a hill, the site of which is now covered with houses. On a gateway belonging to the castle is a colossal statue of very fine workmanship, though much mutilated, which has been supposed to be that of the Amazon Smyrna, from which the city is reported to have derived its name. Marks of a very extensive aqueduct may also be traced, though a late traveller doubts of its very high antiquity.

Smyrna is increasing in population and in wealth. It is a great commercial emporium, and a crowded resort of merchants from all countries, with their various costumes, language, and religion. It is the most general entrepôt for the productions of the Levant, and its port is crowded with ships from the most distant ports. It has a safe and capacious roadstead, where there is good anchorage, and where the largest ships can load and unload close to the wharfs. Nearly every power in Europe has a consul at Smyrna, who is vested with more than ordinary authority. There are about twenty commercial houses at Smyrna; and the Venetians, Genoese, and other Italians, the Dalmatians, Dutch, French, and Americans, have also establishments. No other town in Asiatic or European Turkey has so great a trade. All classes are engaged in business. The higher order of Franks deal often to a great extent; while the lower classes, consisting of persons from nearly every country in the Mediterranean, obtain employment as boatmen, carpenters, tailors, shoemakers, and the trade is carried on by Jews, mostly brokers. The Greek dealers are in general petty shopkeepers, very cunning, and not remarkably trustworthy. The Jews are liable to the same objections, but they often guarantee each other's transactions. The Armenians are the largest traffickers, but though usually strict at a bargain, they are generally solvent, and honourable as well as honest. The Turkish dealers, are, however, superior to them in all moral qualities, as they are inferior in means and in talents for business; yet they sometimes deal largely, and their bond is punctually discharged the day it becomes due.

The largest article of import is coffee, the favourite beverage of all classes in Turkey and Western Asia. The chief supply is derived from America, from England, France, also in smaller quantities from Holland, Trieste, Leghorn, and Genoa. Sugar is the next article in importance, and the supply is furnished by the same countries which supply coffee. Indigo is exclusively imported from England. The exports from Smyrna consist of silk from Brassa, about two hundred miles from Smyrna, which is forwarded by caravans to this port, and is the richest article of export. This branch of trade promises to increase, as there is so great a demand for the raw material in Britain. Opium is largely exported, particularly to America, whence it has found its way to China, though the trade is now vigorously proscribed by the Chinese authorities, and has caused the expulsion of the English from the port of Canton. Drugs and gums are exported to the English market; galls for England, Germany, France, and Valona or Avlona, a sea-port in European Turkey at the entrance of the Gulf of Venice. British shipping receives full cargoes of this more than of any other article, with the exception of fruit. These, with madder, sponges, olive-oil, wax, hare-skins, goats and sheep's wool, complete the articles of export. Figs and raisins may be considered as the great staple article of Smyrna, which are celebrated for their excellence, and are exported in large quantities. The exports from this country to Smyrna are increasing. From 1827 to 1830, they had increased from L.531,704 to L.1,139,616, nine-tenths of which were cotton goods, for which there is a great desire, being cheaper than those from any other quarter; and the late commercial treaty concluded with Turkey in 1838 will extend this trade.

Smyrna is well supplied with provisions, with fish and fruit of all kinds, and with excellent wines from the interior or from the islands. Of late years a great change has taken place in the manners and character of its inhabitants. Mr. Arundel, who resided many years in the place as British chaplain, has stated that numerous printing-presses, and journals in the different languages, viz. French, English, Greek, and Italian, have familiarised the inhabitants of Smyrna with the politics and literature of Europe. Even a few years ago, the Greek youths of Smyrna had no other means of acquiring knowledge, but very inferior day-schools and private instruction. There are now not only several seminaries, one dignified with the name of a college, for the education of the French youth of both sexes, but likewise for the Greeks there are various free schools, where numerous pupils not only learn the rudiments of knowledge, but also every branch of polite literature. There is a public dispensary, where persons of all nations are gratuitously relieved without regard to any distinction of religion. It is not easy to form an accurate account of the population. Mr. Arundel estimates the number of inhabitants from 100,000 to 120,000. There are twenty mosques, three Greek churches, two for Roman Catholics, one Armenian, one Protestant Episcopal, and one Dutch. The Jews have numerous synagogues, and the environs are adorned with cypress groves, the burial-places of the Mahometans.

Smyrna was one of the most celebrated cities in the ancient world, and claims, along with others, to be the birthplace of Homer. It is said originally to have been a colony from Ephesus, and soon attained to great prosperity. The original city was destroyed by the Lydians, and was rebuilt by Antigonus and Lysimachus, though on a somewhat different spot. It surpassed its former splendour: the streets were beautifully laid out, well paved, and adorned with porticoes. Under the Roman emperors, Smyrna, which was esteemed one of the most beautiful of the Ionian cities, was ruined by the desolations of the barbarians. It was captured by Tamerlane, and sacked, with great slaughter of the inhabitants. When the Turks gained undisputed possession of the Greek empire, and peace was restored, commerce again revived, owing to the favourable position of the place; and from that period it enjoyed almost uninterrupted repose, until the era of the Greek revolution. That event has now passed away, and Smyrna is prospering as the greatest commercial city in the Levant. Long. 27. 4. 45. E. Lat. 38. 29. N.

SNAFFLE, in the manege, is a very slender bit-mouth without any branches. It is much used in England, the true bridles being reserved for war.

SNAITH, a town in the Wapentake of Osgoldcross, in the West Riding of the county of York, one hundred and seventy-four miles from London. It stands on the navigable river Aire, in a pleasant situation. The inhabitants were in 1801, 688; in 1811, 743; in 1821, 834; and in 1831, 885; but the inhabitants of the whole parish are 8530.

SNAKE, in *Zoology*. See SERPENTS.

SNARES, a cluster of seven craggy islands in the South Pacific Ocean, discovered by Vancouver. Long. 166. 20. E. Lat. 48. 3. S.

SNEEK, a town in the Netherlands, in the province of Friesland, the capital of a circle of the same name. It is situated on a canal connected with Leuwarden, a place of much activity, having many saw and oil mills, and some manufactories of pottery ware, and exporting much corn. It contains two churches, a stadthouse, and 6455 inhabitants.

SNEEZING, a convulsive motion of the muscles of the breast, by which the air is expelled from the nose with much vehemence and noise. It is caused by the irritation of the upper membrane of the nose, excited by acrid substances floating in the air, or by medicines called *sternutatory*.

This irritation is occasioned either externally, by strong smells, or by dust floating in the air, and taken in by inspiration; or by sharp pungent medicines, as cresses and other sternutatories, which vellicate the membrane of the nose; or internally, by the acrimony of the lympha or mucus, which naturally moistens that membrane. The matter cast forth in sneezing comes primarily from the nose and throat, the pituitary membrane continually exuding a mucus; and, secondarily, from the breast, the trachea, and the bronchia of the lungs.

The practice of saluting the person who sneezed existed in Africa, among nations unknown to the Greeks and Romans. The accounts we have of Monomotapa inform us,[1] that when the prince sneezes, all his subjects in the capital are advertised of it, that they may offer up prayers for his safety. The author of the *Conquest of Peru* assures us, that the cacique of Guachoia having sneezed in presence of the Spaniards, the Indians of his train fell prostrate before him, stretched forth their hands, and displayed to him the accustomed marks of respect, while they invoked the sun to enlighten him, to defend him, and to be his constant guard.

Every body knows that the Romans saluted each other on these occasions: and Pliny relates,[2] that Tiberius exacted these signs of homage when drawn in his chariot. Superstition, whose influence can debase every thing, had degraded this custom for several ages, by attaching favourable or unfavourable omens to sneezing, according to the hour of the day or night, according to the signs of the zodiac, according as a work was more or less advanced, or according as one had sneezed to the right or to the left.[3] If a man sneezed at rising from table or from his bed, it was necessary for him to sit or lie down again. You are struck with astonishment, said Timotheus to the Athenians, who wished to return into the harbour with their fleet,[4] because he had sneezed; you are struck with astonishment, because among ten thousand there is one man whose brain is moist.

Polydore Virgil pretends, that in the time of Gregory the Great, there reigned in Italy an epidemic distemper, which carried off by sneezing all those who were seized by it; and that this pontiff ordered prayers to be made against it, accompanied by certain signs of the cross. But besides that there are very few cases in which sneezing can be considered as dangerous, and that it is frequently a favourable symptom,[5] it is evident, that we ought not to date from the sixth century the origin of a custom which loses itself in the obscurity of antiquity. Avicenna and Cardan aver that it is a sort of convulsion, which gives occasion to dread an epilepsy, and that this disease is endeavoured to be warded off by prayers. Clement of Alexandria considers it as a mark of intemperance and effeminacy, which ought to be proscribed; and he inveighs bitterly against those who endeavour to procure sneezing by external aid. Montaigne, on the contrary, explains this fact in a tone rather cynical. It is singular enough, that so many ridiculous, contradictory, and superstitious opinions, have not abolished those customary civilities which are still preserved equally among high and low; and which only the Anabaptists and Quakers have rejected, because they have renounced salutations in every case.

Among the Greeks sneezing was almost always a good omen. It excited marks of tenderness, of respect, and attachment. The genius of Socrates informed him by sneezing, when it was necessary to perform any action. The young Parthenis, hurried on by her passion, resolved to write to Sarpedon an avowal of her love; she sneezes in the most tender and impassioned part of her letter: this is sufficient for her; this incident supplies the place of an answer, and persuades her that Sarpedon is her lover. Penelope, harassed by the vexatious courtship of her suitors, begins to curse them all, and to pour forth vows for the return of Ulysses. Her son Telemachus interrupts her by a loud sneeze. She instantly exults with joy, and regards this sign as an assurance of the approaching return of her husband. Xenophon was haranguing his troops; a soldier sneezed in the moment when he was exhorting them to embrace a dangerous but necessary resolution. The whole army, moved by this presage, determined to pursue the project of their general; and Xenophon ordered sacrifices to Jupiter the preserver.

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[1] Strada, Prol Acad.

[2] Plin. Hist. Nat. lib. ii. cap. 2.

[3] Spond. Comment. in Homerum.

[4] Frontin. lib. i. cap. 11.

[5] Hippocrates. Halleri Phys.

This religious reverence for sneezing, so ancient, and so universal even in the times of Homer, always excited the curiosity of the Greek philosophers, and of the rabbins. These last have spread a tradition, that, after the creation of the world, God made a general law to this purport, that every living man should sneeze but once in his life, and that at the same instant he should render up his soul into the hand of his Creator, without any preceding indisposition. Jacob obtained an exemption from the common law, and the favour of being informed of his last hour. He sneezed and did not die; and this sign of death was changed into a sign of life. Notice of this was sent to all the princes of the earth; and they ordained that in future sneezing should be accompanied with forms of blessing, and vows for the persons who sneezed.

Aristotle likewise remounts to the sources of natural religion. He observes, that the brain is the origin of the nerves, of our sentiments, our sensations, the seat of the soul, the image of the Divinity; that upon all these accounts, the substance of the brain has ever been held in honour; that the first men swore by their head; that they durst not touch nor eat the brains of any animal; that it was even a sacred word which they dared not to pronounce. Filled with these ideas, it is not wonderful that they extended their reverence even to sneezing. Such is the opinion of the most ancient and sagacious philosophers of Greece.

According to mythology, the first sign of life Prometheus's artificial man gave was by sternutation. This supposed creator is said to have stolen a portion of the solar rays; and filling with them a phial, which he had made on purpose, sealed it up hermetically. He instantly flies back to his favourite automaton, and opening the phial, holds it close to the statue; the rays still retaining all their activity, insinuate themselves through the pores, and set the fictitious man a-sneezing. Prometheus, transported with the success of his machine, offers up a fervent prayer, with wishes for the preservation of so singular a being. His automaton observed him, and, remembering his ejaculatious, was very careful, on the like occasions, to offer these wishes in behalf of his descendants, who perpetuated it from father to son in all their colonies.

SNIGGLING, a method of fishing for eels, chiefly used in the day time, when they are found to hide themselves near wears, mills, or flood-gates.

SNIPE. See ORNITHOLOGY.

SNOW, a well-known meteor, formed by the freezing of the vapour of water in the atmosphere. It differs from hail and hoar-frost, in being as it were crystallized, which they are not. This appears in examining a flake of snow by a magnifying glass; when the whole of it will appear to be composed of fine shining spicula diverging like rays from a centre. As the flakes fall down through the atmosphere, they are continually joined by more of those radiated spicula, and thus increase in bulk like the drops of rain or hailstones. Dr. Grew, in a discourse of the nature of snow, observes, that many parts thereof are of a regular figure, for the most part stars of six points, and are as perfect and transparent ice as any we see on a pond. Upon each of these points are other collateral points, set at the same angles as the main points themselves; among which there are divers other irregular, which are chiefly broken points, and fragments of the regular ones. Others also, by various winds, seem to have been thawed and frozen again into irregular clusters, so that it seems as if the whole body of snow were an infinite mass of icicles irregularly figured; that is, a cloud of vapours being gathered into drops, the said drops forthwith descend; upon which descent, meeting with a freezing air as they pass through a colder region, each drop is immediately frozen into an icicle, shooting itself forth into several points; but these still continuing their descent, and meeting with some intermitting gales of warmer air, or in their continual waftage to and fro, touching upon each other, some of them are a little thawed, blunted, and again frozen into clusters, or entangled so as to fall down in what we call flakes.

The lightness of snow, although it is firm ice, is owing to the excess of its surface, in comparison to the matter contained under it; as gold itself may be extended in surface till it ride upon the least breath of air.

The whiteness of snow is owing to the small particles into which it is divided; for ice, when pounded, will become equally white. An artificial snow has been made by the following experiment. A tall phial of aquafortis being placed by the fire till it is warm, and filings of pure silver, a few at a time, being put into it, after a brisk ebullition, the silver will dissolve slowly. The phial being then placed in a cold window, as it cools, the silver particles will shoot into crystals, several of which running together, will form a flake of snow, which will descend to the bottom of the phial. While they are descending, they represent perfectly a shower of silver snow, and the flakes will lie upon one another at the bottom, like real snow upon the ground.

According to Signor Beccaria, clouds of snow differ in nothing from clouds of rain, but in the circumstance of cold that freezes them. Both the regular diffusion of the snow, and the regularity of the structure of its parts, particularly some figures of snow or hail which fall about Turin, show that clouds of snow are acted upon by some uniform cause like electricity; and he endeavours to show how electricity is capable of forming these figures. He was confirmed in his conjectures by perceiving, that his apparatus for observing the electricity of the atmosphere never failed to be electrified by snow as well as rain. Professor Winthrop sometimes found his apparatus electrified by snow when driven about by the wind, though it had not been affected by it when the snow itself was falling. A more intense electricity, according to Beccaria, unites the particles of hail more closely than the more moderate electricity does those of snow, in the same manner as we see that the drops of rain which fall from thunder-clouds are larger than those which fall from others, though the former descend through a less space.

But we are not to consider snow merely as a curious and beautiful phenomenon. The Great Dispenser of universal bounty has so ordered it, that it is eminently subservient, as well as all the works of creation, to his benevolent designs. Were we to judge from appearances only, we might imagine, that so far from being useful to the earth, the cold humidity of snow would be detrimental to vegetation. But the experience of all ages asserts the contrary. Snow, particularly in those northern regions where the ground is covered with it for several months, fructifies the earth, by guarding the corn or other vegetables from the intenser cold of the air, and especially from the cold piercing winds.

Snow or ice water is always deprived of its fixed air, which escapes during the process of congelation. Accordingly, as some of the inhabitants of the Alps who use it for their constant drink, have enormous wens upon their throats, it has been ascribed to this circumstance. If this were the cause of these wens, it would be easy to remove it by exposing the snow-water to the air for some time. But several eminent physicians have rejected the notion that snow-water is the cause of these wens; for in Greenland, where snow-water is commonly used, the inhabitants are not affected with such swellings; and on the other hand, they are common in Sumatra, where snow is never seen.

SNOWDON, one of the highest mountains in Wales. It is within the county of Carnarvon, but extends to the borders of Merionethshire. The highest point of the range is 3571 feet above the level of the sea. The snow begins to fall on it in November, and is seldom melted till the middle of June. It is easily accessible in several directions. The view from the summit is extensive and grand, on a clear day, which does not often occur. The hills of Scotland are to be seen, with a part of the coast, as well as the Isle of Man; and the hills of Lancashire, Westmoreland, and Cumberland, and, in some very translucent days, the hills of Kerry, in Ireland, have been perceived. The mountain of Snowdon was held sacred by the ancient Britons.

SNYDERS, Francis, a Flemish painter, born at Antwerp in 1579, and bred under his countryman Henry Van Balen. His genius first displayed itself in painting fruit; he afterwards attempted animals, huntings, &c., in which he exceeded all his predecessors. He also painted kitchens, &c., and gave dignity to subjects that seemed incapable of it. He was made painter to Ferdinand and Isabella, archduke and duchess, and became attached to the house of the cardinal infant of Spain. The king of Spain and the elector Palatine adorned their palaces with huntings by this artist. Rubens, Jordaens, and Snyders, used to co-operate in the enriching of each other's pictures according to their several talents; and thus they became more valuable than if finished by either of them singly. Snyders died in 1657.

SOAGHIM, a town of Hindustan, in the Mahratta territories, province of Malwah, sixty miles west from Ooojain. Long. 74. 50. E. Lat. 23. 12. N.

SOANE River has its rise on the east of the table land of Omercuntire, in the province of Gundwana. It flows through Pindarah, where, being joined by numerous other streams from the north-east side of this mountainous territory, it proceeds in a northerly course to the Ganges, which it joins in the province of Bahar, after a winding course of about five hundred miles.

SOANK, a small river of Hindustan, in the province of Bahar, whence it flows in a southerly direction, and being joined by the small river Borkee, their united streams form the Braminy Nuddy river.

SOAP, a composition of caustic, fixed alkaline salt, and oil, sometimes hard and dry, sometimes soft and liquid; much used in washing, whitening linens, and by dyers and fullers. Soap may be made by several methods, which however all depend upon the same principle. The soap which is used in medicine is made without heat.

In manufactures where large quantities of it are prepared, soap is made with heat. A lixivium of quicklime and soda is made, but is less concentrated than that above referred to, and only so much that it can sustain a fresh egg. A part of this lixivium is to be even diluted and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When this mixture begins to unite well, the rest of the lixivium is to be added to it; and the whole is to be digested with a very gentle heat, till the soap be completely made. A trial is to be made of it, to examine whether the just proportion of oil and alkali has been observed. Good soap of this kind ought to be firm, and very white when cold; not subject to become moist by exposure to air, and entirely miscible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the surface. When the soap has not these qualities, the combination has not been well managed, or the quantity of salt or oil is too great, which faults must be corrected.

In soft or liquid soaps, green or black soaps, cheaper oils are employed, as oil of nuts, of hemp, of fish, &c. These soaps, excepting in consistence, are not essentially different from white soap. Fixed alkalies are much disposed to unite with oils that are not volatile, both vegetable and animal, since this union can be made even without heat. The compound resulting from this union partakes at the same time of the properties of oil and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap is less combustible than when pure, from its union with the alkali, which is an inflammable body. It is miscible, or even soluble, in water, to a certain degree, by means of the alkali. Soap is entirely soluble in spirit of wine; and still better in aquavitæ sharpened by a little alkaline salt, according to an observation of Mr. Geoffroy.

The manufacture of soap in London first began in the year 1524; before which time this city was served with white soap from foreign countries, and with gray soap speckled with white from Bristol, which was sold for a penny a pound; and also with black soap, which sold for a halfpenny a pound.

Concerning the decomposition of soap by means of acids, we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting fixed alkali, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with bases of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acid of these salts, may unite more or less intimately with the substance which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has shown. When first exposed to fire, it yields a phlegm called by him a *spirit;* which nevertheless is neither acid nor alkaline, but some water which enters into the composition of soap. It becomes more and more coloured and empyreumatic as the fire is increased, which shows that it contains the most subtle part of the oil. It seems even to raise along with it, by help of the oil and action of the fire, a small part of the alkali of the soap: for, as the same chemist observes, it occasions a precipitate in a solution of corrosive sublimate. After this phlegm the oil rises altered, precisely as if it had been distilled from quicklime, that is, empyreumatic, soluble in spirit of wine, at first sufficiently subtle and afterwards thicker. An alkaline residuous coal remains in the retort, consisting chiefly of the mineral alkali contained in the soap, and which may be disengaged from the coal by calcination in an open fire, and obtained in its pure state.

Alkaline soaps are very useful in many arts and trades, and also in chemistry and medicine. Their principal utility consists in a detersive quality that they receive from their alkali, which, although it is in some measure saturated with oil, is yet capable of acting upon oily matters, and of rendering them saponaceous and miscible with water. Hence soap is very useful to cleanse any substances from all fat matters with which they happen to be soiled. Soap is therefore daily used for the washing and whitening of linen, for the cleansing of woollen cloths from oil, and for whitening silk and freeing it from the resinous varnish with which it is naturally covered. Pure alkaline lixiviums being capable of dissolving oils more effectually than soap, might be employed for the same purposes; but when this activity is not mitigated by oil, as it is in soap, they are capable of altering, and even of destroying entirely, by their causticity, most substances, especially animal matters, as silk, wool, and others; whereas soap cleanses from oil almost as effectually as pure alkali, without danger of altering or destroying; a circumstance which renders it very useful.

Soap was imperfectly known to the ancients. It is mentioned by Pliny as made of fat and ashes, and as an invention of the Gauls. Aretæus and others inform us, that the Greeks obtained their knowledge of its medical use from the Romans.

The following Table shows the quantity of Soap charged with the duties of Excise in the United Kingdom during the years 1835, 1836, *and* 1837, *and the number of Soap-makers during the same period, with the duties paid by them.*

	Quantities Charged.			Amount of Duty.								
	1835.	1836.	1837.	1835.			1836.			1837.		
Hard Soap, lbs.	148,806,207	146,539,210	140,822,611	£930,038	15	8	£915,860	18	4½	£880,141	6	3
Soft Soap........	12,103,109	13,358,894	11,794,834	50,429	12	5	55,662	1	2	49,145	2	10
Soap-makers....	450	432	402	1,800	0	0	1,728	0	0	1,608	0	0

The direct duty charged on hard soap is 1½d. per lb., and on soft soap 1d. per lb. Previously to June 1833, the duty on hard soap was 3d. per lb. The exorbitant amount of the tax, which was fully 100 per cent. on the cost, gave occasion to a great deal of smuggling, which is still carried on to some extent, and is facilitated by the injudicious regulation of taxing this commodity in one part of the kingdom, and leaving it untaxed in another; no duty being charged on soap manufactured in Ireland, and the duty being drawn back from such quantities as are imported into Ireland from Britain.

SOCAGE, in its most general and extensive signification, seems to denote a tenure by any certain and determinate service. And in this sense it is by our ancient writers constantly put in opposition to chivalry or knight-service, where the tenure was precarious and uncertain. The service must therefore be certain, in order to denominate it socage; as to hold by fealty and twenty shillings rent; or, by homage, fealty, and twenty shillings rent; or, by homage and fealty without rent; or, by fealty and certain corporal service, as ploughing the lord's land for three days; or, by fealty only without any other service; for all these are tenures in socage.

Socage is of two sorts: *free*-socage, where the services are not only certain but honourable; and *villein* socage, where the services, though certain, are of a baser nature. Such as hold by the former tenure are called, in Glanville and other subsequent authors, by the name of *liberi sokemanni*, or tenants in free-socage. The word is derived from the Saxon appellation *soc*, which signifies liberty or privilege, and, being joined to an usual termination, it forms *socage*, in Latin *socagium*, signifying a free or privileged tenure.

It seems probable that the socage-tenures were the relics of Saxon liberty; retained by such persons as had neither forfeited them to the king, nor been obliged to exchange their tenure for the more honourable, as it was called, but at the same time more burthensome, tenure of knight-service. This is peculiarly remarkable in the tenure which prevails in Kent, called *gavelkind*, which is generally acknowledged to be a species of socage-tenure; and its preservation from the innovations of the Norman conqueror is a fact universally known. And those who thus preserved their liberties were said to hold in free and common socage.

Society.

SOCIETY, a number of rational and moral beings, united for their common preservation and happiness. There are shoals of fishes, herds of quadrupeds, and flocks of birds. We call crows and beavers, and several other species of animals, *gregarious;* but it is hardly good English to say that they are *social.* It is only human society that can be regarded in this light, and the phenomena which it presents are highly worthy of our notice.

Mankind the only social beings subject to our observation.

Such are the advantages which each individual evidently derives from living in a social state; and so helpless does any human being appear in a solitary state, that we are naturally led to conclude, that if there ever was a period at which mankind were solitary beings, that period could not be of long duration; for their aversion to solitude and love of society would soon induce them to enter into social union. Such is the opinion which we are led to conceive when we compare our own condition as members of civilised and enlightened society with that of the brutes around us, or with that of savages in the earlier and ruder periods of social life.

A social and a savage state.

When we hear of Indians wandering naked through the woods, destitute of arts, unskilled in agriculture, scarcely capable of moral distinctions, void of all religious sentiments, or possessed with the most absurd notions concerning superior powers, and procuring means of subsistence in a manner equally precarious with that of the beasts of prey, we look down with pity on their condition, or turn from it with horror. When we view the order of cultivated society, and consider our institutions, arts, and manners, we rejoice over our superior wisdom and happiness. Man in a civilized state appears a being of a superior order to man in a savage state; yet some philosophers tell us, that it is only he who, having been educated in society, has been taught to depend upon others, that can be helpless or miserable when placed in a solitary state. They view the savage who exerts himself with intrepidity to supply his wants, or bears them with fortitude, as the greatest hero, and possessing the greatest happiness.

Whatever be the supposed advantages of a solitary state, certain it is that mankind, at the earliest periods, were united in society. Various theories have been formed concerning the circumstances and principles which gave rise to this union; but it has been sufficiently proved, that the greater part of them are founded in error; that they suppose the original state of man to have been that of savages; and that such a supposition is contradicted by the most authentic records of antiquity. For though the records of the earlier ages are generally obscure, fabulous, and imperfect, yet happily there is *one* free from the imperfections of the rest, and of undoubted authenticity, to which we may safely have recourse. This record is the Pentateuch of Moses, which presents us with a genuine account of the origin of man and of society.

SOCIETIES, associations voluntarily formed by a number of individuals for promoting knowledge, industry, or virtue. They may therefore be divided into three classes; societies for promoting science and literature, societies for encouraging and promoting arts and manufactures, and societies for diffusing religion and morality and relieving distress. These, however, are so numerous and fluctuating, that it would be difficult to offer any thing like an accurate account of them. The reader is referred for information on the subject to the articles, LONDON, DUBLIN, EDINBURGH, and the other towns and countries where these institutions have been established. We shall only notice the Royal Societies of London and Edinburgh.

The Royal Society of London is an academy or body of persons of eminent learning, instituted by Charles II., for the promoting of all the different branches of physical knowledge. The origin of this society is traced by Dr. Sprat, its earliest historian, no farther back than to "some space after the end of the civil wars" in the seventeenth century. The scene of the first meetings of the learned men who laid the foundation of it, is by him fixed in the university of Oxford, at the lodgings of Dr. Wilkins, warden of Wadham College. But Dr. Birch, on the authority of Dr. Wallis, one of its earliest and most considerable members, assigns it an earlier origin. According to him, certain worthy persons, residing in London about the year 1645, being "inquisitive into natural and the new and experimental philosophy, agreed to meet weekly on a certain day, to discourse upon such subjects, and were known by the title of *The Invisible* or *Philosophical College*." In the years 1648 and 1649, the company who formed these meetings was divided, part retiring to Oxford and part remaining in London; but they continued the same pursuits as when united, corresponding with each other, and giving a mutual account of their respective discoveries. About the year 1659 the greater part of the Oxford society returned to London, and again uniting with their fellow-labourers, met once, if not twice a-week at Gresham College, during term-time, till they were scattered by the public distractions of that year, and the place of their meeting made quarters for soldiers. On the restoration in 1660 their meetings were revived, and attended by a greater concourse of men eminent for their rank and learning. They were at last taken notice of by the king, who having himself a considerable taste for physical science, was pleased to grant them an ample charter, dated the 15th of July 1662, and afterwards a second dated 15th April 1663, by which they were erected into a corporation, consisting of a president, council, and fellows, for promoting natural knowledge; and to give their investigations, against which strange prejudices were entertained, every possible support, he sometimes honoured their meetings with his presence.

Their manner of electing fellows is by balloting. Their council consists of twenty-one, including the president, vice-president, treasurer, and two secretaries, eleven of which are continued for the next year, and ten more added to them; all being chosen on St. Andrew's day.

The services which this illustrious society has rendered to the public are very great. They have improved naval, civil, and military architecture; advanced the security and perfection of navigation; improved agriculture; and put not only this kingdom, but also Ireland, the plantations, &c., upon planting. They have registered experiments, histories, relations, observations, &c., and reduced them into one common stock; and have, from time to time, published those which they reckoned most useful, under the title of *Philosophical Transactions*, &c. They have a library adapted to their institution; towards which Mr. Henry Howard, afterwards duke of Norfolk, contributed the Norfolcian library, and which has been vastly increased by a continual series of benefactions.

The Royal Society of Edinburgh was incorporated by royal charter on the 29th of March 1783, and has for its object the cultivation of every branch of science, erudition, and taste. Its rise and progress towards its present state was as follows. In the year 1718 a literary society was established in Edinburgh by the learned Ruddiman and others, which in 1731 was succeeded by a society instituted for the improvement of medical knowledge. In the year 1739 the celebrated Maclaurin conceived the idea of enlarging the plan of this society, by extending it to subjects of philosophy and literature. The institution was accordingly new-modelled by a printed set of laws and regulations, the number of members was increased, and they were distinguished from that time by the title of *The Society for Improving Arts and Sciences*, or more generally by the title of *The Philosophical Society of Edinburgh*. Its meetings, however, were soon interrupted by the disorders of the country during the rebellion in 1745; and they were not renewed till the year 1752. Soon after this period the first volume of the Transactions of the Philosophical Society of Edinburgh was published, under the title of *Essays and Observations, Physical and Literary*, and was followed by other volumes of acknowledged merit. About the end of the year 1782, in a meeting of the professors of the university of Edinburgh, many of whom were likewise members of the Philosophical Society, and warmly attached to its interests, a scheme was proposed by the late Dr. Robertson, principal of the university, for the establishment of a new society on a more extended plan, and after the model of some of the foreign academies. It appeared an expedient measure to solicit the royal patronage to an institution of this nature, which promised to be of national importance, and to request an establishment by charter from the crown. The plan was approved and adopted; and the Philosophical Society, joining its influence as a body in seconding the application from the university, his majesty, as we have already observed, was graciously pleased to incorporate The Royal Society of Edinburgh by charter.

Members are elected by ballot. The general business of the society is managed by a president, two vice-presidents, with a council of twelve, a general secretary, and a treasurer. These officers are chosen by ballot annually on the last Monday of November. All public deeds, whether of a civil or of a literary nature, are transacted by this board, and proceed in the name of the president or vice-president.

As it was thought that the members would have a greater inducement to punctual attendance on the meetings of the society, if they had some general intimation of the nature of the subjects which were to be considered, and made the topics of conversation, it was therefore resolved to divide the society into two classes, which should meet and deliberate separately. One of these classes is denominated the *Physical Class*, and has for its department the sciences of mathematics, natural philosophy, chemistry, medicine, natural history, and whatever relates to the improvement of arts and manufactures. The other is denominated the *Literary Class*, and has for its department literature, philology, history, antiquities, and speculative philosophy. There are many valuable papers in the volumes that have been published of the *Transactions* of this society.

SOCIETY Isles, a cluster of isles, so named by Captain Cook in 1769. They are situated between the latitudes of 16. 10. and 16. 55. south, and between the longitudes of 150. 57. and 152. west. See POLYNESIA.

SOCINIANS, in church history, a sect of Christian heretics, so called from their founder Faustus Socinus. They maintain, "that Jesus Christ was a mere man, who had no existence before he was conceived by the Virgin Mary; that the Holy Ghost is no distinct person, but that the Father is truly and properly God. They own, that the name of God is given in the Holy Scriptures to Jesus Christ; but contend, that it is only a deputed title, which however in-

Socotara, Socrates.

vests him with an absolute authority over all created beings, and renders him an object of worship to men and angels. They deny the doctrines of satisfaction and imputed righteousness; and say that Christ only preached the truth to mankind, set before them in himself an example of heroic virtue, and sealed his doctrines with his blood. Original sin and absolute predestination they esteem scholastic chimeras. They likewise maintain the sleep of the soul, which they say becomes insensible at death, and is raised again with the body at the resurrection, when the good shall be established in the possession of eternal felicity, while the wicked shall be consigned to a fire that will not torment them eternally, but for a certain duration in proportion to their demerits."

This sect has long been indignant at being styled *Socinians*. They disclaim every human leader; and professing to be guided solely by the word of God and the deductions of reason, they call themselves *Unitarians*, and affect to consides all other Christians, even their friends the Arians, as *Polytheists*. Modern Unitarianism, as taught by Dr. Priestley, is, however, a very different thing from Socinianism, as we find it in the Racovian Catechism and other standard works of the sect.

SOCINUS, Lælius, the first author of the sect of the Socinians, was born at Sienna in Tuscany in 1525. Being designed by his father for the law, he began very early to search for the foundation of that science in the word of God; and by that study discovered that the Romish religion taught many things contrary to revelation. Being desirous of penetrating farther into the true sense of the scriptures, he studied Greek, Hebrew, and even Arabic. In 1547 he left Italy, to go and converse with the Protestants; and spent four years in travelling through France, England, the Netherlands, Germany, and Poland, and at length settled at Zürich. He by this means became acquainted with the most learned men of his time, who testified by their letters the esteem which they had for him; but as he discovered to them his doubts, he was greatly suspected of heresy. He however conducted himself with such address, that he lived among the capital enemies of his opinions, without receiving the least injury. He met with some disciples, who heard his instructions with respect; these were Italians who had left their native country on account of religion, and wandered about in Germany and Poland. He communicated likewise his sentiments to his relations by his writings, which he caused to be conveyed to them at Sienna. He died at Zürich in 1562. Those who were of sentiments opposite to his, and were personally acquainted with him, confess that his outward behaviour was blameless. He wrote a paraphrase on the first chapter of St. John; and other works are ascribed to him.

Socinus, *Faustus*, nephew of the preceding, and principal founder of the Socinian sect, was born at Sienna in 1539. The letters which his uncle Lælius wrote to his relations, and which infused into them many seeds of heresy, made an impression upon him; so that, knowing himself not innocent, he fled as well as the rest when the inquisition began to persecute that family. He was at Lyon when he heard of his uncle's death, and he departed immediately to take possession of his writings. He returned to Tuscany; and made himself so agreeable to the grand duke, that the charms which he found in that court, and the honourable posts which he filled there, hindered him for twelve years from remembering that he had been considered as the person who was to put the last hand to the system of divinity, of which his uncle Lælius had made a rough draught. At last he went into Germany in 1547, and paid no regard to the grand duke's advices to return. He stayed three years at Basel, and there studied divinity; and having adopted a set of principles very different from the system of Protestants, he resolved to maintain and propagate them; for which purpose he wrote a treatise *De Iesu Christo Servatore*. In 1579 Socinus retired into Poland, and desired to be admitted into the communion of the Unitarians; but as he differed from them in some points, on which he refused to be silent, he met with a repulse. He did not however cease to write in defence of their churches against those who attacked them. At length his book against James Palcologus furnished his enemies with a pretence to exasperate the king of Poland against him; but though the mere reading of it was sufficient to refute his accusers, Socinus thought proper to leave Cracow, after having resided there four years. He then lived under the protection of several Polish lords, and married a lady of a good family; but her death, which happened in 1587, so deeply afflicted him as to injure his health; and to complete his sorrow, he was deprived of his patrimony by the death of Francis de' Medici, great duke of Florence. The consolation which he found in seeing his sentiments at last approved by several ministers, was greatly interrupted in 1598; for he met with a thousand insults at Cracow, and was with great difficulty saved from the hands of the rabble. His house was plundered, and he lost his goods; but this loss was not so uneasy to him as that of some manuscripts, which he extremely regretted. To deliver himself from such dangers, he retired to a village about nine miles distant from Cracow, where he spent the remainder of his days at the house of Abraham Blonski, a Polish gentleman, and died there in 1604. All Faustus Socinus's works are contained in the first two volumes of the great collection entitled *Bibliotheca Fratrum Polonorum*.

SOCOTARA, an island of the Indian Ocean, about forty leagues to the eastward of Cape Guardafui. It is mountainous, with a bold shore and excellent harbours, and the inhabitants are in general civil to strangers. The principal produce is aloes. The town has a handsome appearance, the houses being built of stone, and some with several mosques. The residence of the king is in long. 53. 33. E. Lat. 12. 39. N.

SOCRATES. The name of Socrates is familiar to every one among his earliest classical recollections. Who has not heard of the Athenian sage, the great moralist of heathenism, and his persecution and constancy even to death? There is no name indeed which stands forth more conspicuously in the history of the philosophy, or of the religion, or of the general civilization of the ancient world. It marks a distinct era in the progress of the human race. The character of a great period in the history of man is concentrated, in fact, in the life and teaching of this extraordinary individual; and his name accordingly has descended to us with all the importance of the crisis itself at which he flourished; recommended as it is to our affection and admiration, not so much by the characteristics of his personality, as by the tradition of his influence and authority.

For when we come to consider his particular biography, we find our attention arrested by little that belongs merely to the individual. We read of a long life passed for the most part in uniform tenour within the walls of his native Athens; and until we come to its tragical close, scarcely distinguished in point of incident from that of the mass of his contemporaries. When, again, we ask for writings from which, as from the proper mirror of the philosopher's mind, we may collect some express lineaments of his character and teaching, we find nothing even on this ground on which our curiosity can fasten; so little have we derived that interest, which the mention of Socrates now awakens, from himself immediately; and so much, on the other hand, are we indebted for our acquaintance with this philosopher to a popular feeling preserving and handing down to us the name which represents the thought and character of an age.

The conjuncture of events at the time of Socrates was peculiarly favourable to the development of such a character. Socrates, born at Athens in the year 469 or 470 B.C. grew up to manhood during those years when Athens, standing on the proud eminence of her victories of Marathon and Salamis, was consolidating her power as a sovereign state and seat of empire. In the course of the fifty years which intervened between her triumphant resistance to the Persian invasion and the commencement of the Peloponnesian war, Athens, like Rome in her struggle with her Italian neighbours, had gradually converted her allies in the islands and on the coasts of Asia Minor and Thrace into dependent subjects and tributaries. But Athens had not, like Rome, the prudence to combine these scattered members of her empire, elements of discord and trouble as much as of strength to the sovereign state, by the free communication of the rights of citizenship. Nor indeed could this wise expedient have availed in the case of Athens as in that of Rome. For the states over which the empire of Athens extended were either independent governments reluctantly submitting to her yoke, or the weak dependencies of a rival power, and indisposed to acknowledge the sovereignty of Athens but so long as that power wanted the vigour and the enterprize to head a coalition against the common oppressor. There were thus in the very constitution of the Athenian empire, materials of jealousy and disunion, which no line of conduct but the impolitic one of surrendering an arbitrary rule into the hands of the people who had groaned under it, could long have kept from explosion. And, in fact, it was not the policy of Athens (masterly as that policy was under the hands of her great leaders) which sustained her empire for more than fifty years, so much as the inertness of her great rival, Lacedemon, and the difficulty of bringing the several grievances of the subject-states to bear on some decisive point, capable of influencing the movement of the whole in a strenuous concerted effort of resistance. At length we see this effort in the outbreak of the Peloponnesian war, as well as the difficulty of it in the complicated diplomacy by which that great movement was preceded, and in the reluctance of Lacedemon to bring home to herself the necessity of exertion.

But, whilst Athens was thus aggrandizing herself against a day of retribution from the insulted states of Greece, she enjoyed the sunshine of her day of empire, in the brilliant assemblage, which she then witnessed within her walls, of the great, and the learned, and the eloquent, from all parts of Greece.[1] While her arms and her enterprize were setting foot on every sea and land, her attractiveness as a home of genius and civilization, was evidenced in the number of strangers frequenting her porticoes, and groves, and theatres, and temples, and the houses of her nobles. During thirty years of this period of glory, the philosopher Anaxagoras was employed in propagating there the doctrines of the Ionic school, honoured by the patronage of her great men, and the revered master of her choicest spirits in the newly-acquired taste for philosophical inquiry. During, also, a considerable portion of the same period, the sophist Prodicus was domesticated within her walls, surrounded by crowds of admiring pupils from the highest ranks of her citizens, eagerly catching the inspiration of that rhetorical ability for which he was famed. Occasionally, too, amongst the distinguished visitors of the city, might be seen other illustrious professors of the day, also familiarly known by the name of sophists, then a complimentary designation,—Protagoras of Abdera, Gorgias of Leontium, Hippias of Elis,—drawn there by the demand for that literary merchandize, of which they claimed the monopoly. There also were now collected, as in a school of all arts, the great masters of the drama, of sculpture, and painting, and music, and the gymnastic exercises. So that Athens, at this time, contained within her own bosom abundant resources for the enlargement of the mind, whether in the eminent men who formed her society, in the lectures and conversation of the professors of science, or in noble works, the specimens and examples of what genius could effect. Athens contained, also, doubtless, much to enervate and corrupt the moral judgment, whilst she presented every thing to exalt the imagination and refine the taste. Her political institutions, well-balanced as they had been left by Solon, were now violently disturbed. In the course of these years of imperial greatness and prosperity, they received a large infusion of that licentious spirit, which the naval successes of the Athenians had engendered in the lower order of the citizens,[2] and the flattery of successive demagogues had fostered and diffused through the whole of the state. Now, also, faction divided the ties of family and kindred, and formed associations of the people for every lawless purpose of private ambition and cupidity. Their highest and purest court,—one principal anchor of the state, according to the intention of their great legislator,[3]—the Areopagus, was mutilated in its powers. And whilst numerous courts of law, thronged by their hundreds of judges, chosen by lot from the whole body of citizens, were constantly open,[4] and an idle populace were encouraged, by pay from the public treasury, to attend on the business of these courts, the functions of the legislative and deliberative bodies were virtually suspended. The peremptory power of these judicial committees, in which the people at large felt and exercised a despotic authority, became the real executive of the state. Then came into intense activity the vile system of sycophancy,—a system, under which the life and property of the wealthy were at the mercy of every needy adventurer who could speak to the passions of the people, and earn a livelihood for himself by a career of successful prosecutions.

Nor was public corruption unattended by its usual evils of private luxury and debauchery. At this time too, there might be observed in the heart of a city which prided itself on its pious feeling,[5] and amidst the frequency and splendour of festivals and external rituals of religion,[6] a profane scepticism with regard to the fundamental principles of religion and morality. A spirit of self-conceit and of presumption of knowledge, already natural to the Athenians, had now widely spread among the people; and every one was by turns dogmatist or sceptic,—according as it was his own opinion that he asserted,—or as he might display his ingenuity in questioning some received principle, or disputing some opinion proposed by another.

Add to these circumstances, the effect of a large slave population, the degraded ministers to the wants and the wealth of an insolent body of citizens, and of a number of resident foreigners engaged in carrying on the manufactures and trade of the city, paying a tax for their protection, and contributing to the military strength of the state, though excluded from its franchise. The slave, indeed, and the foreigner, lived more happily at Athens than at Lacedemon, or perhaps any other city of Greece, especially during a time of war, when their services were needful to the state.[1] Slavery, therefore, acted probably less injuriously on the character of the Athenian master, than it did elsewhere in Greece. It was tempered by the social humour of the people. But the facility thus afforded to the citizens of living in indolence and ease, and abandoning all domestic employment for the excitement of the public assemblies, and the courts, and the spectacles, naturally induced a neglect of the private and domestic duties. There is reason to believe, that whilst the Athenians appeared in the face of the world the most light-hearted of men, they were secretly unhappy in their homes; living in listlessness from day to day on the alms of their public pay; many of them reduced from affluence to poverty through the loss of lands and property by the ravages and pressure of war, and yet unable or unwilling to use the necessary exertions to relieve themselves from their distress. It is evidently no singular instance which Xenophon has given of this state of things at Athens, when he tells us of Aristarchus complaining to Socrates of the number of poor female relatives who, from losses in the course of the Peloponnesian war, were thrown on him for support. The difficulty which Aristarchus felt, was, that he could not expect persons who were free-born and his own kindred, to undertake any manual labour, so as to assist in maintaining themselves. Happily, however, he adopts the friendly suggestion of Socrates, and makes the experiment of setting them actively to work. The experiment succeeds; and thus contentment and cheerfulness are introduced to a home where before all was gloom and mutual suspicion.[2]

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[1] Isocrat. Panegyr. Καὶ τὸ πλῆθος τῶν ἀφικνουμένων ὡς ἡμᾶς τοσοῦτον ἐστιν, κ.τ.λ. p. 59.

[2] Aristot. Polit. ii. 9, τῆς ναυαρχίας γὰρ ἐν τôις Μηδικôις ὁ δῆμος ἄιτιος γενόμενος ἐφρονηματίσθη, κ.τ.λ.

[3] Plutarch. Solon, 19, οἰόμενος ἐπὶ δυσὶ βουλᾶις ὥσπερ ἀγκύραις ὁρμôυσαν, ἧττον ἐν σάλῳ τὴν πολιν ἔσεσθαι, κ.τ.λ. Tom. i. p. 352, ed. Reiske.

[4] Aristoph. Nub. 208, ἄιδε μὲν Αθῆναι. Στ. τί σὺ λέγεις; οὐ πέιθομαι, ἐπει δικαστας οὐχ ὁρῶ καθημένους.

[5] Soph. Œd. Col. 1006, ἐί τῖς γῆ θεοὺς ἐπίσταται τιμᾶις σεβίζειν, ἥδε τôυθ' ὑπερφερει.

[6] Xenophon, in his *Memorabilia*, i. c. 4, gives an instance in Aristodemus of one who not only had a contempt for all religion, but even derided those who concerned themselves with it.

In the meantime, a great number of mechanics and tradesmen had risen to wealth and importance, in consequence of the demand for every species of labour and trade, resulting from the multiplied population of the city and its numerous foreign dependencies and connexions, and, in particular, from the magnificent public works carried on during the administration of Pericles. All this while, Athens was becoming more and more a mercantile community, in the midst of strong aristocratic prejudices, still surviving, and rendered, indeed, more intense by the opposition growing up around them. In many instances, the older families would be declining in wealth, exhausted by the burthens of the state or the extravagance of individual expenditure; whilst new families, the creations of successful trade and enterprize, would be obtaining influence by the force of their wealth, and encroaching on the privileged ground hitherto occupied only by right of birth. It may be easily conceived, therefore, that the mass of the society of the city would be now all fermentation and restlessness; the one class pushing their interests and their claims to equality founded on their personal title, whilst the other obstinately clung to the exclusiveness and the pride of hereditary right.

But we shall best judge of the distempered state of the social atmosphere of Athens, by adverting to the character of female society as it existed there. It has often been remarked, as the glory of modern and Christian civilization, that it has restored woman to her due place in the scale of social importance, and thus most effectually chastened and elevated the general intercourse of human life. In a country so essentially social as Greece, and especially at Athens, it was practically impossible to impose on the women the absolute seclusion of eastern despotism. Still it was even at Athens considered the rule of propriety, that the wives and daughters of citizens should live in the strict privacy of their homes, and be known and noticed as little as possible among the other sex, even for their virtues.[3] But whilst the virtuous matron was excluded from the social circles, the place which she should have held in Athenian society was filled by other females, strangers to family ties, and attracted to Athens by the licentiousness and wealth of an imperial city. The union of high intellectual endowments, and a masculine dignity of understanding, in some distinguished individuals of this class, with the graces of female loveliness, appealed with a powerful interest to the sensual elegance of Grecian taste. We find, accordingly, at Athens, at this time, forming, as it were, the female court of the sovereign people, the Milesian Aspasia, and others of less name, living in the profession of a scandalous course of life, not only without shame, but even in the enjoyment of public respect. It was not the general of the commonwealth only that felt the spell of the charms of Aspasia, but grave philosophers resorted to her house; and even the ladies of private families, in violation of the restrictions of custom, were taken there by their friends; all eager to hear those interesting conversations, and lectures in political and rhetorical science for which she was famed.[4] We may judge how deeply corrupted must have been the standard of public opinion in Greece, when female profligacy could thus veil itself from the eye of moral observation, under the graces of splendid accomplishments of mind and person. So thoroughly had refinement of intellectual taste and of manners, together with the grossest impurity of morals, pervaded the whole society of Athens, that even those who were elevated above the world around them in talents, and strength of character, and kindliness of disposition, as Socrates was, imbibed in some measure the poison of the infected atmosphere which they breathed.

Such, then, was that state of things in which Socrates was trained, and which will greatly account to us for that peculiar form which the character of his philosophical teaching exhibits. For he was ever an Athenian instructing Athenians. He spoke as one fully conversant with the habits of thought and action of his countrymen; as knowing what kind of instruction they most needed, and by what mode of address he might best win their attention. We might expect, therefore, to see in him some leading traits of the Athenian civilization of his time; a teaching, admirable indeed in its main features, but bearing, at the same time, some marks of that corrupt state of society which called it forth, and to which it was immediately addressed.

The son of Sophroniscus a sculptor, and Phænareté a midwife, and himself brought up in his father's art, he yet enjoyed those advantages of mental culture and social refinement which were common to every citizen of the democratic Athens. The meanness of his birth and his poverty, much as high birth and wealth were esteemed there, would not exclude him from familiar intercourse with persons of the highest rank and consideration in the state. Nor, indeed, could the advantages of education be restricted to a privileged few, where every one lived in public, and where knowledge was for the most part acquired and communicated by conversation and oral discussion.

If, in the general relaxation of discipline at Athens, the citizen was no longer obliged to submit himself to a prescribed course of education under the eye of the state, and it was left to each person to avail himself, or not, of the sources of instruction presented in the intellectual society of the city, Socrates was not a person to neglect the advantages placed in his way. Money he had not, to pay to the Sophists, the great masters of his day. But he had from childhood an inquisitive mind. He felt that he was thrown on his own resources of thought, and that he must be his own master in the art of education. And to this great object he appears to have bent, from the earliest time, all the powers of his energetic mind. making it his constant employment to inquire from every one,[1] and collect on every occasion, some hint towards the right prosecution of it. We may picture to ourselves the young Socrates, resembling the Socrates of mature life, freely entering into conversation with all to whom he had access; feeling and acknowledging his own ignorance; listening attentively to all that he heard; weighing and discussing it in his own mind with patience and acuteness; and not resting until he had traced it out in all its bearings to the utmost of his power. Thus would he gradually form and strengthen that faculty of observation, and that analytical acumen for which he was afterwards so eminently distinguished.

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[1] Aristoph. Nub. 5, ἀπόλοιο δῆτ᾽, ὦ πολέμε, πολλῶν ὅυνεκα ὅτι ὅυδὲ κολάσαι ἔξεστί μοι τοὺς οἰκέτας.

[2] The story is beautifully told by Xenophon in his simple manner in the *Memorabilia*, book ii. chapter 7. See also Mem. ii. 8.

[3] Thucyd. ii. 45, τῆς τε γὰρ ὑπαρχούσης φύσεως μὴ χείροσι γενέσθαι ὑμῖν μεγάλη ἡ δόξα, καὶ ἧς ἂν ἐπ᾽ ἐλάχιστον ἀρετῆς πέρί ἢ ψόγου ἐν τοῖς ἄρσεσι κλέος ᾖ.

[4] Plato, Menex.—Xenoph. Mem. ii. 6.—Plutarch. Pericles. 24. Καὶ γὰρ Σωκράτης ἐστιν ὅτε μετὰ τῶν γνωρίμων ἐφοίτα. καὶ τὰς γυναῖκας ἀκροασομενας οἱ συνήθεις ἦγον ὡς ἀυτην, κ.τ.λ. Tom. i. p. 638, Reiske.

Nor has Plato improbably put a prophecy of his future eminence in the mouth of one of the great masters of the day, when he makes Protagoras say of him, with the self-complacency of the man of established reputation: "For my part, Socrates, I commend your spirit, and the method of your reasoning; for whilst in other points I am no bad sort of person, as I think, I am the farthest from being an envious one. For concerning you in particular, I have already observed to many, that of all I meet, I admire you by far the most; of those of your own age, even to the extreme; and I say too, I should not be astonished if you were to turn out a man of celebrity for philosophy."[2] To the same effect is the story, that his father, being at a loss how to educate him, consulted the Delphic oracle, and was advised to leave him entirely to his own bent, inasmuch as he had a director in himself superior to a thousand teachers.[3] The simple interpretation of what is here thrown into the form of marvel probably is, that he gave, even when a child, striking indications of a devotedness to those studies which became the business of his manhood.

The notice of a wealthy individual of Athens, the excellent Crito, appears to have been early attracted to Socrates. Crito was of about the same age as Socrates;[4] and an attachment to the pursuit of philosophy, and an admiration of the character of Socrates, naturally led to that intimacy which he now commenced with the young philosopher, and steadily maintained through his subsequent life. Through him Socrates was relieved from the necessity of earning his livelihood by the profession of a sculptor; or, as Laertius expresses it, "was raised from the workshop."[5] Sculpture, indeed, was in high honour at Athens, especially at this time. For Phidias, enjoying the protection of Pericles, was now adorning the city with the immortal productions of his own chisel, as well as other noble works of art executed under his taste and direction. But to follow up the profession with success, required a devotion of mind and hand that must preclude the opportunities indispensable for the moral student. And though, for a time, Socrates worked at the art,—and with success, if a statue of the Graces in the citadel of Athens, attributed to him, were really his workmanship;[6]—we may imagine how distasteful the occupation, however intellectual in itself, must have been to a mind, so eager for observation on living man, so intent on mental and moral phenomena, as that of Socrates; and how gladly he would exchange the labour of his paternal art for that philosophic leisure which the friendship of Crito held out to him.

The world of that day reproached the philosophers with servility, taunting them with being ever seen at the "gates of the rich." In some instances, the reproach may have been just. But in general, the fact was the reverse. Their society rather was courted by the great and wealthy, who were proud of the reputation of being patrons of philosophy. To Socrates, indeed, the patronage of a man of wealth would be peculiarly acceptable, not so much for the means of subsistence, about which he was absolutely thoughtless and indifferent, as for the society itself to which he would thus be introduced, and the opportunity of carrying on his researches into philosophy, both by books and by the oral instructions of its living professors. To him it would be the very means by which he would enlarge his field of moral observation. The social evenings of Athens were the natural sequences of the mornings of the agora, and the courts, and the council, and the assembly. They prolonged in festive conversation that strife of words and competition of argument, which had been begun in the busy and serious discussions of the morning, and of which the last murmurs had scarcely died away on the ear of the assembled guests. For Athenian life was a life of constant excitement. What Demosthenes observed an hundred years afterwards, and an apostle four hundred years later still,—that the Athenians did nothing but go about and ask the news of the day,—was a characteristic of the people already strongly developed at this period of their history. Socrates, who, in his own person, gave a philosophical cast to this inquisitive spirit, would be peculiarly interested by such opportunities of exercising it as were presented in the animated encounters of the symposium. There he would see human nature displayed in some of its most striking forms. There he would meet the citizen full of years and honours, experienced in the arts of government and diplomacy, and in the service of the state by land and sea; the poet flushed with his victories in the dramatic contest; the sophist armed at all points for the display; the philosopher expounding his theories; the orator, the idol of the people in his day; the courtly patron of literature; and a circle of young men, the flower of the highest rank in the state; each bearing his part in the free and lively interchange of thought, emulously provoking one another to discussion, and contending for the mastery in the conflict of debate.

By such society Socrates would be effectually prepared for that active enterprize of philosophy, which formed the whole engagement of his life. In the meagre information handed down to us respecting the details of his history, we are not able to ascertain at what precise period of life he began his career of public teaching, or at least attracted notice as the philosopher of Athens. The transition would probably be gradual, from the youthful inquirer, to the mature and expert teacher of others. This transition would be the less perceptible in the case of Socrates, from the circumstance, that he never professed to *teach*, even when he was most actively employed in teaching; but still, at the last, as he had done from the first, merely to *inquire*.[7] For his part, he disdained the *profession* of philosophy. He was disgusted with the vain pretension advanced by the Sophists, of being masters of every science, and capable of imparting instruction on any given subject. He accordingly set out with the antagonist position, that he *knew nothing:* that his only wisdom, if he possessed any beyond other men, consisted in his being *aware* of his real ignorance, whilst others ignorantly presumed on the possession of a knowledge which they had not. His teaching, therefore, was only a continuation of the process of educa-

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[1] Plato, Laches, p. 186, c., ἐγὼ μὲν οὖν, κ.τ.λ. p. 176, Bip. ed.

[2] Plato, Protag. Op. iii. p. 193.

[3] Plutarch. de Gen. Socr.

[4] Plato, Apol. p. 78, ἔμος ἡλικιώτης.

[5] Diog. Laert. in vit. ii. 5.

[6] Xenoph. Mem. i. 2, οὐδὲ πώποτε ὑπέσχετο διδάσκαλος εἶναι τούτου.

[7] Diog. Laert. ii. 5. Pausanias, i. 22; ix 35.

tion of his own mind, by extending it to the minds of others. He was fond of describing it as an *examination* or *scrutiny* of the mind; a method of finding out the real condition of each mind, and so of preparing it for the due exercise of its powers in the practical emergencies of human life. He saw that the evils of life arose, in great part, from the wrong judgments of men,—from their mistaking their own powers, presuming on their knowledge, and ability, and the truth of opinions adopted without inquiry. He endeavoured then to effect the cure of human error and unhappiness by a reformation of the intellect. The first step towards this would be taken, if men could be only divested of this vain self-confidence; if they could be brought to *suspect* that they might be mistaken in their judgments, and so to *question* themselves. This preliminary labour was employment enough for any one man's life, especially in a society such as that of Athens, so entirely infected with the sophistical leaven. Socrates wisely confined his exertions to this simple object. He is content to excite inquiry,—to provoke discussion,—and thus to suggest the necessity of self-discipline in order to right judgment. He does not, like other philosophers, quit the seclusion of a study, or the field of foreign travel, to come forth to the world the accomplished teacher of the accumulated wisdom of years of solitary thought and reflection. Whilst philosophizing in the agora and the streets of Athens, in the workshops of the artizan, or at the banquets of the rich, he is still employed in the work of *disciplining* the mind. Thus he passes on insensibly from the education of himself to the education of others, and it is difficult consequently, or rather impossible, to say in his case, where the character of the learner ends, or where that of the philosopher and teacher begins.

Yet, entirely as Socrates disregarded all positive knowledge, and threw himself on the resources of a shrewd and extensive observation of human nature, we must not suppose that he neglected to inform himself in the existing systems of philosophy, and the particular sciences as they were then understood and taught. There is reason to believe, that he had accurately studied the systems of the early physical philosophers of the Ionic school, as well as the moral and mathematical theories of the Pythagoreans, and the dialectics of the school of Elea. Without supposing him so deeply versed in the doctrines of the several schools, as would be inferred from his exact discussions in the dialogues of Plato, there is still ample evidence, from the more direct account of Xenophon, that he was by no means ignorant of them. He had doubtless read much,[1] as well as observed much, when he commenced his philosophic mission. Xenophon indeed tells us that Socrates considered the physical and dialectical theories of his predecessors as unprofitable. But he takes care to add, that Socrates was not unacquainted with these theories. And in particular, as to the sciences of astronomy and geometry, he thought the attention of the student wasted in investigating their more abstruse theorems. But he was able (as Xenophon further observes), to speak on the subjects of these sciences also from his own knowledge of them.[2]

Nor are we to suppose that, whilst he had properly no master in that line of philosophical study which he had marked out for himself,[3] he had no aid in the cultivation of his mind, from the living masters of philosophy in his day. The long residence of Anaxagoras at Athens, probably coincides in time with part of the early life of Socrates.[4] To him, therefore, Socrates would naturally have access, as well as to Archelaus,[5] his disciple, and the inheritor of his doctrines. If he had no personal intercourse with Anaxagoras, it is at least highly probable, from the testimony of Plato, that he was acquainted with the famous treatise of Anaxagoras, which contained his theory of the universe.[6] And perhaps we may distinctly trace the early and abiding influence of the lessons of this great philosopher throughout the teaching of Socrates, in his uniform maintenance of the principle of an all-disposing mind, the glory of the system of Anaxagoras.

To the writings of Heraclitus, his attention appears to have been drawn by the poet Euripides; if the anecdote be true, as related by Laertius, that on being asked by Euripides, who had put them into his hand, what he thought of them, he replied, alluding to the studied obscurity of that philosopher; "What I understand is excellent; so also, I suppose, is what I do not understand; only there is need of some Delian diver to reach the sense."[7] He had also opportunities of conversing with Zeno the Eleatic, and Theodorus of Cyrene; the former eminent for his dialectical skill, the latter the most distinguished geometrician of the time. And though his scanty means precluded his attendance on the professional lectures of Prodicus, the fashionable teacher of rhetoric at that day at Athens, it cannot be doubted that he would on several occasions have been among the company assembled at the house of some wealthy citizen, and there heard from the lips of that accomplished master of language those elaborate oratorical displays which made his name proverbial for wisdom.[8] With the poet Euripides, indeed, the disciple of Anaxagoras and Prodicus, and who was his senior only by a few years, he appears to have lived in habits of intimacy. With Euripides he would probably often have discussed those ethical topics which the poet so greatly delighted to transfuse into his tragic scenes, and associate with the interest of dramatic incident. They were in fact brother-labourers in the same cause, though in different ways. For whilst Euripides endeavoured to work a reformation of his countrymen, by didactic addresses insinuated through their feelings, amidst the interest of tragic story, Socrates appealed at once to their understandings, and amidst the business or pastime of real life. The envy of contemporaries was prone to attribute the excellence of the poet in some of his dramatic efforts, to the aid of his philosopher-friend.[9] The truth probably is, that the benefit of their intercourse was mutual; that, whilst the poet's imagination was informed and chastened by the shrewd and severe wisdom of the philosopher, the philosopher also, ever intent on his calling, would enlarge his mind with riches drawn from the genius, and taste, and learning of the poet.

The co-existence of literary and philosophic elegance with the most disgusting coarseness of moral feeling and conduct, in the character of the Athenian courtesan, has been already noticed. To Aspasia, the heroine of her class, as we may call her, when we refer to her influence over Pericles, and the encomiums of her by Plato and others, Socrates is expressly stated to have been indebted for instruction in rhetoric, as also in other subjects.[1] Whilst Xenophon also introduces him familiarly conversing with Theodota, whom he describes as living in great splendour at Athens, the object of general admiration for her personal charms, and inviting her to become his disciple,[2]—Plato leads us to believe that Socrates was himself the disciple of another of the same class, the Mantinean Diotimè, who, among her other accomplishments, was distinguished in particular for her skill in the art of divination.[3]

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[1] Xenoph. Mem. i. 6.

[2] Xenoph. Mem. iv. 7.

[3] He reckons himself in Xenoph. Conviv. i. 5. among the αὐτουργὸι τῆς φιλοσοφιάς.

[4] It must be admitted, however, that the chronology of the life of Anaxagoras is very doubtful.

[5] Archelaus is called both a Milesian and an Athenian. The probability is that he was a Milesian, since philosophy had scarcely yet found a home at Athens.

[6] See the Phædo, p. 97. The writings of Anaxagoras appear to have been extensively circulated. Socrates is made in Plato's *Apology* to say to Melitus, ὄιει αὐτοὺς ἀπειρους γραμμάτων εἶναι, ὥστε ὀυκ ἐιδέναι ὅτι τ᾽ Ἀναξαγόρου βιβλία τοῦ Κλαζομενίου γέμει τουτων τῶν λόγων.

[7] Diog. Laert. in vit. ii. 7.

[8] Plato, Meno. p. 96. Κινδυνεύομεν, ὦ Μένων, ἐγώ τε καὶ σὺ, φαῦλοι τινες ἔιναι ἄνδρες, καὶ σέ τε Γοργίας ὀυχ ἱκανῶς πεπαιδέυκεναι, καὶ ἐμὲ Πρόδικος. P. 382. Bipont.

[9] Aristoph. Nub. Diog. Laert. in vit. ii. 5.

Instruction in music formed an important part of Athenian education. Socrates, it seems, did not neglect the opportunities which the presence of the great masters of the art in Athens afforded him of learning its principles. Connus accordingly is claimed for him, as his master in music.[4] Damon, another celebrated musician, though not more eminent in the science which he professed, than as a politician and sophist, was resident at Athens during part of the administration of Pericles, the intimate and counsellor of that great statesman, as well as his instructor in music.[5] From him also, we are told, Socrates received instruction in the art. By these accounts, however, we may probably understand, not that he became a proficient in the musical art, but that he had listened to Damon as well as to Connus, discoursing on the subject, and studied its theories under them, so far, at least, as music entered into the general pursuit of philosophy.[6]

It should be observed, indeed, that though Socrates strongly discouraged the *presumption* of knowledge in all with whom he conversed, he did not disapprove of the acquisition of particular kinds of knowledge. He communicated whatever he knew to every one that came in his way; and where he was himself unacquainted with any subject, he referred his hearers to those who possessed the information.[7] He was not in fact opposed to knowledge in itself. He was glad to embrace it wherever it could be found. But he was an enemy to the substitution of mere intellectual acquisitions,—and those often superficial and unreal,—for *education* of the mind and character. He felt, and justly felt, that knowledge by itself was vanity. The tendency of the age was to ascribe value exclusively to mental acuteness and dexterity. Ingenuity and cleverness obtained the merit and the prize of wisdom. His labour was to draw his countrymen from thinking too highly of their boasted knowledge. He wished them to see how greatly they overrated intellectual acquirements,—how much they had yet to learn if they would be real proficients in wisdom.

Socrates indeed appears to have regarded philosophy in the light of a sacred mission, to which he was specially called, rather than of a study and exercise of the mind. This notion of philosophy had already been exemplified by Pythagoras and his followers. But they had realized it by forming themselves into distinct communities or colleges; separating themselves from the world around, by a solemn initiation, and the practice of an ascetic discipline. Socrates, however, had no thought of changing the outward form of society. He did not propose, like Pythagoras, to institute a refuge from the pollutions and misery of the world, or to educate a peculiar brotherhood, who should afterwards act on the social mass. He did not address himself to the few. His school was all Athens. or rather indeed all Greece. Leaving society as it was, he sought to infuse a new spirit into it, by carrying his philosophy into every department of it. He therefore went about among all classes of people, preferring none, despising none, but adapting his instructions to every variety of condition and character. Thus did he in truth, according to the observation commonly applied to him from the time of Cicero, bring down philosophy from heaven to earth; but not so much by being the first to give a moral tone to philosophy, as by the universality and philanthropy of his teaching. Philosophy in his hands was no longer an exclusive and privileged profession. It no longer spoke as from an oracular shrine, and in the language of mystery. It now conversed with every man at his own home,—submitted to be familiarly approached and viewed without reserve,—and, instead of waiting to be formally consulted by its votaries only, volunteered to mingle in the business, and interests, and pleasures of every-day life.

His manner of life and of teaching is thus described by Xenophon.[8]

"He was constantly in public. For early in the morning he would go to the walks and the gymnasia; and when the agora was full, he was to be seen there; and constantly during the remainder of the day, he would be wherever he was likely to meet with the most persons; and for the most part he would talk, and all that would might hear him."

The nature of his conversations is thus further reported by the same faithful authority:

"No one ever saw Socrates doing, or heard him saying, any thing impious or profane. For not only did he not discourse about the nature of all things, as most others, inquiring how, what by the sophists is called the universe, consists, and by what laws each heavenly thing is produced; but he would point out the folly of those who studied such matters. And the first inquiry he would make of them was, whether they proceeded to such studies from thinking themselves already sufficiently acquainted with human things; or whether they thought they were acting becomingly in passing by human things, and giving their attention to divine. He would wonder, too, it was not evident to them, that it was not possible for men to find out these matters; since even those who most prided themselves on discoursing of them, did not agree in opinion with each other, but were affected like madmen in relation to one another. For of madmen, whilst some did not fear even the fearful, others were terrified at things not terrible; whilst some were not ashamed to say or do any thing even before the multitude, others objected even to going out into the world; whilst some paid no honour to sacred things, or altars, or any other religious object, others worshipped even stones, and common stocks, and brutes. So of those who speculated on the nature of the universe, whilst some thought that Being was one only, others thought it was infinite in number; whilst some thought that all things were in perpetual motion, others thought it impossible for any thing to be moved; whilst some thought that all things were in a course of generation and destruction, others thought that nothing could possibly be generated or destroyed. He would further consider respecting them thus: whether, as the learners of human things think they shall be able to make practical use of their knowledge for themselves and any one else at pleasure, so also the searchers into divine things hold, that having ascertained by what laws each thing is generated, they shall be able to produce at pleasure winds, and waters, and seasons, and whatever else of the kind they may want; or whether they have no such expectation, but it suffices them only to know how every thing of this kind is generated. Such, then, was his manner of speaking about those who busied themselves with these matters. But, for his part, he was ever discoursing about human things, inquiring what was pious, what impious, what honourable, what base, what just, what unjust, what sobriety, what madness, what courage, what cowardice, what a state, what a statesman, what a government of men, what the character of a governor; and about other subjects, which, by being known, would make men honourable and virtuous, whilst those who were ignorant of them, would justly be called slavish."

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[1] Xenophon, Mem. ii. 6. Μὰ Δί, οὐχ, ὥς ποτε ἐγὼ Ἀσπασίας ἤκουσα. ἔφη γὰρ, τὰς ἀγαθὰς προμνηστρίδας, κ. τ. λ. P. 101. Plato, Menexenus, p. 235. Καὶ ἐμοὶ μὲν γε, ὦ Μενέξενε, οὐδέν θαυμασὸν οἵῳ τ' εἶναι εἰπεῖν, ᾧ τυγχάνει διδάσκαλος οὖσα ὀυ πάνυ φαύλη περὶ ῥητορικῆς, ἀλλ' ἥπερ καὶ ἄλλους πολλοὺς καὶ ἀγαθοὺς ἐποίησε ῥήτορας, ἕνα δὲ καὶ διαφέροντα τῶν Ἑλλήνων, Περικλέα τον Ξανθίππου. Μ. τίς αὔτη; ἢ δηλονότι Ἀσπασίαν λεγεις; Σ. λέγω γάρ; καὶ Κόννον γε τὸν Μητροβίου. οὗτοι γάρ μοι δυο εἰσὶ διδάσκαλοι· ὁ μὲν μουσικῆς, ἡ δὲ ῥητορικῆς. P. 277. Bipont.

[2] Xenophon, Mem. iii. 12. Ælian. Var. Hist. xiii. 31.

[3] Plato, Conviv. p. 201. op. t. 10. p. 227. Bipont.

[4] Plato, Menexenus.

[5] Plutarch in Pericl. op. t. i. p. 594. Reiske.

[6] Diog. Laert. in vit. ii. 5, 15. Laertius says that Socrates learned to play on the lyre.

[7] Xenoph. Mem. iv. 7.

[8] Mem. i. 1. 10; also Plutarch, *Utrum seni ger. Resp.*

Xenophon has thus fully touched the character of the teaching of Socrates in its leading points, and the nature of his constant occupation at Athens. The intermissions of military service appear to have been the only occasions of any variation in this uniform course of life. No other country had any charms for him, as no other afforded such rich opportunities of conversing with men, and studying human nature.[1] His activity was essentially different from that either of his predecessors or successors in the path of philosophy. They travelled from place to place searching for knowledge, storing their minds with various observations, and making philosophy their formal business. Socrates, as he had no stated school or place of audience, so he had no design of framing any system of philosophy, or of enlarging the researches and discoveries of former philosophers, or of pursuing knowledge as an ultimate object. He regarded himself as called by the voice of Deity, to undertake the reformation of men, and especially of his fellow-citizens, as constituting his proper sphere of duty, from their corruptions of sentiment and conduct. He stood, therefore, by the great stream of human life which was ever flowing at Athens, and watched its course. He is said once to have visited Samos in company with Archelaus, the disciple of Anaxagoras, and also to have gone to the Pythian and the Isthmian games. With these exceptions, and those of the occasions of military service abroad, he appears to have constantly remained at home, unattracted from the town, the seat of his philosophic mission, by invitations even to the courts of princes. In vain did Scopas of Cranon, and Eurylochus of Larissa, offer him money, and invite him to visit them.[2] He could refuse also the hospitality of Archelaus, king of Macedonia, the same with whom the poet Euripides found a kind and honourable refuge in his old age, from the envy of his countrymen, and domestic grievance. His refusal of the invitation of Archelaus is said indeed to have been accompanied with the declaration of his feeling, that he could not brook the acceptance of a favour which it was entirely out of his power to return.[3] Nay, so entirely engrossed was he in the work to which he had devoted himself, that he was a stranger, as Plato represents him, even to the immediate neighbourhood of the city. The banks of the Ilyssus, even then classic ground, rich with legendary associations, could not seduce him from the agora and the crowd; so that he seemed scarcely at home beyond the walls of Athens.[4]

No Athenian, however, could decline the military service of the state. And this service, at the time of Socrates, often engaged the citizen in hazardous enterprizes and long absences far from his home. The first occasion on which Socrates is related to have served, was in the Chersonese at Potidæa, just before the opening of the Peloponnesian war. The service in which the Athenian soldiers were engaged here was one of great hardship. It was in the winter season, and the climate in those parts was most severe. Amongst those who distinguished themselves by their resoluteness and gallantry, none was so conspicuous as the philosopher. Whilst others were clothing themselves with additional garments, and wrapping their feet in wool, he was observed in his usual dress, and walking barefoot on the ice, with more ease than others with their shoes. Nor even amidst these circumstances, did he merge the character of the philosopher in that of the soldier. He was seen one morning at sun-rise fixed in contemplation. At noon he was in the same position, and still in the evening, and so continued through the night, until the sun-rise of the following day. Such, too, was his bravery in the engagements at Potidæa, that he earned for himself the prize of distinction, but readily sacrificed his claim to the wishes of the generals, in favour of a more illustrious candidate in the person of Alcibiades. Alcibiades himself would have refused the honour as due rather to Socrates; for to the unwillingness of Socrates to leave him wounded on the field, he had been even indebted for his own life, and the preservation of his arms, after the battle. But the philosopher, with a true magnanimity, insisted on the award of the generals.[5]

The next occasion of military service, in which he was scarcely less distinguished than at Potidæa, was in the eighth year of the Peloponnesian war, at the battle of Delium in Bœotia. The battle was an unsuccessful one to the Athenians, and they were forced to retreat in disorder. Alcibiades was also present on this occasion, and overtook Socrates in company with Laches, one of the generals, on the way. He was on horseback, and comparatively therefore out of danger, whilst they were on foot. He had opportunity, therefore, of admiring the presence of mind which Socrates displayed on the occasion, even beyond Laches, and the steadiness and vigilance with which he kept the enemy from pressing upon them, and so secured their retreat.[6]

These incidents seem to rest on indisputable evidence. The account of them is put into the mouth of Alcibiades by Plato, in that most ingenious of his dialogues, the *Banquet*. The very form in which they are introduced, related as they are by an eye-witness, and that witness Alcibiades, the person, next to Socrates himself, most interested in them, may justly be regarded as giving a sanction to their history, independent of the fictitious circumstances of the dialogue.

The third occasion on which Socrates served as a soldier was again in Thrace, at Amphipolis,[1] in the same year as that of the unfortunate expedition to Delium. No particulars are mentioned of this adventure. But the fact itself is sufficiently attested. Nor, though it follows immediately on the affair of Delium, is it improbable on that account. For at this busy period of the war, when the Athenians were making demonstrations of their power, by the presence of their forces in different places at once, and when Brasidas was pushing his successes against them in Thrace, no individual of the military age, (and Socrates was not more than forty-six or forty-seven years of age at this time), would enjoy any long interval of relaxation from foreign service.

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[1] Plato, Laches, 187, e. Ὃυ μοι δοκεῖς εἰδέναι ὅτι ὃς ἂν ἐγγυτάτω Σωκράτους ᾖ λογῳ, ωσπερ γένει, καὶ πλησιαζῃ διαλεγόμενος, ἀνάγκη αὐτῷ . . . . περιαγὸμενον τῷ λόγῳ, μὴ παύσασθαι ὑπὸ τούτου πριν ἐμπέσῃ εις το διδόναι περὶ αὐτôυ λόγον, ὅντινα τρόπον νῦν τε ζῇ, καὶ ὅντινα τὸν παρεληλυθότα βίον βεβιώκεν, κ. τ. λ. P. 180.

[2] Diog. Laert. in vit.

[3] Aristot. Rhet. ii. 23.

[4] Plato, Phædr. 230. Συ δε γε ὦ θαυμάσιε, ἀτοπώτατός τις φαινῃ· ἀτεχνῶς γὰρ ὁ λέγεις, ξεναγουμένῳ τινὶ καὶ οὐκ ἐπιχωρίῳ ἔοικας· ὅυτως ἐκ τôυ ἄστεος οὔτ᾽ εἰς τὴν ὑπερορίαν ἀποδημεῖς, ὀυτ᾽ ἔξω τέιχους ἔμοιγε δοκεῖς τοπαράπαν εξεῖναι. ΣΩ. Συγγίνωσκε δὴ μοι, ὦ ἄρισε, φιλομαθὴς γὰρ ἐιμι· τὰ μὲν οὖν χωρία καὶ τὰ δένδρα οὐδὲν με θέλει διδάσκειν, όι δ᾽ ἐν τω ἄστει ἄνθρωποι. P. 287; also Crito, p. 120.

[5] Plato, Conviv. 220, a. p. 266; also Charmides.

[6] Plato, Conviv. p. 270. The story is again alluded to by Plato, in the dialogue, *Laches*. Laches is made to say that he had had experience of the *actions* of Socrates, and reminds Socrates of the day of their common danger, ᾗ μετ᾽ ἐμόυ συνδιεκινδύνευσας, κ. τ. λ. P. 182. Laertius says that Socrates saved Xenophon, who had fallen from his horse in the battle of Delium, (in vit. Soc. ii. 5–7.) But this cannot be true, as Xenophon would be much too young at that time for military service. In the Deipnosophists of Athenæus, (v. 55), doubt is thrown on these accounts of the military service of Socrates, and instances are given of the historical inaccuracy of Plato. The objections, however, as there given, are evidently thrown out in the wav of discussion, and not with perfect seriousness, as if the speaker really thought them of weight.

With these exceptions, Socrates appears then to have constantly resided at Athens. All this time, throughout his whole life indeed, he lived in great poverty, content with the least that might suffice for mere sustenance and clothing from day to day.

Yet it was no artificial, and melancholy, and fanatical life that he led. He accustomed himself to a strict moderation, not with any view to the mortification of the body, or as thinking that abstinence was in itself a virtue, but in order to self-command; by rendering himself as independent as possible of the circumstances of the body, to disencumber the soul of every burthen and obstruction to its free operation. There was nothing, indeed, of austerity in his life or manner. He might be seen walking barefoot, but it was not for the pain that it might inflict. It was only that he might bear cold and privations of every kind the better, and suffer the less inconvenience when exposed to necessary hardships, and require the less for his ordinary subsistence. So far was he from studying a discipline of bodily severity for its own sake, that he was observed at times mingling in the social festivities of his fellow-citizens with the full freedom of Athenian conviviality, and shewing that he could bear excesses which mastered others, without losing his self-command.[2]

One account, indeed, but not a very credible one, as it rests on the authority of Aristoxenus, an invidious writer, states that he was supported by the alms of friends, contributed from time to time for his relief. With his very limited wants, and his ready access to the house of Crito and other liberal patrons of philosophy at Athens, he would not have to depend on this precarious charity. The pittance which sufficed for the humblest citizen would suffice for him. He is said to have inherited a patrimony of seventy or eighty minæ.[3] But this sum, it is added, he lost (though the time is not stated when the loss occurred) by the failure of the person with whom it had been placed at interest. He possessed also a house in Athens; and he was able, however scantily, to support a family. So that we cannot suppose he was absolutely destitute of all resources of subsistence. He appears then rather to have voluntarily renounced every kind of worldly possession, so far as his own personal comfort was concerned, than to have been absolutely reduced to want by the pressure of circumstances. Poverty, in fact, was his profession, and not the mere necessity of his case. If he prided himself in any thing, it was in his avowal of his contempt for riches, and disregard of domestic interests and comforts, in contrast with the general habits of an age of selfish activity and profusion. The means of enriching himself, at least of extricating himself from want, were often placed in his power, and he as often rejected them. Alcibiades offered him land on which he might build a house, but he refused it pointedly, observing, "Had I wanted shoes, would you have offered me leather to make shoes for myself?—and ridiculous should I have been in taking it." Charmides would have given him slaves, as a source of revenue by their labour. This offer also he refused.[4] In the same spirit, he would often cast a look at the number of things that were sold, and say to himself, "Of how many things I have no need!"[5] Thus was his whole plan of life studiously opposed to the acceptance of any provision for his comfort or ease. It was a service of the Deity in which he felt himself engaged, and in the prosecution of that, solemnly devoted to a course of hardy poverty.[6]

In the domestic relations of life, he lived an Athenian among Athenians. He differed from other heads of families at Athens in this respect, that in his dedication of himself to his philosophic mission, he took no thought about the management of his private affairs. His home was abroad; his household the people of Athens. Still he discharged the duties of a husband, and the father of a family; and that under trying circumstances, unless the proverbial severity of temper of his wife Xanthippe be esteemed an idle scandal of the day. No Athenian, indeed, was truly domestic, in the sense of making his home the scene of his highest interest and enjoyment. Nor was Socrates domestic in this sense. Still less was he so than other Athenians; inasmuch as his very profession of life was a call from the bosom of his family. But in the midst of these avocations from his immediate home, and the vexations to which he was subjected there, he was not estranged from the ties of domestic affection. Xenophon has recorded a simple and touching trait of the character of Socrates under this particular point of view—a trait the more interesting, as almost every thing else that we know of the philosopher is drawn from his life in public. It occurs in the course of a conversation between Socrates and his son Lamprocles, who had complained of the insufferable temper of his mother Xanthippe. "What," said he to the youth, "do you think it more annoying to you to hear what she says, than it is to the actors, when in the tragedies they say every thing bad of one another?" "But they, I conceive," replied the son, "bear it easily, because they do not suppose that the speaker, in contradicting them, intends to hurt them, or that, in threatening, he intends to do them any ill." "Then are you," resumed Socrates, "vexed, when you well know that what your mother says to you, she says, not only intending no evil, but even wishing more good to you than to any one else; or do you regard your mother as unkindly affected towards you?" Lamprocles disclaiming this latter supposition; "Do you, then," he added, "say of her, who is both kind to you, and takes every possible care of you when you are sick, that you may recover, and want nothing proper for you, and who, moreover, prays to the gods in your behalf for many a good, and pays vows,—that she is vexatious? For my part, I think, if you cannot bear such a mother, you cannot bear what is good for you."[7]

From the description given by Plato of the family of Socrates in the prison-scene, it would appear, that Socrates had other three children besides Lamprocles,—for Lamprocles died at an early age, before his father,[1]—who were yet children, one of them a boy, another a child in the arms, at the time of their father's death.[2] We learn from other authorities,[3] that two of his children were named Sophroniscus and Menexenus; but they are said to have been the children, not of Xanthippe, but of another wife, Myrto, the grand-daughter of Aristides the just.[4] To account for this, it has been stated, that after their disasters in Sicily, the Athenians made a decree authorizing double marriages, with the view of recruiting their exhausted population. But this statement does not appear to be borne out by the earlier authorities on the subject of Athenian legislation. Nor is it probable that a law should have been enacted, directly sanctioning a form of polygamy. It appears, that during the pressure and confusion of the Peloponnesian war, persons obtained the freedom of the city of Athens, whose title was objectionable on the constitutional ground of their not being born of citizen-parents on both sides. Thus had Pericles, after the death of his two legitimate sons, obtained the admission of his son, Pericles, by Aspasia, to the privilege of citizenship;[5] though he had himself carried, some time before, a law of strict limitation, under which, nearly four thousand were deprived of the franchise.[6] Such extension of the privilege to the offspring of illegal unions, possibly gave a pretext to the supposition, that a decree passed at Athens sanctioning bigamy.

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[1] Plato, Apolog. 28. c. op. i. p. 67. Diog. Laert. in vit. Ælian, Var. Hist. iii. 17.

[2] Plato, Conviv. Ælian, Var. Hist. iv. 11.

[3] About L.400 of our money. Plutarch (in his life of Aristides) finds fault with Demetrius Phalereus for having endeavoured to remove the imputation of poverty from Socrates, by stating that Socrates had land of his own and seventy minæ put out to interest by Crito. Demetrius, however, seems only to have stated what he believed to be the truth. The idea of his extreme indigence originated probably with the caricatures of his profession of poverty by the comic poets; and true as it was substantially, was afterwards, it seems, maintained by his friends and admirers, as the evidence of the consistency of his life with his avowed contempt for worldly possessions.

[4] Diog. Laert. in vit.

[5] Ibid.

[6] Plato, Apolog. Ἀλλ᾽ ἐν πενίᾳ μυρίᾳ εἰμι διὰ τὴν τοῦ θεοῦ λατρείαν. Op. i. p. 5.

[7] Xenoph. Mem. ii. 2.

Some difficulty, however, arises on the subject of the marriage of Socrates, from the conflict of authorities. Whilst it is asserted on the one hand, that he was married to Myrto and Xanthippe at the same time; on the other hand, others assign them both as his wives, but in succession, and also differ as to the order of succession. But the silence of Plato and Xenophon respecting any other wife of Socrates but Xanthippe, and their coincidence in speaking of her only as the mother of his children, may be regarded as sufficiently decisive of the point against every subsequent authority. Indeed, the reference to Aristotle, given by Laertius, which is the chief ground for believing that Socrates was married also to Myrto, is very questionable. Plutarch doubts whether the treatise to which Laertius appeals for the fact, is the genuine work of Aristotle. From the manner, too, in which the name of Myrto appears to have been introduced in the account, nothing more may have been intended, than that Socrates found her in a state of widowhood and distress from poverty, and took care of her at his own home.[7] Aristides belonged to the same tribe and the same demus or borough, as Socrates; and a reverence for the virtues of the grandfather, may have combined with these almost domestic ties, to call forth such an act of friendliness to the disconsolate Myrto. And, if this be the case, as is probable, it would only add an interesting instance of that liberal benevolence which characterized the whole conduct of Socrates.[8]

It is a confirmation of this conclusion, that all the anecdotes of the private life of Socrates, with one exception, and that evidently a fabricated instance,[9] bring Xanthippe on the scene. On his inviting some wealthy persons to supper, it is Xanthippe who is distressed by their deficient means of hospitality, and to whom he replies, "Take courage; if they are worthy people, they will be satisfied; if they are worthless, we shall care nothing about them."[10] It is Xanthippe whom he reproves for her particularity about her dress on the occasion of some public spectacle, as more desirous of "being seen than to see."[11] It is of her again that Alcibiades expressed his wonder how he could bear with her, when he simply, but pointedly referred him to her just claims on his affection as the mother of his children.[12] On another occasion, his disciple, Antisthenes, is said to have asked him, with reference to Xanthippe, why he did not study to improve the disposition of his wife, whose violence of temper (he observed) was unexampled in the history of domestic life. Instead of confirming the censorious remark, he turned it, according to his usual method, to a practical illustration of his philosophy. "If Xanthippe was hard to be controlled," was the tenour of his answer, "it was only a proper discipline to him for the management of men; as those who would be masters in horsemanship, began with managing the most spirited horse, after which, every other would be tractable."[13] These stories, and the like, handed down or invented by the humour of the times, may be merely exaggerations of the fact of the inconvenience and dissatisfaction occasionally felt at the philosopher's home, by his habitual neglect of his domestic concerns, and the duty of exertion consequently imposed on Xanthippe beyond Athenian women in general. She appears indeed to have tenderly loved her husband, if Plato has faithfully traced the picture of her visit to his prison, and her extreme anguish at that trying hour. And he also knew her value, if his affection may be judged of, as surely it may, by the kind and gentle considerateness of his manner in committing her to the care of his friends at parting, and his absolute reserve of his feelings on that occasion.[14] The picture indeed is drawn by the hand of a consummate master; and Plato, it is true, was not present on the occasion. But we must believe, that in painting a scene that must have been impressed on the mind of the disciples of the philosopher, above every other incident of his life, and of which persons then living must have retained a lively recollection, he took his outlines at least of these interesting particulars from the real state of the case.

But the allusion to these circumstances brings us prematurely to the solemn tragedy which closed his intrepid and energetic career. We have yet to contemplate him pursuing for many a year his unwearied labour of awakening his countrymen from their dreams of knowledge and happiness to the realities of their condition in the world. Great indeed must have been the address, which could recommend the severe and wholesome truths inculcated by him, to the hearing of the vain and volatile Athenians. To none is the practical application of a principle, so condemnatory of human folly and impertinence, as the maxim, "know thyself," truly welcome. And yet this was the burthen of the teaching of Socrates for a series of years, among a people, whom it was far easier to please by praising to excess, than not to displease by censuring ever so slightly. They would listen, indeed, patiently to general invectives on their public conduct, conveyed in the impassioned eloquence of their orators; as persons will even now sympathize with general descriptions of the depravity of human nature, or of whole classes of men. But all refuse the pain of direct self-application of the truth; and Athenians, especially, regarded with invidiousness every attempt to impart to them moral instruction. Every Athenian, they thought, was capable of communicating this kind of knowledge, at least every educated Athenian, every individual of the higher order of citizens.[1] They wanted no one to teach them virtue. Hence the allusion made on so many occasions by Socrates to the question, whether virtue could be taught or not. It was, indeed, part of the profession of the Sophists to teach virtue;[2] but it was as an accomplishment or art, and not as a *discipline of life*, that it entered into the system of the Sophists. Socrates uprooted this vain notion. He laboured to impress on the Athenians, that so far from their being able to teach virtue, there were none who knew what virtue was. They had yet to learn *themselves* in order to that purpose. This, then, was his great difficulty. It was not the difficulty of communicating *new* knowledge, but that of leading men to unlearn their presumptions and conceits, and to *feel the necessity* of moral instruction.[3] That he should have succeeded then in any degree in such an attempt,—that he should have been able to carry on the effort for so many years, in the very centre of Greek civilization,—that, proceeding on so broad and fundamental a principle of reformation, presenting no definite system on which a sect might fasten, no specific lure to the zeal of party, he should have drawn around him so many followers and admirers,—this is the extraordinary effect in the case of Socrates, which shows the powerful charm of his address. To persons offering any particular instruction, or professing to qualify them for the office of statesmen and orators, the Athenians were most ready to attend; and many doubtless did attend to the conversations of Socrates with this view. They could not but admire the skill which he displayed in arguing with every one that came in his way; not with the vulgar only, but with those who had the highest reputation for talent in reasoning, and for the extent of their knowledge. They saw his superiority to the Sophists, on the very ground on which the Sophists set up their pretensions. Many, accordingly, flocked to him as the best master in political science and dialectical skill, particularly as he was always accessible, and his instructions were perfectly gratuitous. Some, too, of a better nature than the rest, were won by the honest and manly purpose which shone through his teaching and manner on all occasions; whatever disguise of irony, or humour, or sophistry, he might assume. There were even some of the young men, whose habits of life were reproved, and principles condemned, by his searching interrogatories, but who yet were won to attention by the charm of his instruction, and patiently heard from him truths which they would not have listened to from any other lips. For who else could stay, even for a moment, the wild impetuosity of Alcibiades, or the ferocious arrogance of Critias? Their motives in resorting to Socrates were chiefly selfish and political. It was in pursuit of their schemes of ambition that they sought his society. Still he was able to retain them for a time at least, though they found his instructions very different from what they calculated on receiving; and so long as they continued to associate with him, they exercised a degree of self-restraint which strikingly contrasted with the habitual profligacy of their lives.[4] Alcibiades is represented by Plato, as confessing that he, to whom the feeling of shame was scarcely known, yet felt abashed before Socrates; that he was enchanted by him as by the flute of Marsyas, and constrained to acknowledge his own deficiences and neglect of private duty in the midst of his officious zeal for the public service. And this feeling, Alcibiades says, was general; for that there was no one, woman, or man, or boy, that could hear him, or even his words repeated by the most indifferent speaker, but felt taken by surprize, and riveted in attention.[5]

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[1] Plutarch, De Gen. Socr. p. 331.

[2] Plato, Phædo, pp. 135, 262.

[3] Aristotle, cited by Laertius in vit. Socr.

[4] Diog. Laert. in vit.

[5] The same who was among the generals at the battle of Arginusæ, and who were cruelly and iniquitously sacrificed to party spirit after their great victory.

[6] Plutarch in Pericl. Op. i. p. 667.

[7] The poverty of the family of Aristides appears from Ælian, Var. Hist. x. 15.

[8] Plutarch in Aristides, Op. ii. p. 542. Plutarch adds, that Panætius had sufficiently refuted the story of the double marriage in his observations on Socrates. The story is also questioned by Athenæus. Deipnosoph. xiii. 2.

[9] Porphyry in Theodorit. Therapeut. xii. tells of altercations, even to blows, between Xanthippe and Myrto, whilst Socrates stands by and laughs, amidst their joint attacks on himself.

[10] Diog. Laert. in vit

[11] Ælian, Var. Hist. vii. 10.

[12] Diog. Laert. in Vit.

[13] Xenoph. Conviv. ii.

[14] Plato, Phædo p. 135.

This attention, too, it should be observed, was excited by the address of Socrates, amidst much in his outward form and mien, that, by exciting ridicule, might have repelled the sentiment of respect. The comparison of him to the satyr Marsyas, with all allowance made for comic exaggeration, was true in more respects than that of the enchantment of his conversation. His countenance, strongly marked by that arch intelligence, which half-concealed, half-betrayed, the earnest deep thought, under the light veil of irony and humour, presented features resembling those of the grotesque images of the Sileni. There were the prominent dilated eyes, scarcely parted by the low ridge of the nose, the broad expanded nostrils, the wide mouth with its thick lips, such as the sculptors delighted to represent in those rude but poetic forms.[6] Then his manner of looking about him, his head fixed, whilst his eyes traversed the space around, glancing from side to side, excited the smile of wonder in the spectator, as to what this strange solemnity of aspect might portend. Add to this, the clumsy protuberance of his figure, so repugnant to Grecian notions of the symmetry of form, and the awkwardness of his movement[7] before the eyes of a people who had a lively perception of elegance in every gesture and motion.[8] These were circumstances which, to the fastidious taste of the Greeks, would appear more important than we, in these times, can well conceive. They judged of intellectual character more from physiognomy[9] (physiognomy, that is, considered as a science, of mental indications from bodily forms in general) than we are apt to do. Thus in regard to Socrates, the physiognomist, Zopyrus, who, as Cicero informs us,[10] professed to discern the manners and natures of men from their body and features, pronounced that Socrates was stupid and heavy, because the outline of his throat was not con-

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[1] Xenoph. Mem. iv. 2. 24. Κατέμαθες οὖν πρὸς τῷ ναῷ που γεγραμμένον τὸ Γνῶθι σαυτόν; Ἔγωγε. Πότερον ουν οὐδέν σοι τοῦ γράμματος ἐμέλησεν, ἢ προσέσχες τε καὶ ἐπεχείρησας σαυτὸν ἐπισκοπεῖν ὅστις εἴης; Μα Δί, οὐ δῆτα ἔφη. καὶ γὰρ δὴ πάνυ τοῦτό γε ᾤμην εἰδέναι· σχολῇ γὰρ ἂν ἄλλο τι ᾔδειν, εἴγε μηδ' ἐμαυτὸν ἐγίγνωσκον, κ.τ.λ.

[2] Isocrates speaks of them as σύμπασαν ἀρετὴν καὶ εὐδαιμονίαν πωλοῦντες, and, again, as τὴν εὐδαιμονίαν παραδιδόντας Or. c. Soph. 3. 4.

[3] Plato, Euthyphro, 3. c. Αθηναίοις γάρ τοι, ὡς ἐμοὶ δοκεῖ, ου σφόδρα μέλει, ἄν τινα δεινὸν οἴωνται εἶναι, μὴ μέντοι διδασκαλικὸν τῆς αὐτοῦ σοφίας· ὃν δ' ἂν καὶ ἄλλους οἴωνται ποιεῖν τοιούτους, θυμοῦνται· εἴτ' οὖν φθόνῳ, ὡς σὺ λέγεις, εἴτε δι' ἄλλό τι. Op. 1. 6. See the same indicated at the opening of the Protagoras, where Socrates ironically throws out his opinion, that virtue cannot be taught; founding it on the fact of the indiscriminate admission of all persons to advise on political affairs in the Assembly, whilst on particular subjects, as in a question of building, those only were consulted who were proficients in the art. Ἐπειδὰν δέ τι περὶ τῆς πόλεως διοικήσεως δέῃ βουλεύσασθαι, συμβουλεύει αὐτοῖς ανιστάμενος περὶ τούτων ὁμοίως μὲν τέκτων, ὁμοίως δὲ χαλκεὺς, σκυτοτομος, ἔμπορος, ναύκληρος, πλούσιος, πένης, γενναῖος, ἀγεννής. Plato, Op. iii. p. 105; also Meno. Op. iv p. 375.

[4] Xenoph. Mem. i. 2. 24.

[5] Plato, Conviv. 215, Op. x. p. 257.

[6] Xenoph. Conviv. v. Plato, Theætet. 143 e.

[7] The idea of his attempting to dance excites a laugh in the guests in Xenophon's Banquet. Xenoph. Sympos. He says there that he practised dancing for the sake of exercise.

[8] Xenoph. Conviv. ii. 19.

[9] Aristotle introduces in his Analytics (Anal. Prior. ii. c. ult.) a notice of the subject, as affording matter of consideration to the dialectician.

[10] Cicero, De Fato, c. 5.

cave, but full and obtuse. Prejudices accordingly drawn from the personal appearance of Socrates may reasonably be believed to have tended to render his teaching unwelcome in its first impressions. But soon this fastidiousness would give way as he proceeded; and those who began to listen with a smile at the uncouthness of his form, and the quaintness of his manner, would be attracted to admiration of the intelligent and kindly expression which lighted up those rude features, and would find themselves lingering in his presence in spite of themselves.

The story of Euthydemus "the handsome," as he was called, may be taken as a specimen of such an effect. Euthydemus, proud of his personal accomplishments, and not wishing to be thought indebted to any one for his learning and eloquence, had studiously avoided the society of Socrates. Socrates, however, with his usual dexterity, contrives to excite his attention, and gradually interests him in conversation. Euthydemus shrinks back at first on his self-conceit, but at length is so won upon by the persuasive reason of the philosopher, as freely to acknowledge his own ignorance and need of instruction; and, ever afterwards, he is found by the side of Socrates, his devoted admirer and follower.[1]

Some, indeed, took offence at the plain truths which Socrates brought home to them, and no longer frequented his society.[2] But these were the inferior sluggish minds, which no arts of address could rouse to a sense of their intellectual poverty. Generous, susceptible minds overcame their first reluctance, and yielded themselves fully to his guidance. The faithful attachment of many was evidenced, to the last moment of the philosoper's life. He might have commanded the use of Crito's wealth, had he desired it. Such, indeed, was the confidence which Crito reposed in his sincerity of purpose, and so highly did he value his instructions, that to no other would he commit the education of his sons, but made them fellow disciples with himself of his own revered master and friend. And this friendship was warmly requitted by Socrates. For it was by his counsel that Crito was saved from the malicious arts of the sycophants. These pests of Athenian society were not to be encountered by the simple testimony of a life contradicting their mercenary calumnies; and Crito was one of those who would rather pay their money, and compromise the attack, than take the trouble of defending themselves. They were only to be foiled by turning their own weapons against themselves. By the suggestion of Socrates, accordingly, Crito enlisted in his service a clever individual of this class, Archedemus, who effectually checked the iniquities of which his patron was the object, by counter-prosecutions of the sycophants, and exposure of their conduct; acting as a watch-dog, according to Xenophon's description, against those rapacious wolves.[3]

The devotedness of Plato and Xenophon to their master, speaks from every line of their writings. These writings are, in fact, as much monuments of the influence of Socrates over their minds, as of their own genius. And what human teacher has ever had such glorious trophies erected of the conquests of his philosophy as the extant works of these master minds? Entirely different as they are in character,—the one flowing with the full stream of impassioned feeling, and lively elegant imagination, and the abundant treasures of literary and traditionary wisdom,—the other sensible and acute and practical, forcible by his very simplicity and the terseness of his unaffected eloquence,—they bear distinct yet conspiring evidence of the ascendancy of that mind which could impart its own tone and character to such disciples. Both of them, indeed, lead us to think that they felt his society as a kind of spell on them. For, when Plato speaks of the charm of the discourses of the Sophists, he seems to speak in irony of them what he thought in truth of Socrates himself. So too, when Xenophon introduces Socrates describing himself as skilled in "philters and incantations," he is evidently presenting that idea which the conversations of Socrates impressed on his own mind. He seems almost to confess this of himself when he informs us, how Socrates triumphantly appealed to the marked devotedness of his followers, in saying, "Why think you that this Apollodorus and Antisthenes never quit me? Why too, that Cebes and Simmias come here from Thebes? Be assured, that this is not without many philters, and incantations, and spells."[4]

To the same honourable band of attached disciples might be added many other names afterwards renowned in the annals of Grecian history and literature. Isocrates, Aristippus, Antisthenes, each of whom became afterwards masters themselves, were content to follow in his train. Antisthenes especially, who, by perverting the Socratic simplicity of life into a profession of austerity, became the founder of the Cynic school, was never from his side. He would walk from the Piræus to Athens, a distance of about four miles, every day, in order to be with Socrates. And whilst Cebes and Simmias came from Thebes, Euclid, the founder of the Megaric sect, was not deterred by the bitter hostility between Athens and his own city of Megara, from seeking the society of Socrates at the hazard of his life. Even during the war, when the Megareans were excluded by a rigid decree, he continued his visits to Athens, adopting, it is said, the disguise of female attire, and so passing unobserved into the city at nightfall, and returning at daybreak.[5] The same individual gave still more conclusive evidence of his zealous attachment to Socrates afterwards; when he opened his house and his heart to receive, at Megara, his brother disciples, in their panic on the death of their master. So strong was the tie of reverence and affection which subsisted between the philosopher and those whom he drew around him. They formed, indeed, a sort of select family, each of whom was engaged in the pursuit of his own peculiar employments and tastes in the world, whilst all looked up to Socrates as their father and head, and ever recurred to his society as to their common home.

This domestic intercourse subsisted in the midst of a city harassed with jealousies and dissensions, and with severe afflictions of war and pestilence. Socrates remained unmoved through all these convulsions of the city, preserving a constant evenness of temper, so that Xanthippe could testify of him, that she never saw him returning at evening with a countenance changed from that with which he left home in the morning.[6] Nor could even the merriment of which he was sometimes the object, discompose his settled gravity and good humour. On one occasion, returning from supper late in the evening, he was assaulted by a riotous party of young men, personating the Furies, in masks, and with lighted torches.[7] The philosopher, however, without being irritated by the interruption, suffered them to indulge their mirth; only he required them to pay that tribute which he exacted from every one that came in his way, to stop and answer his questions, as if he had met them in the Lyceum, or any other accustomed place of his daily conversations. Himself sound in mind and body, (for his habitual temperance saved him from the infection of the plague which so obstinately ravaged Athens,) he was enabled to give advice and assistance to all of his country in the midst of the physical and moral desolation, in which every one else seems, more or less, to have participated.

Thus were the years of a long life quietly and usefully spent; and he had nearly reached that limit at which nature herself would have gently closed the scene of his philanthropic exertions, when the hand of human violence interposed to hasten the approaching end.

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[1] Xenoph. Mem. iv. 2.
[2] Ibid. 40.
[3] Ibid. ii. 9.
[4] Ibid. iii. 2.
[5] Aul. Gell. vi. 10.
[6] Ælian, Var. Hist. ix. 7.
[7] Ibid. c. 29.

The annals of party spirit at Athens had already recorded many a deed of dark and wanton cruelty. But they were yet to be stained with the iniquity of a persecution even to death, of him, who had been the greatest benefactor and ornament, not only of Athens, but of the whole community of the Grecian name.

The banishment by ostracism had this redeeming merit, that it was an avowal in the face of Greece, of the envious and factious spirit, which drove from the state the individual whose talents or virtues too greatly distinguished him from among his fellow-citizens. The enmity to which Socrates fell a sacrifice, exhibits a deeper character of malignity; inasmuch as it masked itself under a hypocritical zeal for religion and virtue, and thus courted public sympathy for proceedings, against which every voice in Athens and in all Greece should have indignantly protested. Ostracism, again, was content to remove the obnoxious great man from the eyes of his fellow-citizens. The attack on Socrates was satisfied with nothing short of the destruction of its victim.

It was in the midst of the tranquil, but busy course of his daily engagement, that Socrates was suddenly arrested, and without, it seems, any previous intimation of the intended attack, summoned to the portico of the king-Archon, to answer a charge of impiety.[1]

The accusation was in this form: "Socrates is guilty of the crime of not acknowledging the gods whom the state acknowledges, but introducing other new divinities: he is guilty also of the crime of corrupting the young." The penalty proposed was death. It has been commonly supposed that the charge was laid before the court of Areopagus. But it would appear rather, from the course of the trial, to have been before one of the popular courts, and probably, from the great number of dicasts or jurors who voted on the cause, before the principal court, the Heliæa.

The circumstances connected with the accusation remain, after the utmost inquiry now possible, involved in considerable mystery. We are told that Melitus was the accuser, and that he was supported in the prosecution by Anytus and Lycon. These three individuals are also said to have represented distinct classes of persons interested in the proceedings; Melitus, who was himself a poet, appearing in behalf of the offended poets; Anytus, a wealthy tradesman and demagogue, resenting the affronts of his brother-tradesmen; Lycon, an orator, or politician by profession, standing up as the assertor of the pretensions of his factious order. But these particulars, though they may account to us in a great measure for the success of the prosecution, do not exhibit the secret agency by which it was effected. The accusers themselves were men of no note or importance in the state. Melitus was a young man; a vain and weak person, it seems, of whom nothing more is known than that the accusation was made in his name. Nor of Anytus and Lycon have we anything to mark the importance, beyond the fact, that the former was included, together with Alcibiades and Thrasybulus, among the persons exiled by the Thirty, and the notice taken of him by Plato, where he represents him the inexorable foe of every thing in the shape of a philosopher, and as parting from a conversation with Socrates in anger.[2] Merely personal offence, however, could not have given sufficient pretext or weight to so grave an accusation. Nor can we suppose that it was even the combined interest of the three classes represented by the three accusers—the poets, the tradesmen, and the orators—which carried the condemnation of so respected a person. The ground of the attack must lie deeper; and the men whose names appear so prominently in this fatal conspiracy against the life of the venerable old philosopher, could only have been the puppets moved by some secret and more commanding force. The trial would seem to have been only a solemn pageant, exhibited before the public, as a prelude and justification of a deed of murder already resolved on by its real though invisible perpetrators. Whilst the charges themselves, as set forth by the nominal accusers, were but feebly sustained, it is evident that no defence, however just and able, could have availed to avert the sentence of condemnation. The body of jurors before whom the cause was heard, appear to have been disposed to acquit the accused, if we may judge from the number of votes which were given in his favour; and yet the majority were overruled. This in itself would lead us to think that some secret influence had been exercised, to obviate the chance of failure of the ordinary ostensible means of judicial assault. And so Socrates himself appears to have felt; if Plato and Xenophon have faithfully reported the substance of his reply to the accusation in their Apologies. His defence, as there represented, is that of one who retires, on his own consciousness of right, from a bootless conflict with adversaries who are not to be appeased by argument and persuasion. It does not set forth the strength of his cause as against an opponent, but simply asserts the truth and merit of the course of life which he had been pursuing.[3] The sentence accordingly excites no surprize in him. He yields himself up as to the sweeping of a tempest, with which it is vain to parley. Would we then explore the circumstances of the trial and condemnation of Socrates, we must obtain a deeper insight into the moving power of Grecian politics,—the spirit of the heathen religion, and the mode of its action on the conduct of states and individuals. This appears to be the proper solution of the case of Socrates. The circumstances of the case evidently point to this. And though, from the want of information, we cannot very distinctly trace the working of the religion of the times in the particular instance before us, we may, from a closer consideration of the facts, not unreasonably suspect its active operation and instrumentality.

Speculators have sometimes spoken of the mild and tolerant spirit of paganism. The observation, however, is superficial and untrue. The facility with which the polytheistic worshipper transferred his offerings and prayers to every new idol, has been mistaken for a readiness to admit any variation from the established worship, or any freedom of opinion respecting divine things, without offence. The contrary is the fact. The heathen, resting his religion on ancient tradition[4] and the authority of the priests, and not on any intrinsic evidences of its truth, could not but feel a jealousy of any departure from what he had thus received, or any attempt to bring the subject into discussion. It was not only the primitive Christians that were stigmatized by heathens as atheists, because they renounced the divinities of the heathen creed, but the same reproach was long before cast upon those among the heathens themselves, who, with however pious disposition, ventured to speculate on religion. A traditionary religion will tolerate any laxity of thought or conduct which professedly admits its authority, whilst it peremptorily puts down every thing which impugns the principle of absolute deference to its authority. Thus we shall find, that, where that principle is carried to the utmost, there co-exists with it a scarcely concealed infidelity, and an unrestrained licentiousness of conduct; and, at the same time, also an extreme sensitiveness in regard to deviation from the orthodox profession and language. We have unhappily seen this in those Christian countries, where the true faith, the principle of devout submission to the word of God, has been transformed and perverted into a doctrine of implicit deference to the authority of the ministers themselves of that word. There,—as, for example, in Spain and Italy,—where the authority of the church is bowed to most submissively, practical infidelity and immorality shew their front with impunity, whilst the expression of opinion or argument on questions of theology is discouraged and silenced, if no longer now, as once, crushed at its outbreak by the dark terrors of an Inquisition. The same fact was intensely exemplified in heathen Athens. At no place was piety, as piety was understood by heathens, more in honour. No state boasted such a tradition of sacred associations as Athens. In none were there so many festivals and solemnities of religious observance, as in Athens.[1] In none did the priests of religion hold such sway. Witness their power over Alcibiades, at the moment of his political triumph, and amidst the caresses and admiration of his fellow-citizens, when he felt himself obliged to relinquish his command in Sicily, and desert his country, rather than encounter at home the threatened prosecution for his profanation of sacred things. Witness their power again in the instance of the same Alcibiades, at his restoration to the command of the army, when, to conciliate their favour, he delays the urgent expedition, and keeps the soldiers under arms along the road by which the sacred procession passed from Athens to Eleusis. Witness further, the frequent prosecutions at Athens on charges of impiety of which we read, and of which we have monuments in extant orations. But, amidst this strictness of external profession, in no place was there a more entire license as to practical irreligion. Their festivals abounded with rude and obscene mirth. Their drama, whilst it inculcated in direct precept the belief and worship of the gods, indulged in the most profane ribaldry and ludicrous representation of sacred things. Yet were these follies and excesses tolerated, because under them a regard was still maintained to the authority which upheld the religion, as in the "mysteries" and "moralities" enacted with the connivance of the papal power in modern times; and the people at large were satisfied with a religious system, which was exhibited to them as so good-humoured and humane. They were tolerated, indeed, but not without the like injury to the religious feelings, as in the parallel cases, where a corrupted secular Christianity has ventured on the like palliations of its despotism. For all the while the people were losing their hold of the popular religion. Those who thought at all on the subject, either rejected it altogether, or accounted it a mere matter of opinion and external ordinance; whilst those, on the other hand, who were content to receive every thing traditionary as divine on the mere principle of deference to the priests, readily engrafted every new superstition on the received religion. Thus, whilst infidelity and superstition grew up at Athens, and flourished together, and often perhaps in the same mind, the connexion between religion and morality was altogether lost sight of and dissolved. Men began to regard themselves as devout, and friends of the gods, whilst they were committing deeds of violence and lust, and blindly and wickedly endeavoured to support the cause of religion by forcible suppression of the truth, and persecution of those who subjected their tenets or their rites to the test of inquiry. Thus, whilst Aristophanes was amusing the people, not of Athens only, but from all parts of Greece, at the public festivals, with ludicrous representations of the popular theology, and loosening more and more any existing associations of reverence towards the objects of their worship, severe prosecutions were carried on from time to time against all who in any way made religion a matter of debate, or seriously brought it into question with the people. The same persons can take part in the vulgar low jest, and shew their real contempt of religion by their carelessness about oaths and the practical duties of religion, and yet join zealously in the prosecution of offenders against established notions of religion. It is the same habit of mind in both cases; a habit of looking at religion as a general rule of orthodox profession,—as a rule binding on a community, and a test of its soundness of doctrine,—rather than as a personal concern, and a trial of the spirit of a man. "He has brought Gentiles into the temple, he has abolished circumcision, he has profaned our religion," was the outcry against St. Paul; and yet these same persons thus clamorous against the apostle, were minding earthly things all the while, sticklers for externals, yet idolaters in their personal religion, as men of covetousness, and slaves to the appetites of the body.

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[1] Plato, Thætet. ad fin. Euthyphro. et alib. The king-Archon was a sort of minister of state for the department of religion—the representative, under the democracy, of the priestly office of the king during the monarchy at Athens. See Demosthenes, c. Neær. p. 1370, ed. Reiske.

[2] Xen. Hell. ii. 3. 42, 44.—Plato, Meno.

[3] See the same exemplified in what Socrates is made to reply to Callicles in the Gorgias of Plato, p. 162, τοσοῦτον μέντοι καὶ ἐγω οἶδα ὅτι παθος παθοιμι ἂν εἰσελθὼν εις δικαστήριον, κ.τ.λ.

[4] Demosthenes, in his Oration against Neæra, p. 1370, speaks of a column erected in the temple at Limnæ, ἐν τῷ ἀρχαιοτάτῳ, ἱερῷ τοῦ Διονύσου καὶ ἁγιωτάτῳ, and standing in his time, which stated, among other things, ἵνα κατὰ τὰ πάτρια θύηται τὰ ἄρρητα ἱερὰ ὑπὲρ τῆς πολέως, καὶ τὰ νομισμένα γίγνηται τοῖς θεοῖς εὐσεβῶς, καὶ μηδὲν καταλύηται, μηδὲ καινοτομῆται: and he sums up the account with εἰδῆτε, ὡς σεμνὰ καὶ ἅγια, καὶ ἀρχαῖα τὰ νόμιμά ἐστιν.

At Athens, accordingly, though there was no freedom of religious opinion, the religion might be employed to excite festive mirth, and gratify the levity and licentiousness of a dissolute yet intellectual populace, amidst the charms of poetry and music and the solemn graceful dance. For then the associations of deference to the mysterious agency which held together the traditions of the popular creed were not violently broken asunder. There still remained in the minds of the people an awe at the indefinite mystic truth, hidden under the embroidered veil held before their eyes. They knew that the splendid drama of religion, which at once gratified their refined intellectual taste and their sensibility, was not the whole of their religion. They had also the Eleusinian mysteries; rites of religion performed in secrecy, and fenced round with the terror of death to him that should divulge them; delegated to a few, the initiated only, and incommunicable to the vulgar; of which the popular rites were but the rude symbols.[2] The popular worship might wear the form of caricature, the grotesque, the farcical, and even the profane, as being merely the pantomime in which some recondite interior religion was dimly and wildly shadowed. The people laughed at what they saw and heard at their festivals. But amidst their laugh there was evidently a feeling of awe, which subdued the luxury of their mirth; a consciousness that, whilst they sportively shook the chain of their superstition, its iron entered into their soul. We see, on the other hand, Aspasia, the favourite of Pericles, at the time of the greatest popularity of that most popular leader, summoned before the courts, to answer a charge of impiety, and scarcely defended by the eloquence and the tears of Pericles himself, from the inexorable power, whose vengeance she had provoked by her philosophical speculations. Protagoras, admired as he was and courted at Athens for his talents in his profession of a Sophist, was expelled from the city and borders of Attica by the Athenians, and his books were collected by proclamation and burnt in their agora, for his avowed scepticism as to the existence of the gods.[1] Æschylus, whose very poetry is instinctive with religion, was accused before the Areopagus of divulging the mysteries in one of his tragedies.[2] The philosopher Anaxagoras, like Galileo under his papal inquisitors, suffered imprisonment at the hands of Athenian persecutors, for having asserted the material nature of the heavenly bodies, and only escaped death by the intervention of Pericles, and by exile from his adopted home. The extent again, to which prosecutions for offences against the popular religion could be carried at Athens, is shewn in the number of persons who were imprisoned on suspicion of being implicated in the impieties charged on Alcibiades, and the execution of so many, on that occasion of panic, on the unsupported evidence of secret informers. Lastly, not many years before the accusation of Socrates, Diagoras the Melian, and Theodorus of Cyrene, were branded with the epithets of atheists; and the former was forced to fly from Athens on a charge of profanation of the rites, with the price of a talent set on his head for any one who should kill him. And long after the time of Socrates, the same spirit subsisted to drive Aristotle from the Lyceum, and later still, to intimidate the speculations of Epicurus. So strictly was the *authority* of the established worship guarded by a jealous and watchful inquisitorial power, in a state which boasted of its perfect liberty of speech, its παῤῥησία, above all others.

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[1] Aristoph. Nub. 298. οὗ σέβας ἀῤῥήτων ἱερῶν, ἵνα
μυστοδόκος δόμος
ἐν τελεταῖς ἁγίαις ἀναδείκνυται,
οὐρανιοίς τε θεοῖς δωρήματα,
ναόι θ' ὑψερεφεῖς καὶ ἀγάλματα,
εὐστέφανοί τε θεῶν θυσίαι θαλίαι τε
παντοδαπαῖς ἐν ὥραις, κ.τ.λ.
Also Thucyd. ii. 38; and De Repub. Athen. attributed to Xenophon.

[2] Isocrat. Panegyr. p. 54. Ἃς οὐχ οἷόντ' ἄλλοις ἢ τοῖς μεμυημένοις ἀκούειν . . . καὶ τὴν τελετὴν, ἧς οἱ μετέχοντες περί τε τῆς τοῦ βίου τελευτῆς, καὶ τοῦ σύμπαντος αἰωνος, ἡδίους τὰς ἐλπίδας ἔχουσιν.

In fact, there was no liberty of speech on this subject in Greece. Every thing relating to religion was to be received as handed down from former ages; as the wisdom of an immemorial antiquity, borne along on the lips of the priest and the prophet, or impressed on mystic rituals, the hereditary trust of sacred families, or symbolized in the pomp and pageant of festivals and games, in the graceful majesty of temples, and the solemn shadows of sacred groves. The inward devotion of such a religion naturally took the form of silence, and reserve, and awe. It was concentrated in the simple dread of profanation. The more superstitious indeed a people is, the more necessary is it that the rites of their religion should be strictly shut up from all inquiry, and a feeling of reserve should be inculcated as essential to the religious character. It is the indefiniteness of superstition that holds together the system. Let any one part of the vaguely-floating system be touched too palpably, and the whole crumbles. Thus it has been found, that superstition and infidelity have always gone hand in hand. Diagoras was made an atheist from being at first superstitious. The Athenian people, in like manner, from their superstitious character, were peculiarly exposed to a reaction of impiety. And it was but a wise policy, therefore, that the religion of Athens should be jealously guarded with an awe forbidding all inquiry into its truth.

The colloquial and lively spirit of the Athenians mitigated the intensity of this feeling in the minds of the people at large; and the managers of the system were fain to relieve it, by blending recreation, and mirth, and interesting spectacles, with its public celebration. Grecian superstition accordingly, whilst it bore the essential marks of its oriental origin, in the submissiveness exacted of its votaries, and its mystic reserve, assumed also the mask of cheerful expression characteristic of the genius of the people. Still we see that submissiveness and that reserve strongly marked in the stern denial of the right, not only of private judgment on questions of religion, but even of bringing such questions at all into discussion.

Now, though, as we have already observed, we cannot distinctly trace the steps by which this spiritual despotism was brought to bear on Socrates, we cannot doubt that his was a case which must have attracted its notice. During more than forty years, Socrates had been seen at Athens, going about among all classes of the people, exciting among them a spirit of moral inquiry, urging on them the importance and the duty of self-knowledge, of taking no opinion on mere hearsay, or indolent and self-satisfied trust, but of bringing every thing to the test of discussion and learning, of acquainting themselves, as their first step to knowledge, with the depth and extent of their ignorance. Observers saw in this extraordinary teacher, one of their own citizens, educated in their own institutions, familiar with the habits of Athenian life, ever at home among themselves, recommending himself alike to the young and the old, by the honest though quaint dignity of his manner, and the interest and charm of his conversation. He was not, like Anaxagoras, or Protagoras, or Prodicus, a stranger sojourning among them; a philosopher or rhetorician by profession, or one pursuing philosophy as a trade and a source of subsistence, waiting to be resorted to and courted by the affluent and noble, and reserving himself for occasions of display or profit; but he was found, an Athenian among Athenians, in the market place, in the streets, in the work-shops, at the tables of the wealthy, himself seeking out persons to instruct, asking questions of all around him, and engaging them, even in spite of themselves, in conversation with him.[3] In other teachers, philosophy had spoken, according to the observation already made, as from an oracular shrine, to those only who came to inquire of it as votaries and disciples. With Socrates, philosophy walked abroad, insinuating itself into the scenes and business of daily life, and drawing forth the secret treasures of men's minds with its own hands. According to that homely but apt illustration of his mode of teaching, which he was so fond of employing, from midwifery, his method freely offered its services in assisting at the birth of the thought with which the pregnant mind was labouring. He busied himself, he used to say, with the officiousness of his maternal art, in exploring the genuineness of the fruit of the intellectual womb, which his dexterous questions had brought to light.[1] Such a person then could not but fix on himself the eyes of every attentive observer of the state of society in Athens. Such teaching evidently could not but have a very considerable influence on public opinion. Particularly when he was seen to be acceptable to men of all parties in the state, to the leaders of the aristocratic faction as well as the humblest citizen, it could not but be inferred that his influence was not a transitory one, dependent on the predominance of any party, but that it would reach to the fundamental constitution of the society at large of the city, and be a leaven of fermentation to the whole mass. What, then, it would naturally be asked, must be the effect of such a teacher on existing opinions in religion? He taught, indeed, that men should acquiesce in what was established in religion; that they should inquire no further here than what simply was the law of the state. He treated, too, the popular imagery of religion with respect. For he would often clothe his instructions in the language of the legends and traditions of their mythology. Nor did he attempt to explain them away, though he waived all discussion of them. He was seen, too, on all stated occasions, sacrificing at the altars of the gods, and joining in the rites.[2] But, it would be asked, if the citizens were taught to examine into received opinions generally, would they abstain from carrying this principle into the subject of religion? Would they continue still blindly and submissively to follow the voice of authority? Would they not rather, so far as they were disciples of Socrates, begin to speculate on divine things, abandoning that reverence which they had hitherto maintained for the objects of public worship, disputing and discussing without reserve, and exposing to the vulgar gaze what had been all along venerated in mystic silence, and under the veil of symbol? The mercurial temperament of the Athenian was just the soil in which the seeds now scattered by the hand of Socrates might be expected to vegetate. The excessive prosperity, too, of Athens, during the fifty years immediately following the Persian war, and then its condition of struggle against internal faction and the confederate arms of Peloponnesus, were circumstances calculated to foster the profane irreligious spirit in a light-hearted people. Then, instances were not wanting of young men, the intimates of Socrates, and whose minds had been especially cultivated by conversation with him, who proved in the end traitors to the religion, as well as to the civil liberties of their country. Critias,[3] afterwards one of the thirty tyrants, and Alcibiades, at once the pride and the pest of his fellow-citizens, whom they loved and hated, and banished and longed for by turns, were striking evidences to the superficial observation of the evil apprehended from the teaching of Socrates. For here were young men of genius, susceptible by nature of the fullest influence of the lessons of the philosopher. And yet these had failed under his hands. What, therefore, might not be expected of minds of inferior order? How would not the religion and the institutions of the city fall into profane neglect and contempt, should the Socratic spirit of inquiry be imbibed by the next generation of citizens? The observation, indeed, was only a very superficial one, which would infer from such instances the evil of the teaching which these individuals misapplied. Still it is plain, that such cases were pointed at with invidious reference to Socrates and philosophy in general. We find the orator Æschines attributing the death of Socrates to the circumstance of his having educated Critias;[4] not that he must be supposed to have believed this to have been the whole account of the trial and condemnation of Socrates; but as an orator, he states for the purposes of his argument, what he conceives would be readily believed as part of the account of that event. Plato also studiously addresses himself to the defence of philosophy, from objection on this ground, with evident allusion to Alcibiades and the like cases; arguing that the same individuals who were most susceptible of the good of philosophy, were also such as would be the most apt to abuse it. And probably he had the same design, and refers to the degenerate sons of Pericles himself, as an instance in point to those who cherished the memory of that great man, and of the times in which he flourished, to show that the philosopher was not to be held responsible for the extravagances and vices of the disciple.[5]

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[1] Diog. Laer. ix. c. 8. Cic. De Nat. Deor. i. 23. See the story of the daughter of Neæra, as told by Demosthenes, in his oration against Neæra, p. 1369. She had been married under the pretence of being an Athenian citizen, to an Athenian who served the office of the king-archon. As the wife of this officer of the state, she was admitted to the rites of religion, and solemnly inducted into the mystic temple of Bacchus at Limnæ. But it was unlawful for any but a true-born citizen to enter into the temple, or to witness the rites; and her husband consequently was tried before the court of Areopagus for the impiety, and only escaped on the plea of his ignorance of the fact, and on the condition of his dismissing her from his house.

[2] Ælian, Var. Hist. v. 19.

[3] Plato, Euthyphro. 3 d. Ἐγὼ δὲ φοβοῦμαι, μὴ ὑπὸ φιλανθρωπίας δοκῶ αὐτοῖς ὅ, τι περ ἔχω ἐκκεχυμένως παντὶ ἀνδρὶ λέγειν, οὐ μόνον, ἄνευ μισθοῦ, ἀλλὰ καὶ προστιθεὶς ἂν ἡδέως εἴ τις μου ἐθέλοι ἀκούειν. Op. t. i. p. 6. Xenoph. Mem. i. 2. Ἀλλὰ τῶνδέ τοι σε ἀπέχεσθαι, ἔφη, δεήσει, ὦ Σώκρατες, τῶν σκυτέων καὶ τῶν τεκτόνων καὶ τῶν χαλκέων, καὶ γὰρ οἶμαι (Critias is speaking) αὐτοὺς ἤδη κατατετρίφθαι διαθρυλλουμένους ὑπὸ σοῦ. P. 21.

The exhibition of the comedy of "The Clouds," appears to have been designed to bring before the people the supposed evil tendency of the teaching of Socrates, as exemplified in such distinguished instances. It was produced in the year B.C. 423, when the philosopher had attained his forty-seventh year, and was at the height of his reputation throughout Greece, and about twenty-three years before his death. There we have Socrates introduced by name under broad caricature, as the representative of the class of sophists, and a consummate master of the arrogant pretension, and sordid cunning, and impiety of the class. The clouds are his only divinities. A profligate spendthrift youth, and a dotard father, are his dupes. The inquisitive method which Socrates practised, is also held up to ridicule and contempt, by identifying it with the frivolous questionings of the grammarians, and dialecticians, and rhetoricians of the day, and with the perverse sophistry which held truth a matter of indifference, or, which amounted to the same thing, called every man's opinion truth, and boasted of its skill to make the worse appear the better cause. It was but too evident to Athenian spectators at least, that the Socrates of Aristophanes was not the Socrates whom they had been accustomed to see and converse with in real life. And the play accordingly failed at the first exhibition. Not all its charms of poetry, and humour, and skilful composition, could obtain for it a favourable reception. Though Aristophanes was aware that the portrait which he had drawn, was not a portrait of the individual, but of the class, there can be little doubt, that he calculated on the sympathy of the people, in giving the name of Socrates to his personification of the sophistical spirit; and that he felt it necessary to depreciate the influence of Socrates as the commanding influence of the day, by attributing to his method all the vices of the schools of the sophists. Socrates is honoured and complimented in the very attempt to weaken the respect for his instructions, and to awaken a clamour against him. The failure of "The Clouds," at the first representation, and one account adds, even at the second, (for the play is said to have been retouched for the third time), has been attributed to the influence of Alcibiades. Alcibiades indeed has been supposed by some commentators to have been no less the object of attack in the play than Socrates himself, and to have been designated under the name of Phidippides, the youthful and accomplished victim of the sophist. There are certainly some traits in the character of Phidippides, which would seem to point at Alcibiades, whom perhaps the poet, bold as he was, could hardly venture to bring on the stage by name or closer description at this particular time. And we may perhaps justly allow some weight to party influence in neutralizing the effect of "The Clouds" at its first exhibition. Still, when we observe in other instances the great power which the comic muse could wield against a political opponent, as in the attack on Cleon in "The Knights," we cannot but think that there was some strong countervailing feeling in the estimation of Socrates himself. If the account of Ælian be true, Socrates could join in the laugh raised against him; for he was present in the theatre during the acting of the play, and finding that he was the object of attraction, placed himself where all could command a view of him.[1] He knew, and every one in Athens knew, that he was a very different person from the sophists with whom the play identified him. They indeed were corrupters of the young; for they unsettled every established principle in the minds of the young, and gave no substitute for what they profligately swept away. They left the young to be drifted away by the tide of their passions, with no criterion of truth or of right beyond the present opinion or the present interest. But Socrates, whilst he taught the young to inquire into the truth of their opinions, lessened their presumption and self-confidence, by shewing them how apt they were to mistake mere assumptions for knowledge, and to be conceited of their ignorance. His object was truth, and accurate knowledge. He stated difficulties and objections, but not in the spirit of a sceptic, but in order to awaken curiosity, to clear away confusion of thought, and inculcate sound principles of judgment and conduct. He could well then laugh at the jest which glanced from him to its proper objects, the sophists themselves, the very persons against whom his whole teaching was directed. He felt doubtless that he had a hold on the people at large, which the sophists had not. They were for the most part known only to the great and wealthy; those who could receive them into their houses, as they went from city to city through Greece; who sought their society as patrons of literature, or aspirants after political distinction, and who could pay for their instructions.[2] He on the contrary was accessible to all. He would receive no money from any one. He was the frequent guest of the rich; but he was no less the associate of the artizan and the poor. And too many must have been present in the theatre, when the Socrates of "The Clouds" was amusing the audience by his sleight-of-hand philosophy, who would remember the real Socrates as a man of honesty, and truth, and disinterested benevolence, from whom they had received much useful counsel from time to time, and whom they had ever found affable, and at leisure to enter into their feelings and views with patience and kindness. If we compare the Socrates of the Memorabilia of Xenophon with the Socrates of "The Clouds," we may judge how great was the contrast to those who compared the well-known philosopher of the agora with his portrait as drawn by Aristophanes. If we can smile at the caricature of "The Clouds," and yet love the excellent moralist of the Memorabilia, we may also conceive how harmless the satire of Aristophanes would really be against the object of it; whilst the jokes of the poet, true as to the personal peculiarities of the philosopher, amused a volatile and clever people. For them to have confounded Socrates with the class of sophists, would have been in them the like palpable mistake, as it would be to confound the philosopher Bacon, on account of some points of resemblance, with the alchemist and empiric of the preceding ages.

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[1] See especially Plato's Theætetus in illustration of this.

[2] Plato, Euthyphr., pp. 11-13, and Phædrus.

[3] Critias is placed by Sextus Empiricus among the atheists. He is said to have resolved all religion into the enactments of legislators providing against the secret commission of crimes, by inculcating the all-seeing power of the gods. He gives also several lines from a poem of Critias to this effect. Adv. Math. lib. viii. p. 318.

[4] Æschin. con. Timarch.

[5] See the Protagoras and Repub. vi.—Xenophon adverts in like manner to the charge of corruption as supported by the instances of Critias and Alcibiades. Memor. i. 2. See also the conversation which Xenophon reports between Socrates and Hippias. Isocrates, in *Busir.* p. 222, c. with the like feeling, *denies* that Alcibiades was educated by Socrates; meaning, it seems, that Alcibiades was too short a time with Socrates to be benefited by the instructions of the philosopher

It might seem matter of reproach against Aristophanes, that, in selecting the name of Socrates to represent the sophistical spirit which had then so largely corrupted the education and the government of Athens, he pointed the shafts of the comic muse against the very person who was in truth its most successful antagonist. In such a view of the case, however, sufficient justice would not be done to the discernment of the poet. He shrewdly observed in Socrates the master genius which would ultimately cast into the shade all those busy professors of the art of education, who, under the name of sophists, or professors of all knowledge, were then attracting the notice of the world to themselves and their doctines. Socrates, in himself, Aristophanes could not but admire and recommend to the imitation of his country. He doubtless knew Socrates to be a true patriot no less than himself,—to be steadily aiming to bring back the Athenians to the purity of their institutions, from which they had so sadly degenerated, by his instructive conversations, as he was by the satirical strokes of the drama. Socrates, too, appears to have been his personal friend; for Plato introduces them in his Banquet as meeting on terms of intimacy, about the very time of the exhibition of "The Clouds." But with that freedom which the state of manners, under an absolute democracy, sanctioned and encouraged, Aristophanes did not scruple to bring even the revered name of Socrates on the stage, to give the due point to his satire. He overlooked the individual, the Socrates with whom he familiarly conversed, and presented before the spectators what he saw in Socrates, the living speaking impersonation of the influence of education on the character of a people, for good or for evil. Anaxagoras, or Protagoras, or Prodicus, or any other of the well-known philosophers or sophists of the day, might have occupied the foreground in the comedy of "The Clouds;" had the poet sought to give merely a fugitive sketch of the sophistical spirit of his times, or to single out for ridicule some of its external superficial features. This is what Plato has done on many occasions, and especially in that most animated picture in the dialogue entitled Protagoras, where he groups together the figures of the leading sophists in such admirable relief with each other, and such happy contrast with the unpretending but dignified form of his own loved master and friend. Such a view, however, could not have answered the design of Aristophanes in his play of "The Clouds." His object was to seize the deep, influential characters of the system of education which was then extending itself throughout Greece, and especially as it was manifested at Athens, the great school of all Greece. Naturally, therefore, and wisely, he fixed his eye on an Athenian—and that Athenian, Socrates,—not only as the first Athenian who had appeared in the office of a philosophical instructor, but who, as an Athenian, gave to his lessons the character of Athenian civilization, and fitly exemplified the influence of philosophical education in the hands of an Athenian, and as operating on Athenians.

The poet, indeed, as addressing the eye and the ear of the ordinary observer, and not Athenians only, but strangers of the Grecian name from all parts, mingles with his colouring some playful lights borrowed from the forms of the well-known professional sophists of the day. But neither are these representations, nor the allusions which he makes to the real eccentricities of manner and uncouthness of person in Socrates, the points on which he desires to fix the attention of the theatre. It is the important modification of the Athenian character, under a system of education which had now reached its maturity. Under the administration of Pericles, that system had already infected the policy of the state, and perverted its courts of justice into sinks of corruption and oppression. Now, at length, it was found domesticated at Athens in the sanctuary of private life. An Athenian had appeared in the character of a professor of philosophy; and around him were gathered citizens of all ranks, from the noble youth who aspired to the helm of the state, and the wealthy patron of literature, to the mean artizan who worked at the forge, and the drudge of the market. What was further to be observed now, was, that the system came recommended by the eloquence of lively and exciting conversation. And how powerful must have been such conversation, as it came forth from the lips of the speaker in the elegant and terse Attic idiom! It was no wonder, therefore, that the comic poet should have seized this moment for portraying the danger which he anticipated to his country from the fashionable education of the day, and thrown all the force of his ridicule on the most attractive form in which it then presented itself, as displayed in the personal teaching and example of Socrates.

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[1] Ælian, Var. Hist.

[2] Plutarch well characterises the teaching of Socrates, in speaking of him, as ἀνδρὸς ἀτυφίᾳ καὶ ἀφελείᾳ μάλιστα δὴ φιλοσοφιαν ἐξανθρωπήσαντος. De Socr. Gen. p. 301.

The testimony of Plato is to the same effect. Plato has not given us an exact portrait of Socrates any more than Aristophanes has; for he has evidently transferred to the Socrates of his Dialogues, not less of his own cast of mind and manner, than Aristophanes did to the Socrates of his comedy, of the general tone of the sophists. And this is to be accounted for, as in the case of Aristophanes, from the fact, that Plato regarded Socrates as the impersonation of the philosophy of the times. He felt that, to give his own doctrines a proper authority and weight, he could not employ a more effectual organ than the tongue of him who had first given to philosophy an Attic expression, and from whom it would henceforth derive its proper Grecian character.

But though the drama of "The Clouds" was unsuccessful as an attack on Socrates, if it were intended as such, or as an attack on the sophists under the name of Socrates, which is the more probable view of its design, it must not be supposed that the play produced no effect unfavourable to Socrates. The tradition, that Aristophanes was employed by Anytus and Melitus to write down Socrates, does not seem altogether without reason; though it can hardly be literally true, when we look to the distance of time which intervened between the production of the play and the accusation. In the *Apology* of Plato there is an allusion to the prejudice excited in the young men by the representation given of the philosopher in this play. Nor had "The Clouds" been the only attack on Socrates by Aristophanes; not to mention other comic writers who had made him the object of their humour. In the year 405, not more than five years before the prosecution, the play of "The Frogs" had been exhibited, in which a pointed allusion is made to the influence of Socrates in terms of reprobation.[1] In the mean time, also, the same note had been struck; for the play of "The Birds" was produced in the middle of this interval between "The Clouds" and "The Frogs," in the year 414; and in that again the Athenians are warned against the corruptions and enchantments of the philosopher.[2] And it is very possible that many who lived to witness the formal accusation of Socrates, might have received their earliest prejudices against the philosopher by what they heard in the theatre then,—prejudices, too, which the course of events, the miseries of the Peloponnesian war, and the anarchy consequent upon it, may have ripened into exasperation.[3] For they saw their country fallen from its proud station in Greece, to the condition of a dependent state; and they were led to ascribe their misfortunes to a change of habits since the days of Marathon and Salamis,—to their having deserted the palæstra and the field, and become, from a body of devoted patriots and soldiers, students of rhetoric and masters in debate.[4] During all this time Socrates continued the unrivalled teacher of the youth of Athens; increasing, indeed, in renown and popularity; and surrounded by a number of students of philosophy and political science from all parts of Greece. He had, in fact, converted Athens into a university of Greece. For though he had no professed school,—no φροντιστήριον, as Aristophanes jocosely represents the scene of Socrates amongst his disciples,—no regular place of meeting, such as Plato had in the Academia, and Aristotle in the Lyceum;—there might be seen around him in familiar conversation, in every part of the city, day after day, the statesmen, and orators, and generals of the republic,—philosophers of established repute from other cities,—the sons of the noblest families of Athens as well as of the humblest citizens,—and the resident foreigners and occasional visitors of the city; some seeking instruction in the art of government, some investigating by his guidance the chief good of man, some studying the theory of eloquence and criticism, some exploring, by the light of his searching questions, the depth of metaphysics, and the subtile speculations of the earlier philosophers; all according to their different pursuits, and in their different degrees, receiving information and general mental culture from the great Athenian sage. Those who clung to the thought of Athens in its days of military glory and empire, would painfully observe how great a change had taken place in the internal habits of the city. Formerly it was enough for the intellectual improvement of the youth, that in childhood he had the grammarian for his instructor, and as he grew up to manhood, was consigned to the poets;[5]

> τοῖς μὲν γὰρ παιδαριοισιν
> ἔστι διδάσκαλος ὅστις φραζει, τοῖσιν δ᾽ ἡβῶσι ποιηταί[6]

Now even the slaves were becoming literary. The distresses of war had occasioned the addition to the roll of citizens, of many even from that class. And these might be seen, as the comic poet represents them, "each with his book, learning clever things;"

> βιβλιόν τ᾽ ἔχων ἕκαστος μανθανει τὰ δεξιά.[7]

Formerly, their wise men were obliged to leave the ignorance and rudeness of their own city, and learn philosophy by foreign travel. Solon had brought back with him from his travels the wisdom of Crete and of Asia to enrich their code of laws, but had not given philosophy a domicile at Athens; had not affected domestic life there with its refinements.

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[1] Aristoph. Ranæ, 1487. [2] Aristoph. Aves, 1282, 1554. [3] See Thucyd. iii. 82, ἐν μὲν γαρ εἰρήνῃ καὶ ἀγαθοῖς πράγμασιν, κ.τ.λ.

[4] In Xenoph. Mem. iii. 5, the younger Pericles asks Socrates how the Athenians are to be brought again to become enamoured of their ancient virtue, glory, and happiness; and afterwards he expresses his wonder how the state ever began to decline. Socrates imputes their degeneracy to their neglect of the institutions of their ancestors. The particulars mentioned are, want of respect to elders, neglect of bodily exercises, even to the ridicule of them, insubordination to authorities, mutual irritation, envy, quarrelsomeness, litigation, covetousness, incompetence of their generals.

[5] If we except the profession of the Sophists, when at its height of public favour, skill in the composition of tragedy was the most highly rewarded of all talents at Athens. Plato, *Laches*, 183, b. p. 169. The poets of Athens, therefore, were naturally jealous of the popularity of philosophers and sophists.

[6] Aristophan. Ran. 1052. [7] Aristophan. Ran. 1111.

From that time, however, a change, introduced by the literary taste of Pisistratus, had gradually prepared the way for establishing a school of philosophy at Athens.[1] Pericles, too, had given a great stimulus to the literary spirit by his own fondness for intellectual pursuits, and the society of intellectual men. In the midst of his active political life, he could find time and thought for the elaborate disquisitions of the ingenious persons whom he invited to him. He could spend a whole day in disputing with Protagoras on so subtile a question as the theory of causation;[2] such was the intense interest which he displayed in every thing tending to the development of mental energy, and such the encouragement he gave to the change of taste then in progress by his own example. In the person of Socrates was found the genius formed to preside over the growing taste for literary and philosophical refinement, and to give it the form of an established institution. What, therefore, were merely indefinite fears at the time of the exhibition of "The Clouds," assumed a more distinct character of alarm to ancient prejudices within a quarter of a century afterwards. The rapidity and violence of several successive revolutions of the government during the latter part of that interval, further prepared the minds of the people for any sudden outbreaks of party spirit, and made every man an object of suspicion to his neighbour. A democracy of an hundred years' existence[3] had been overthrown, and first an oligarchy of four hundred, then a tyranny of thirty, established by foreign arms, in its place. Nor, as it had not been without fraud and bloodshed that the people had been spoiled of their "ancient liberty,"[4] were they disposed to surrender it in quiet; or were those who seized on the government able to retain it long on the same footing. A struggle ensued; in which the individuals of contending parties only sought to provide, each for his own aggrandizement and interest, or at least his own safety, under the constant expectation of some counter-revolution.[5] The people had found that some of those very persons who would never have been suspected of oligarchical views, had in the late changes taken part against the popular government, so that they knew not, at last, whom to trust even of themselves.[6] We are not to wonder that an accusation of Socrates should have succeeded before an Athenian jury at this period of morbid sensitiveness of the public mind.

An accusation of impiety was, we must remember, too, an accusation of a political offence. A change of the popular religion was a change of the fundamental constitution of a Greek state. And as in the absolute rule of a single despot, so in the tyranny of a multitude, the reputation of zeal for religion is studiously maintained from policy, if from no higher motive, to throw around its arbitrary acts the reverence and fear due to the religious character. The teaching of Socrates was indeed eminently religious, but it differed from what the state regarded as such. He proved the existence of an invisible divine power, wisely designing and governing all things, and inculcated the duties of piety and morality as flowing from the belief of such an agency. Such clearly was not the state-religion.[7] This was no system of truth or morality. It was tradition and legend, and immemorial usage, and ritual observance.[8] And it was enough for a charge of impiety that Socrates rested religion on other grounds. A pious Athenian, and yet not pious after the manner of the Athenians, was, in their view, an introducer of new gods. He might well be believed to be a worshipper of the clouds and the air, when he pointed out to them, that the gods would not receive the sacrifice offered by wicked men,[9] that even their silent counsels were not concealed from the divine cognizance, and that justice was an indispensable duty of the worshipper of the gods.[10]

That the accusation further should be credible, as brought in this form, is not strange, when it is known that, during the Peloponnesian war, the worship of new gods had been introduced into the city; as at Rome during the depression of its fortunes in the first years of the second Punic war. So greatly had the vicissitudes of fortune influenced the minds of men, observes Livy, describing this effect,—so great was the influx of religion, and that chiefly foreign, into the state,—that either the men or the gods appeared to have suddenly become different.[11] So at Athens, it appears, the forms of superstition had been multiplied, under the pressure of civil and domestic calamity acting on the fears and credulity of the people. The strong reproof which Euripides puts into the mouth of Theseus, of the austere life of Hippolytus, would seem to point at some ascetic devotees among the Athenians themselves, practising a more refined and scrupulous religion, distinct from that of the vulgar;

> Ἤδη νῦν αὔχει, καὶ δι᾽ ἀψύχου βορᾶς
> Σίτοις καπήλευ, Ορφέα τ᾽ ἄνακτ᾽ ἔχων,
> Βάκχευε, πολλῶν γραμμάτων τιμῶν καπνούς.[12]

In Aristophanes[13] we find still more evident allusion to the introduction of new objects of worship, new fanatical rites, in which the women chiefly officiated, and in which a gross licentiousness mingled with the gloom and solemnities of barbaric superstition.

Again, education was intimately connected with politics in a Grecian state. The state took in hand its youthful citizens, and trained them according to its peculiar institutions, and in its own spirit. At least, in all the early constitutions, great attention was paid to education. Lycurgus made Sparta a constant school of war to his citizens. So too Solon, though he had, with greater knowledge of human nature than Lycurgus, adapted his institutions to the people for whom he legislated, provided that the people should be trained to the system of laws prescribed to them. But this care of the early legislators had begun to be lost sight of in practice.[14] In Aristotle's day it had disappeared everywhere.[15] In Sparta it was still nominally reverenced. In Athens, an entire relaxation of the educational discipline had taken place already in the time of Socrates. Pericles, flattering the democratic spirit of the Athenians of his day, could boast of their ease from labours and the obligation of exercises, and congratulate them on the courage which they could display at the time of action, without being inured beforehand by a course of hardy discipline.[16] But now, whilst the state was remiss in not enforcing education according to its ancient system, a new system had grown up, the offspring of the luxury and refinement of its days of imperial greatness. This new and unauthorized education was diffused throughout the mass of the inhabitants beyond the pale of the citizens. Solon's law imposed the duties of the exercises on the citizens, but excluded the slaves from the gymnasium. Now all classes were hearers of the philosopher; the smith, the carpenter, the fuller, the dresser of leather, were engaged in discussing problems of ethics and politics, no less than the high-born and wealthy citizen, and the orator, and the statesman, and the general. This was an evident indication of a corresponding change in the government itself; a change, which really came to maturity not long after the time of Socrates, when the machinery of the government passed from the hands of the generals and the men of practical ability, into those of the orators of the republic, and when rhetoric, or oratory, became the master science, and only another name for politics.[1]

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[1] Aul. Gell. vi. 17. Libros Athenis disciplinarum liberalium publice ad legendum præbendos primus posuisse dicitur Pisistratus tyrannus, &c.

[2] Plutarch in Pericl. Op. i. p. 665.

[3] Thucyd. viii. 68.

[4] Thucyd. viii. 71, 72.

[5] Thucyd. iii. 82. πάντων δ᾽αὐτῶν αἴτιον, κ.τ.λ.

[6] Thucyd. viii. 66.

[7] Aristotle, Pol. v. 9.

[8] Cic. de Legib. ii. 16.

[9] Xenoph. Mem. i. 3.

[10] Xenoph. i. 6.

[11] Liv. xxv. 1. Quo diutius trahebatur bellum et variabant secundæ adversæq. res non fortunam magis quam animos hominum; tanta religio, et ea magna ex parte externa, civitatem incessit, ut aut homines aut Dii repente alii viderentur facti, &c.

[12] Euripid. Hippolyt. 952.

[13] See Pax. 410, 428. Lysist. 389.

[14] Lysimachus, in the Laches, complains of their fathers having neglected their education, ὅτι ἡμᾶς μεν εἴων τρυφᾶν, p. 162. See this dialogue of Plato throughout, on the subject of Athenian education.

[15] Aristot. Pol. v. 7. ὀλιγωροῦσι πάντες.

[16] Thucyd. ii. 39.

Those, then, whose attention had been drawn to the person of Socrates many years before, and had then only laughed at the exaggerations of the comic muse, might naturally begin to suspect, in the progress of events at Athens, that there was a real danger to the institutions of the country couched under the humorous mien and conversation of the real Socrates. They would now, as they watched his increasing influence and reputation, recal their early associations of the ludicrous with the name of Socrates, not with the good humour with which they were originally received, but with the undefined fears since acquired, in the course of their daily observation, of one in whose hands the destinies of their country seemed to be placed. They would probably then think that they had judged his case too leniently before as spectators, and that they were now called upon to pronounce authoritatively as judges, not so much from the representations and arguments of the accusers, as from their own experience of the great change which their country had evidently undergone, and was still undergoing. Even indeed at the time of trial, nearly half of the great body of jurors were in favour of his acquittal; and Melitus would have failed altogether, but for the speeches of Anytus and Lycon, men of popular and rhetorical powers, who addressed the court in support of the charge; so strongly did the weight of his personal character, and the interest which he had excited by his friendly and instructive intercourse with every class of citizens, prevail in his favour.

We should take into account, further, the general neutrality of Socrates on questions of politics, and his decisive energy on particular political occasions, in which he was called upon by the circumstances of his position to take part. Both lines of conduct would create enemies. Neutrality in a state distracted with parties is the most unpopular course which can be adopted; however candid and reasonable the principle of such conduct may be, all parties look with jealousy at one who will not be associated with them in the guilt and the danger of party-struggles. They envy him his exemption from their violence, his reputation of candour, his safety under every vicissitude of party-ascendancy. Corcyra, as a state, was obnoxious to the other states of Greece for its neutral policy. So was the individual at Athens who kept aloof from public business, amidst that restless pragmatical spirit which actuated the state and its citizens. Athenians could not understand and appreciate the motives of one who abstained from the public assemblies, and the courts, and the theatres,—who shrank from all public offices,—was a member of no faction or club,—engaged in no trade,—disregarded even his own domestic concerns,—and lived a private man, where every one else was the servant of the public, busy with the affairs of the state, and incessantly pushing his own interests by his political activity.[2] The laws of Solon indeed inculcated the principle, that every one should take his side in the contention of parties.[3] Solon wished to interest the people in the maintenance of the constitution which he had given them; and accordingly, obliged them by penalties to attend to public affairs. This was evidently his reason for compelling their attendance in the assemblies and courts, as also for this singular provision. The increased action of the democratic spirit in the time of Socrates must have greatly fostered the opinion thus declared in their ancient laws. And thus we find philosophers in general held in disrepute at Athens, on account of their inactivity and unconcern in public affairs. The busy sophist, the orator, and the man of the world, censured them as pusillanimous, and indolent, and incapable of the duties of a citizen. Some of the early philosophers, indeed, had been distinguished as statesmen, and legislators, and generals. The Pythagoreans in Magna Græcia appear still to have sustained this character in some measure. But now philosophers were observed, for the most part, to lead a contemplative life of leisure, and to present a striking contrast to the general society of Grecian states. Plato takes every opportunity in his writings of defending philosophy from this calumny directed against the persons of its votaries, evidently treating it as a grievance which he had felt in his own case. Aristotle also indicates the prevalence of the same objection against philosophers at his day, when he studiously maintains that exertions of the mind in mere speculation are to be regarded as even more really practical than those which are directed to external results.[4] Socrates accordingly was a puzzle to many of his contemporaries. They wondered that he should freely dispense the treasures of his wisdom, and not convert it into a marketable commodity. Whilst they gave him credit for integrity, they regarded such a proceeding as mere folly.[5] They asked how he could think to qualify others for public life, without taking part in it himself, if he really knew what it was to be a statesman. But he was content, in reply, to point to the number whom he had laboured to render capable of public duties, as a more effectual service on his part to the state, than a mere personal activity.

But though the general conduct of Socrates was to avoid all interference in affairs of state, he had shewn on one or two very important occasions his patriotic feeling, and the energy with which he could carry it into effect. He had served with distinguished courage at Potidæa, Amphipolis, and Delium, as we have seen; and proved himself, on those hard-fought days, one who, as Pericles characterizes the Athenians, could philosophize without effeminacy, and, without being inured to the dangers of the field, could brave them at the moment of trial with no diminished spirit. But still greater occasions of trial were those of civil exertion at home, to which he was called not long before the accusation of impiety. Perhaps one of the most memorable instances of resolute firmness which history presents, is to be observed in the fact, that when the uproar of faction was demanding the iniquitous condemnation of the generals who commanded at Arginusæ, Socrates stood alone among his colleagues in office, and refused to put the question to the vote, as the epistates, or superintendent of the day, in the form proposed.[1] Each of the ten Athenian tribes had its turn of presidency in the council of Five Hundred for thirty-six days of the year; fifty out of the whole tribe being chosen by lot as its representatives during this period. These fifty were further subdivided into tens; and each of these tens, under the name of proëdri, served a week in succession, as it was allotted, until the official term of the tribe was completed. Again, of these ten presidents, seven were appointed by lot, to occupy the chair in succession during their week of office; each one of the seven becoming in his turn epistates, or superintendent for a day. The tribe Antiochis, to which Socrates belonged, happened to be the presiding tribe on the occasion of the impeachment of the generals; and it came to the lot of Socrates to be in the chair of office on the day when the question of their condemnation was so passionately debated. The generals had nobly done their duty to their country, and gained the most brilliant victory which had been achieved at sea in the course of the war by the Athenian arms. But the crisis was an unfortunate one for them. Athens was then on the verge of ruin. The jealousy of parties was at its height. The hopelessness of recovering the lost ground by military strength at this time, gave an opening and encouragement to personal intrigue, and the arts of an unscrupulous diplomacy; and a victory, however honourable to their arms, and hopeful as to the future, seems only to have been hailed with very doubtful congratulations by the struggling factions of the city; each looking at it rather as it might act for or against his party,—as it might tend to the strength of his rivals or their depression,—than as a great public triumph. However this may be, for the event remains a matter of perplexity to the historian, the successful generals were brought to trial through the treachery of their own officers, on the specious charge of having neglected the collecting of the dead bodies of their men after the action.[2] The charge was specious, because it was partly true, and was attested indeed by the very officers who were sent by them on that service, and who were now brought as witnesses against their commanders. It was true, so far as the endeavour to collect the dead bodies had been frustrated by a violent storm which followed the engagement. Still the endeavour had been made. The charge was further specious, because it appealed to religious prejudices, as well as to the democratic spirit. The generals seemed to have been regardless of the solemn rites due to the dead, and of the persons and feelings of the lower orders of the people. The occasion therefore furnished abundant topic of invective to the demagogues; and their addresses too fatally succeeded in obtaining an ungrateful and factious vote of death against the generals. Socrates was threatened with criminal information by the orators of the people; and the people themselves were urging on his assailants, and clamouring against him. Still he remained unmoved, and would not put the unjust question to the vote; preferring the hazard of bonds and death to himself, on the side of the law and right, to a compliance with the popular will in an illegal act.[3] The iniquity was perpetrated ultimately in spite of his resistance; but he at least did his utmost to prevent it.

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[1] Aristot. Eth. Nic. x. Τὰ δε πολιτικὰ ἐπαγγέλλονται μὲν διδάσκειν οἱ σοφισταὶ, πράττει δ' αὐτῶν οὐδείς, ἀλλ' οἱ πολιτευόμενοι, κ.τ.λ. Τῶν δε σοφιστῶν οἱ ἐπαγγελλόμενοι . . . οὐ γὰρ ἂν τὴν αὐτὴν τῇ ῥητορικῇ οὐδὲ χείρω ἐτίθεσαν. c. ult.

[2] Thucyd. ii. 40. ἔνι τε τοῖς αὐτοις οἰκείων ἅμα καὶ πολιτικῶν ἐπιμέλεια, καὶ ἑτέροις πρὸς ἔργα τετραμμένοις τὰ πολιτικὰ μὴ ἐνδεῶς γνῶναι· μονοι γὰρ τόν τε μηδὲν τῶνδε μετέχοντα οὐκ ἀπραγμονα ἀλλ' ἀχρεῖον νομιζομεν.

[3] Plutarch, Solon, 20, tom. i. p. 354, ed. Reiske.

[4] Aristot. Pol. vi. 3. Ἀλλὰ τὸν πρακτικὸν οὐκ ἀναγκαῖον, κ.τ.λ. Also Ethic. Nic. x. 7. The oration of Isocrates against the sophists is addressed to the same popular calumny against philosophy.

[5] Xenoph. Mem. i. 6. Ὦ Σώκρατες, ἐγώ τοι σὲ μὲν δίκαιον νομίζω, σοφὸν δὲ οὐδ' ὁπωστιοῦν, κ.τ.λ. . . . Καὶ πάλιν ποτὲ τοῦ Ἀντιφῶντος ἐρομένου, κ.τ.λ. Ibid.

Such was his conduct under the ascendancy of the democratic power. Afterwards, when the oligarchy was established, and the Thirty were exercising their acts of cruelty and extortion without restraint, he was the first to give a check to their tyranny. In their career of confiscation and blood, they marked out Leon of Salamis for destruction. They conceived that the terror of their power would compel even Socrates to be a ready instrument to their rapacity; and they were desirous also doubtless to implicate him in the criminality of the act. Accordingly, they appointed him with four others to go to Salamis, and bring Leon to Athens, that he might be put to death. They were disappointed, however, in their expectation, so far as they depended on Socrates as an instrument in the dark deed. The order was executed, and the unhappy Leon was sacrificed to their cruel avarice and fears. But Socrates had no hand in it, and resisted it as far as he could. Unawed by their stern command, he said nothing, but as soon as he had left the Tholus, the place where the Thirty were assembled, he left his four colleagues to proceed on their bloody errand and went home. He would not, indeed, have dared thus to disobey the order with impunity; he would surely have felt their vengeance;—for there is nothing that tyrants resent more than a clemency volunteered by the ministers of their cruelties,[4]—but that happily that reign of terror was soon after put down.

By these intrepid acts, Socrates had shewn that the philosopher, in declining the contentions of political life, did not incapacitate himself for his duties when the exigencies of his situation should require him to perform them.[5] As Thales had proved that the philosopher could, if he pleased, make money, by applying to that purpose his observations on the seasons, and his prognostics of an abundant crop of olives;[6] so did Socrates defend philosophy in his own person, and by his conduct on these great occasions, against the imputation of inactivity and selfish ease. It is quite evident, too, that such a spirit as that displayed in these remarkable instances, had he entered into political life, would have subjected him to violent collisions with the successive leaders of party at Athens. "You well know, Athenians," are the words which Plato's "Apology" puts into his mouth, "that had I long ago attempted to take part in political affairs, I should long ago have perished, and I should neither have done you any service nor myself. And be not aggrieved with me for saying the truth. For there is no one of men that can be safe, in giving a spirited opposition either to you or to any other popular government, and in preventing the occurrence of many unjust and iniquitous things in the state; but he that would in reality fight for the right, must, if he would be safe but a little while, lead a private life and not engage in public business."[7] "Think you, indeed," he further asks, "that I should have lived for so many years, had I engaged in public business; and had I, engaging in it in a manner becoming a good man, succoured the cause of right, and, as behoved me, made that the thing of greatest consequence? Far from it; for neither could any one individual of men."[8]

The time, then, appears to have arrived, when the accusation was brought by Melitus, for his exemplification of the truth of this observation in his own person. He had hitherto avoided the impending storm by the quiet tenour of his private life. But he had done enough to offend the partizans of either extreme in the state. Both extremes would be united against him in their enmity to all moderation; for the ascendancy of such counsels as his, would have been a death-blow to their own reckless lust of power. Hence, they were readily disposed to concur in sacrificing him to their mutual resentments. And we thus behold the sad spectacle of one who had been the friend of every poor man at Athens, no less than of the rich and noble, requited with prosecution and death by those very hands conjoined in the unnatural act, which each should have warded off the blow inflicted by the other. The genius of Intolerance was indeed behind the scene, mixing the poisoned cup for its destined victim. But the actors on the public stage of the trial were, at the same time, wreaking their own vengeance on a political opponent; and the more exasperated against him, in proportion as, by his imperturbable demeanour and real inoffensiveness, he seemed to defy their assaults, and to throw them back on the consciousness of their injustice and ingratitude towards him.

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[1] Xenophon, whose own reputation for courage gives a strong sanction to his opinion, says of this act of Socrates, ἣν οὐχ ἂν οἶμαι ἄλλον οὐδένα ἄνθρωπον ὑπομεῖναι. Mem. iv. 4, p. 208. He alludes in the same place to the story of Leon.

[2] Thucyd. ii. Plat. Apol. 28.

[3] Plato, Gorgias.

[4] Herodot. Thalia, 3. 6. Cambyses was glad that his order, given in a moment of passion, to kill Crœsus, was not obeyed; but he could not forgive those who had ventured to reckon upon his return to better feelings; and he accordingly commands that they should be executed for their disobedience.

[5] Plato, Apol. 32.

[6] Cicero, De Divin. i. 49.

[7] Plato, Apol. 31, 32.

[8] Ibid.

Nor can there be any doubt, that there were many individuals, whose pride he had hurt, whose ignorance he had exposed, whose ill-humour he had irritated, and who, such is the infirmity of human nature, would rejoice in the opportunity of revenge by the verdict of a public condemnation of his doctrine. In affronting the sophists by his free discussions of their pretensions, he had excited, doubtless, the hostility of many of the higher order of citizens, their patrons and disciples. Many fathers of families too must then have been suffering from that corruption of public morals which, under the teaching of the sophists, had clothed itself with plausibilities of argument, and impudently arrogated, for its vain pretensions, the importance of philosophy. Disobedient, profligate sons, lifting their hands against their fathers, and adding bitterness to their unnatural rebellion, by the hollow false-hearted principles upon which they had learned to justify it,—forward, petulant youths, insulting the dignity of age by their pretensions to superior wisdom, and their turbulence,—these were the fruits of sophistical education, which came home to every family at Athens. Few that felt the evil in their own homes, would stop to inquire whether Socrates was the teacher whom they had to blame for their suffering. Most would hastily conclude, that all such instruction of the young was pernicious, and their offence at the mischievous doctrine of the sophists would become a disgust to philosophy and philosophers.

Some, indeed, would distinctly trace to Socrates the annoyance which they had experienced from particular individuals. There were many who had frequented the society of Socrates, with no sincere intention of profiting by his lessons,—who observed his inquisitive manner, and its effect in convicting and refuting the errors of those with whom he conversed, and who endeavoured, for their own wanton gratification, to imitate him in their intercourse with others. These would take delight in confounding and perplexing others, and exposing and ridiculing their pretensions to wisdom. It is easy to conceive, that the superficial resemblance to the manner of Socrates in these persons, and the vexation produced by it, would excite angry objection against the real method of Socrates.[1] These persons would be pointed at as his disciples. These would be referred to as instances of the evil tendency of the teaching of the philosopher himself; the discredit of the spurious disciples being reflected on the master, to whom it belonged not in any degree.

It appears, further, as might have been expected, that the doctrines of Socrates were studiously misrepresented at the time. Allusions or illustrations employed by him in his reasonings were construed into positive opinions on the subjects to which he thus referred. For example, when, inculcating honest industry, he quoted Hesiod,[2] saying, "Work there is none that is a scandal, inaction is the scandal," the captious absurdly but maliciously interpreted him, as applying the words of the poet to sanction the doing every thing, whether right or wrong, for the sake of gain. When he quoted from Homer the account of Ulysses silencing the uproar of the people, against the practice of employing worthless persons in the public service, it was represented, that he approved the coercing the common people and the poor by harshness and violence.[3] Again, in urging the necessity of looking to the qualification of those who should be appointed to office, and illustrating this by the fact, that no one would choose, by lot, a pilot, or carpenter, or flute-player, or any one, indeed, in matters where error was far less mischievous than in politics,—he was charged with encouraging contempt of the established laws, and exciting the young to acts of violence.[4] And, (which is the most invidious form of misrepresentation), a general charge of corrupting the young was thrown out against him, unsupported by any specific statements of the means of corruption which he employed. As in the polemics of later days, so in the controversy between Socrates and his assailants, the obloquy of general hackneyed terms of reproach was resorted to as the substitute for definite grounds of imputation. Thus were the off-hand allegations against all philosophers,—"that they searched into the things in the air and the things under the earth, and rejected all belief in the gods, and made the worse appear the better reason,"[5]—used as a cover, on this occasion, to the envy and malignity which shrank from the light and the evidence of facts.

The accusation of Melitus, it will be observed, was distributed into three heads: 1. Contempt of the established religion. 2. The introduction of new divinities.[6] 3. The corruption of the young. The second of these charges requires to be more particularly noticed, because it has reference to a peculiarity in the conduct of Socrates which gave it a colour of truth.

The mind of Socrates appears to have been deeply imbued with religious feeling. The observation of final causes particularly excited his interest; so much so, as to lead him to think that no other account should be attempted to be given of the phenomena of the world, but as they are the results of a wise and benevolent design. He delighted thus in contemplating every thing in a moral and religious point of view. He thought that the introduction of physical and mechanical causes into the study of nature, only perplexed and misled the mind. He had at first been greatly attracted by the speculations of Anaxagoras. What won his attention in the system of this philosopher, was its distinguished merit beyond all previous systems, in assigning mind as the master principle of the universe. But when he came to study the writings of Anaxagoras more closely, he was grievously disappointed, and threw up the system in disgust. For he found that it lost sight of the grand and true principle with which it set out, and, after all, constructed the universe out of mere material and mechanical elements.[7]

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[1] Xenophon speaks of persons who were pointedly corrected by Socrates, *μὴ μόνον ἃ ἐκεῖνος κολαστηρίου ἕνεκα τοὺς πάντ' οἰομένους εἰδέναι ἐρωτῶν ἤλεγχεν.* Mem. i. 4. Such persons would bear a grudge against him, as Anytus in particular appears to have done, and would not be very scrupulous, with this angry feeling dwelling in their minds, as to the mode of resenting the affront.

[2] Op. 311. *ἀεργείη δέ τ' ὄνειδος.*

[3] Xenoph. Mem. i. 2.

[4] Plato, Euthyphro, 3, 6. *ὥστ οὖν καινοτομοῦντος σοῦ περὶ τὰ θεῖα, γέγραπται ταύτην τὴν γραφήν· καὶ ὡς διαβαλῶν δὴ ἔρχεται εἰς τὸ δικαστήριον, εἰδως ὅτι ευδιάβολα τὰ τοιαῦτα πρὸς τοὺς πολλούς.* Op. i. p. 6.—Xenoph. Mem. i. 2, 9.

[5] Plat. Apol. 23, p. 54.

[6] Athenians preserved the same character at the time of St. Paul in this respect, also, as well in their eagerness after news; as is seen in their accusing him of setting forth strange gods. (Acts xvii. 18.) *ξένων δαιμονίων δοκεῖ καταγγελεὺς εἶναι.*

[7] Plato, Phædo.—Apolog.

He saw, indeed, how futile, as to any real knowledge of the universe, had been the inquiries of the early philosophers. As an Athenian, he participated in that general prejudice against physical science, which Athenians had ignorantly imbibed against all philosophy, when they characterized it as idle talk and drivelling dotage. But as a genuine philosopher, in spite of his Athenian prejudices, he saw and felt that there was a real moral agency pervading the world; and he judged that, by observation of this, principles of real use for the right direction of human life might be discovered. Tinctured too, as an Athenian, with the superstition of his countrymen, and at the same time correcting it by his superior judgment and feeling, he was disposed to draw every phenomenon into his moral and religious theory of the universe. To stop to inquire into any thing whether it might be explained on simple natural causes, or to doubt its moral design, would appear to his mind as sceptical and profane. Hence, we see at once displayed in him the common character of the Athenian, in his dislike of physical science, and his susceptibility of superstitious influences from the most trivial things; and, on the other hand, the wisdom and religiousness of the true philosopher, in his constant devout disposition to refer all things to a providential design and moral agency.

It is well known how anxiously the heathens watched the most minute circumstances, not only in their religious rites, but in the actions of daily life, as intimations of the will of the gods. Not only dreams and visions, but flights of birds, the meeting any particular object, sneezing, a voice, or any sound, and the like trivial things, were regarded with seriousness and awe. Socrates felt the mystic influence of such incidents; only he thought more deeply on them than the generality, and that,—not with the vulgar emotions of fear or of hope, according as the omen might be interpreted,—but with calm and pious reference to the benevolent design which he attributed to them as divine intimations. Further, not only did he apply this sentiment to the outward circumstances of daily life; but he also took into his view the state of his own mind. He conceived that he received at times mysterious signs distinctly perceptible to himself, not indeed of any positive good to be expected from a particular course of conduct, but of precaution,—warnings against evil concerning others as well as himself. These presages he interpreted,—or others perhaps, taking his account of his impressions in too literal a manner, have so represented it,—as a voice addressed to him on each occasion. Instances too, are alleged in which this divine voice was the means of saving him and those who obeyed its direction, from danger. In the retreat of the Athenians after the unfortunate battle at Delium, it is said to have prevented his taking a particular road, and thus saved him, together with Alcibiades and Laches, from being pursued and overtaken by the enemy; whilst others taking another way were overtaken and slain.[1] This circumstance, according to Plutarch, was a great occasion of the fame at Athens of the "demonion,"—or "genius," as it was called by Latin writers,—of Socrates.[2] To this voice is attributed his active devotion of his life to the moral reform of his countrymen by private and personal addresses to them, and his refraining at the same time from all political exertion.

The name of a particular dæmonion, or genius, was evidently not assigned by Socrates himself to these extraordinary presages, while he confidently declared their reality. It was rather the misconstruction of the vulgar, and of his assailants, interpreting what he affirmed generally of divine intimations, as assertions of the presence of some particular divinity ascertained by his own convictions, and distinct from the gods worshipped at Athens. Heathens were incapable of forming a notion of the Deity, but as a local and tutelary god. They could not rise to the sublime conception of the one universal Being, *τὸ δαιμόνιον*, the God in all the world, than whom there is none else. In the view of Socrates, this belief in a presaging voice addressed to his private ear, was nothing more than an extension of the prophetic science, or divination of the heathen world, to practical purposes, and to the cultivation of religious feelings.

It must be remembered, that the Athenians had their augurs or prophets among the regular officers of the republic, without whose presence no matter of public counsel or of war was ever transacted. These were the recognized interpreters of the divine will. But Socrates claimed a special authority for the presages with which he was peculiarly favoured, and thus seemed to innovate on the science, and encroach on the established forms, of divination. He enjoined, indeed, a devout reference to the Delphic oracle, in all questions of hazardous conduct, teaching that, whilst human reason was the guide in all matters of human power, in those, on the contrary, which were out of human power, as the future event of actions, resort should be had to every means offered for exploring the will of the gods. He professed to have adopted his own course of life on the evidence of such communications. He advised Xenophon to consult the Delphic oracle, as to whether he should do well in accepting the invitation of Proxenus to join the expedition of Cyrus.[3] But with this reverence for the recognized sources of divine information, he combined a suspicion of the pretenders to prophecy, who were countenanced by the popular superstition,—the *θεομάντεις* and *χρησμωδοι*,—who abounded at Athens.[4] He relied rather on the sagacious auguries of his own mind, drawn from observation of some passing incident, or some rapid conclusion respecting the consequences of actions—a kind of intuitive judgment and forecaste, mingling and confounding itself with his religious impressions,—a second hearing, as it were,—a perception of a voice unperceived by the common ear, mysteriously telling of danger to come from some particular course of conduct. Thus was a pretext given to his enemies to say, that he introduced "new divinities;" whilst public opinion tolerated the grossest pretensions to divine revelations, and a system of mercenary imposture founded on them. Public opinion upheld the system of divination as it existed, with its external array of augurs, and prophets, and ceremonial. Socrates, on the contrary, led every man to consult the will of the Deity, not without devout preparation in the inward recesses of his own mind, nor without reference to his own obedience and moral improvement.[5] Superstition, doubtless, strongly tinctured his notions of religious duty. This made him construe many things into divine intimations, which were frivolous and irrelevant. Still he rose above the superstition of the popular divination, in the personal piety which laid hold of each occasion for its exercise and cultivation, and taught men to regard the Divinity as interested in the protection of the good, and ever present to the words, and actions, and even the silent thoughts of men.[6]

Xenophon appears to have faithfully stated the difference between the popular divination and that professed by Socrates, in the following account: "He introduced nothing new beyond others who, acknowledging the reality of divination, make use of omens, and voices, and objects presented on the way, and sacrifices. For these do not conceive, that the birds, and the persons that meet them, know what is expedient to those who divine by them, but that the gods, by means of them, signify this. And so he held. But the generality say, that they are dissuaded and persuaded by the birds, and the objects that meet them; whereas Socrates spoke of it as he thought. For he said that it was the Divinity, *τὸ δαιμόνιον*, that gave signs to him. And to many of his intimates he prescribed to do some things,[1] to forbear other things, on the ground, that the Divinity had presignified it to him; and it was to the advantage of those who took his advice, whilst those who rejected his advice had to repent it."[2]

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[1] Plutarch. de Socr. Gen. 298. Cicer. de Divin. i. 54.

[2] Ibid. p. 299.

[3] Xenoph. Anab. iii. 1, 4.

[4] Plato, Apol. 22. c. p. 51.

[5] Plato, Alcib. ii. 150, p. 99. *Καὶ γὰρ δεινὸν εἴη, ἐι προς τὰ δῶρα και θυσιας ἀποβλέπουσιν ἡμῶν ὁι θεοὶ, ἀλλὰ μὴ πρὸς τὴν ψυχὴν, ἂν τις ὅσιος καὶ δίκαιος, κ. τ. λ.*

[6] Xen. Mem. i. 1, 19. *Καὶ γὰρ ἐπιμελεῖσθαι θεοὺς ἐνόμιζεν ἀνθρώπων, ὀυχ ὃν τρόπον οἵ πολλὸι νομιζουσιν, κ.τ.λ.*

But how great was the change from the practical devotion of the mind here taught by Socrates, from that popularly entertained at Athens! The history of divination, as it was regarded, not at Athens only, but throughout Greece, is but a picture of the invidiousness and malignity of the human heart transformed into attributes of the Divine Being. Let us only hear Solon, as he is described by Herodotus, speaking of the Deity as a principle of envy and turbulence, and as guided by no fixed course in the disposition of human affairs; and we may judge what a task he had enterprized, who entered into conflict with this inward and subtile idolatry of human passions, established by the heathen system of divination. It was indeed teaching divinities new to Athenian ears, when Socrates inculcated an inward reformation of the character of those who would look for the favour of the gods, or expect a special interposition and direction from the benevolent principle which guided the course of the moral world.

Whereas, too, the popular divination was employed on the most trivial occasions, and made the substitute for the proper exertion of men's faculties on matters cognizable by them, Socrates differed from this prevalent notion of the subject. He contended, that, where the line of conduct was plain, men should use the best of their judgment in acting,—that they should use their experience and reason in learning what the gods had given them to learn by such means, and only have resort to consultation of the Divine will by the extraordinary means of divination, where the results of conduct were uncertain. Thus might he be construed as dissuading men from the use of divination, when he only dissuaded from an improper use of it, and exhorted to a rational activity.

We may see from the story of Aristodicus of Cyme, how the practice existed among the Greeks, of endeavouring to obtain from the oracles sanctions even to iniquities and impieties. Aristodicus consults the oracle whether he may surrender an unhappy fugitive; and the oracle permits him, dexterously reproving, by the very permission, the attempt to cast the burthen of personal responsibility on the oracle itself, and to cover an immoral act with the veil of religious duty.[3] Divination, in fact, was indolently resorted to in the heathen world, to relieve the mind of the labour and anxiety of thought, and the searchings of conscience. And Socrates addressed himself to the correction of this practice, by recommending, as we have seen, exertion of the judgment, and the acquisition of information on all matters within the sphere of human reason. He would thus provoke the hostility of many a professed diviner, who made a trade of his art, and would find individuals of this class ready to join in the outcry raised against him, of innovation on the popular theology.

The jealousy of the sophists in particular, the very class with whom the accusation of Melitus identified him, would also swell the popular envy against him on this head. For the sophists, among their pretensions, claimed to be regarded as endued with a predictive sagacity, so as to be expert practical guides respecting the future.[4] Socrates would offend them in this point in two ways,—both as directing persons to have recourse to their own judgment, and the regular means of information on all ordinary questions to which human reason was competent; and as teaching a reference to a secret divine intimation on all other matters beyond the compass of man's understanding. For in both respects would the sophists find their course interfered with. The use of men's own judgment, or the appeal to the signs of the Divine will, would equally lessen the value for those counsels which they pretended to impart.

What added still further to this invidious feeling was, that the reputation of Socrates now eclipsed theirs throughout Greece. And Socrates appears himself confidently to have appealed to this public estimation of his character against the partial censures of his countrymen at the time of his trial. He vindicated his assertion of divine intimations specially granted to him, by referring to the oracle of Delphi as having honoured him with its distinct approbation. Chærephon, in the devoutness of his admiration of his master, had, on some occasion, consulted the oracle respecting him, and obtained an answer that Socrates was the wisest of men. The authenticity of the anecdote has been questioned. But the introduction of it in the two "Apologies,"[5] may be taken as a voucher of its substantial truth. It at any rate shews the favourable opinion which had been conceived of him out of Athens itself; that, as Lycurgus had been complimented by the verdict of an oracle, so the same tribute of public applause might, with equal probability, be assigned to Socrates.

According to Laertius, the sentence of condemnation was carried by a majority consisting of 281 votes. The number was little more than sufficient to decide the question on that side; for it only exceeded the number of votes of acquittal by three. "Had but three votes only fallen differently," says Socrates himself, in the "Apology" of Plato, "I should have been acquitted." Nor, indeed, would Melitus alone, without the aid of Anytus and Lycon, (he is made there confidently to declare) have obtained even a fifth part of the votes to save him the penalty of a thousand drachmas, affixed by the law to an unsustained prosecution. But when the penalty of death was further put to the vote, and he was found unwilling to propose the substitution of any other penalty, such as a fine or exile, but evinced his indignant contempt of their unjust sentence, by asking rather, in his ironical way, instead of even a slight punishment, the highest honour of the state, that of a public maintenance in the Prytaneum, the multitude of the jurors was so exasperated by the unbending spirit thus displayed, that eighty additional votes were given on the hostile side, determining the sentence of death. So evidently was the whole case ruled by passion and the arts of demagogues exciting the people to treat it as a slight on their majesty, rather than as a cause in a court of justice. Otherwise it could not have happened, that when the previous question of guilt had been carried with nearly an equal number of dissentients, the severest penalty should have obtained such an accession of voices in its favour.

We have already remarked the little solicitude shewn by

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[1] Xenophon here differs from Plato's Apology, in saying, that Socrates received intimations of what was to be done; whereas Plato expressly says the directions were only negative.

[2] Xenoph. Mem. i. 1, 3, p. 3. Xenoph. Apol. 13, *ἐγὼ δε τοῦτο δαιμόνιον καλῶ.*

[3] Herodotus, Clio. c. 158, 159. The same is illustrated in the story of Glaucus in Erato, c. 86. The oracles were consulted, also, on frivolous matters, such as the petty thefts of Amasis. Euterpe, c. 174.

[4] Isocr. c. Soph. 2, 4, *περὶ τῶν μελλόντων μὲν εἰδέναι προσποιουμένους.*

[5] Xenoph. Apol. p. 249. Plato, Apol. p. 48.

Socrates in regard to his defence from the accusation. As he strongly disapproved the affected artificial rhetoric of his times, and the practice of appealing to the passions against the judgment of the hearer, so neither would he study beforehand what he should say on the occasion of his trial. Twice had he essayed (he observes to Hermogenes) to consider what he should say in his defence, and as often had he been prevented by those secret divine intimations to which he habitually referred his conduct.[1] Nor again would he receive the proferred services of friends in pleading his cause. The celebrated orator Lysias composed an oration for this purpose. On reading it, he expressed his admiration of it, but declined it as unsuitable to him. When Lysias wondered that he could admire it, and yet say it was unsuitable, he observed, in his usual manner of illustration, by an apposite case; "Would not also fine coats and shoes be unsuitable to me?" Plato, however, it is said, could not be restrained from appearing in his behalf, and made an effort to address the court. But the uproar was so great, that on his uttering the words, "ascend the bema," he was met with the cry, "descend," and forced to abandon the attempt.[2]

So neither, again, would he resort to those appliances to the feelings which were usual in the Athenian courts. The Athenian juryman expected that the defendant should come before him in the character of a suppliant, and entreat his clemency rather than claim his justice. He was to be assailed with prayers and tears, no less than with arguments addressed to his understanding. But Socrates would not condescend to these methods of persuasion. He would not produce his wife and children in the court, to excite compassion, or bring forward his connexions and friends to intercede in his behalf. He felt it unbecoming in him at his age, and with his reputation as a philosopher, to supplicate for his life. It would have given to his whole previous demeanour the appearance of insincerity and hypocrisy. It would have shewn that dread of death, against which all his teaching had been directed.[3] It would have been an evidence that he disregarded the sanctity of religion, in trying to influence his jurors to decide by favour against their oaths, and so far would have substantiated the charge of Melitus against him.[4] For the same reason, he had refused to offer to submit to a mitigated penalty, when challenged, according to the practice in the Athenian courts, to propose his own estimate of the offence. Afterwards, indeed, he softened this bold vindication of his merits, by adding, in the same ironical manner, that he could perhaps pay the fine of a mina of silver, and would therefore fix that amount of damages; or that as Plato, Crito, Critobulus, and Apollodorus, suggested the sum of thirty minæ, and would be good sureties for the payment, he would fix the latter amount.[5] To have seriously proposed any such estimate would, in his opinion, have been an admission of his guilt.[6]

He displayed throughout the trial, the same calm and cheerful temper which characterized his ordinary behaviour. There were in his manner, even at that solemn crisis, touches of the same ironical humour, the same half-earnest, half-playful strokes of argumentative attack, which had given so much interest and point to his daily familiar conversations; and when the trial was over, he evinced no further emotion than the indignation of a sincere and honest man. at the malicious and mischievous arts by which the result had been accomplished. He was sustained by the consciousness that no crime had been proved against him; whilst his assailants must feel the reproaches of conscience for the real impiety and iniquity of which they had been guilty; some for having instigated others to bear false witness against him; some for having themselves borne this false witness. The disgrace of the condemnation fell not on him, he asserted, but on those who had passed such a sentence. He consoled himself with the thought, that it was the will of the Deity, and it was best for him now to die; that, though condemned by his present judges, like another Palamedes, he should receive from posterity that verdict of approbation which was withheld from Ulysses, to whose successful plot the life of that chief was sacrificed.[7] Availing himself also of the prophetic power which the popular belief attributed to the words of a dying man, he warned his countrymen, as he left the court, that they were embarked in a course which must involve them in bitter repentance.[8] He concluded his address with the following striking admonition: "I have only this request to make. As for my sons, when they shall have grown up, punish them, I pray you, by troubling them in the same manner in which I have been in the habit of troubling you, if they appear to you to concern themselves either with money or any thing else in preference to virtue. And if they would seem to be something when they are nothing, reproach them as I do you, that they take no concern about what they ought, and think themselves to be something when they are nothing. And if you do this, I shall have suffered justice at your hands, both myself and my sons. But it is now time to depart; for me to die, for you to live; but which of us is going to a better thing is uncertain to every one except only the Deity."[9]

In his way from the court to the prison to which he was now consigned, he was observed with eye and mien and step composed, in perfect unison with his previous address. On perceiving some of those who accompanied him, weeping, "Why is this," he said; "is it now that you weep? did you not long ago know, that, from the moment of my birth, the sentence of death had been decreed against me by nature? If, indeed, I were perishing beforehand in the midst of blessings flowing in upon me, it would be plain that I and my kind friends would have to grieve; but if I terminate my life at a time when troubles are expected, for my part I think you ought all to be in good heart, as feeling that I am happy."[10] Apollodorus, whose admiration of his master amounted to an amiable weakness, complained to him of the great hardship of his suffering by an unjust sentence. Acknowledging the affectionate feeling thus shewn to him in a familiar manner, by passing his hand over the head of his attached disciple, he, at the same time, gently reproved him, saying, "Would you then, my dear Apollodorus, rather see me dying justly than unjustly?" and smiled at the question. On seeing Anytus pass by, he could not forbear, it is said, the expression of a strong censure on the conduct of that individual towards his own son. He foretold, what the unhappy result proved too true, that the heart of Anytus would one day be embittered by the evil fruits of that low and unworthy education to which, with mercenary views, he had subjected his son, a young man with whom the philosopher had formerly conversed, and who had seemed destined for better things.

The execution of Socrates, by the poisoned cup, would have followed immediately on his condemnation, but for the peculiar circumstances under which the trial had taken place. It was after the commencement of the Delian festival; an annual commemoration, of the safe return of Theseus and his devoted companions to Athens, from the fatal labyrinth of Crete, and the acquittal thenceforth of the bloody tribute exacted by Minos, by the mission of a vessel to Delos with sacrifices to Apollo, and other religious rites. When the priest of Apollo had once crowned the stern of the sacred vessel with the festive garland, it was not lawful to pollute the city by a public execution, until the solemn pomp should have been performed, and the vessel had returned. This ceremony had been performed only the day before the trial of Socrates. Thus he obtained the respite of thirty days between his trial and execution.

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[1] Xenoph. Mem. iv. 8. Ἔφη γὰρ ἤδη Μελίτου γεγραμμένου αὐτὸν τὴν γραφὴν, αὐτὸς ἀκούων αὐτοῦ πάντα μᾶλλον ἢ περὶ τῆς δίκης διαλεγομένου λέγειν αὐτῷ, ὡς χρὴ σκοπεῖν ὅ τι ἀπολογήσεται, κ. τ. λ.—and Apol. 2, *et sqq*.

[2] Diog. Laert. in vit. Socr.

[3] Plato, Apol. Op. i. p. 79.

[4] Ibid. p. 82.

[5] Plato, Apol. 38 b. Op. i. p. 88.

[6] Xenoph. Apol. p. 23, κελευόμενος ὑποτιμᾶσθαι.

[7] Xenoph. Apol. 24.

[8] Plato, Apol.

[9] Plato Apol. ad fin.

[10] Xenoph. Apol. 27.

These were days of high interest and importance not only to his sorrowing friends, but to the cause of that admirable practical philosophy which all his previous life had inculcated. During this time he employed himself in literary exercises which he had never practised before. He composed a poem in honour of the god Apollo, whose festival was then in course of celebration. And feeling a religious scruple as to whether by the general pursuit of philosophy, he had fully complied with the suggestions of dreams repeatedly urging him, as he said, to "cultivate music," he now applied himself to the fulfilment of this supposed charge, by turning the fables of Æsop into verse.[1] But these were only pastimes illustrative of the serenity of his mind. Now, too, in his prison, with the chains on his body, and the near prospect of a violent death, he could discourse with an unanswerable cogency and eloquence of argument, of the vanity of human things, and the real happiness of man, as consisting in the cultivation of the spiritual and immortal principles of his nature. He had professed his whole life to be a meditation or discipline of death. He now had the opportunity,—which, as a philosopher, (could the voice of natural instinct have been silenced,) he would most have desired,—of realizing, by his own example, that death to which his thoughts and pursuits had been studiously directed. Unlike his successors in the schools of the Stoics, he did not advocate a doctrine of suicide, however he depreciated the importance of human life. With that good sense which restrained his religion and his philosophy from running into fanaticism, he held it to be impious in any one to release himself, by his own hand, from that post of duty in which the Deity had placed him.[2] Though, however, he had not courted death, or rashly placed himself in the way of it, he felt that, in the circumstances in which he was now placed, he was called to go through this last act of his philosophic profession. He seems, indeed, to have rejoiced in the opportunity thus afforded him of summing up his philosophy in one great principle, from which every observation and argument, in the course of previous teaching, had been drawn, by demonstrating, so far as reason could avail to demonstrate the fact, the absolute and eternal existence of the great principles of moral truth. The occasion was one which the genius of Plato would not fail to seize as most felicitous for the development of its own enthusiastic and transcendental view of the philosophy of Socrates. Plato, accordingly, has, in that most exquisite of his Dialogues, the Phædo, invited us to the couch of Socrates, on the last sad morning of his imprisonment, to listen to the philosopher, with the chill of death almost upon him, discoursing on the immortality of the soul. The affectionate and eloquent disciple doubtless shed natural tears over his dying master. But he wished also to elevate his own philosophy to the dignity of being the dying confession of the great sage of Athens. And he wished, further, that his own philosophy should speak, as it were, the funeral oration over him to whom it was indebted for its earliest inspirations, and pour its own libation on his tomb. Thus he has especially elaborated the last scene of his master's life, and made us contemplate with the deepest interest the death of Socrates, not only as an act of heroic self-devotion and patient martyrdom to the truth, taught by the great sage himself, but as a splendid episode in the dramatic development of his own philosophy.

During his imprisonment, Socrates was not denied the solace of receiving his friends, and conversing with them day after day. Early each morning might be seen a company of devoted friends, whom nothing could separate from him, assembled at the hall of justice, where the trial had taken place, and which was close to the prison, watching for the jailor to open the gate and admit them. Being admitted, they would commonly remain with him in the prison until evening, engaged in earnest and instructive conversation. His wife and children, too, appear to have been constantly with him.[3] He was importuned by these affectionate followers to suffer them to effect his escape. Crito earnestly entreated him to be allowed to execute a plan which he had concerted for rescuing him. Simmias, the Theban, also brought a sum of money with him to Athens for that purpose. Cebes and others were equally ready with their resources. They argued, that, so far from being at a loss what to do with himself out of Athens, as he had said on his trial, they could ensure him friends in Thessaly, and many other places, who would most gladly welcome him, and protect him. But to none of these importunities would he yield. He answered, that, while he highly estimated their kindness, he was pledged to obey reason only, and that he saw no ground in his present circumstances for taking a different view of his case. As for the duty of providing for his children, by preserving his own life,—a consideration which Crito appears to have strongly pressed on him,—this was not now a matter for him to consider;—it was for those to consider, who, as his Athenian judges, treated life and death as such light concerns; for his part, he must look simply to what was right or wrong to be done.[4] Thus steadily and calmly did he persevere in his resolution of awaiting the utmost extremity.

At length it was announced that the Theoric galley had been seen off Sunium, and might very shortly be expected to arrive at Athens. Crito proceeded in anxious haste to the prison, and being well-known to the jailor from his frequent visits there, obtained admission at a very early hour. He found Socrates asleep, and sat by him in silence, wondering to see him sleep so soundly in so much trouble, until he at length awoke to receive the fatal intelligence. This he received with the same composure as if it had been some ordinary communication. His only answer to Crito was, that he was quite resigned to the will of the gods, if it were so, but that he was persuaded by a dream, from which he had just waked, that the vessel would not come that day, but the following one. His reliance on dreams as divine intimations, has been already mentioned. He told Crito, accordingly, of his having dreamed that a woman of noble form, clothed in white, came to him and called him, and said to him in the words of Homer,[5] "On the third day to deep-soiled Pthia thou shalt come." The event, at any rate, accorded with his expectation from the dream. On the morrow the vessel reached the harbour of Piræus; and the following day was appointed for the execution.

By the dawn of that day, the sorrowing party again met at the accustomed place, and were informed by the jailor, that the Eleven,—the officers who superintended the public executions,—had given orders that the chains should be taken off, and that Socrates should die on that day. After being kept waiting some time, they went in and found the philosopher already loosed from his chains, and sitting on the couch, with Xanthippe and his youngest child in her arms, by his side. By his desire they conduct her home, the kind Crito entrusting her to the care of his attendants, amidst cries of passionate grief, which had broken forth from her afresh at the sight of them now come to bid their last farewell. The occasion naturally leads to the conversation which follows a discussion, according to Plato, on the immortality of the soul,—Socrates interrogating and arguing with all his wonted vivacity; whilst the party around him answer and listen with eager interest, and, as may naturally be conceived, with undescribable sensations of mingled delight and pain. Crito would have dissuaded him from this exertion, for he feared, from what he had been told by the executioner, that the heat of the body thus produced, would add to his discomfort in his last moments, by rendering the effects of the poison more lingering. He only observed, that "it mattered not; the executioner should only be ready to do his duty, and mix the draught twice, or even thrice over, if it should be found necessary."[1]

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[1] Plato, Phædo. p. 60 d. *et sqq.*

[2] Plato, Phædo, p. 61, c. 'Ου μὲν ἴσως βιάσεται ἀυτόν. οὐ γὰρ φασὶ θεμιτὸν ἔιναι.

[3] Plato, Phædo. p. 60 a. Op. i. p. 135.

[4] Plato Crito, p. 48, c. Op. i. p. 111.

[5] Ἤματί κεν τριτάτῳ Φθίην ἐρίβωλον ἵκοιο.

The discourse being brought to a close, he rose to proceed to the bath, as an immediate preparation for his death; when Crito detained him for a while, to ask his last commands about his children, or any other matter in which their services might gratify him. He replied, "that he had nothing new to say beyond what he had ever been saying,—that by attending to themselves, they would most gratify him and his, as well as themselves, in all they might do, though they might even make no promise now; but that if they neglected themselves, and were unwilling to follow in the track pointed out in all that he had said to them up to this last occasion, all that they could do would be of no avail, however much, and however earnestly, they might promise at the present moment."[2] Crito assented to this advice, but in his eagerness still to do some act of kindness to his revered friend, subjoined, "But in what way are we to bury you?" This mode of speaking of his burial, gives occasion to a very characteristic reproof from him, of this solicitude on the part of Crito. "As you please," was his answer, "if at least you can take me, and I do not escape from you." Then gently smiling, and looking off to the surrounding company, he added, "I cannot, my friends, persuade Crito, that I am the Socrates that is now conversing, and ordering every thing that has been said; but he thinks that I am that man whom he will shortly see a corpse, and asks how you should bury me. But what I have all along been talking so much about,—that when I shall have drunk the poison, I shall no longer stay with you, but shall, forsooth, go away to certain felicities of the blest,—this I seem to myself to have been saying in vain, whilst comforting at the same time you and myself. Bail me therefore, to Crito the opposite bail to that which he bailed me to the judges; for he was bail for my staying; but do you be bail for my *not* staying when dead, but going away; that Crito may bear it more easily, and may not feel aggrieved for me, as if I were suffering something dreadful, when he sees my body either burning, or being interred; nor may say at the burial, that he lays out, or carries out, or inters *Socrates*. For," he continued, turning himself again to Crito, "be assured, excellent Crito, that the speaking improperly is not only wrong in itself, but also produces some evil in the soul. However, take courage, and say that you are burying *my body*; and bury it as may be agreeable to you, and in the manner you may hold most lawful."[3]

He then went into another apartment to bathe, Crito following him, whilst the rest of the party awaited his return. After bathing, he received his children,—two of whom were yet little ones, the third a youth,—and the females of his family. Having conversed some time with these in the presence of Crito, and given them his final commands, he dismissed them, and came out again to the assembled friends. This affecting interview had occupied a considerable time, and when he returned, it was near sunset. He had not long sat down, when the officer of the Eleven presented himself, and respectfully intimated to him that the fatal moment was at hand. The noble and gentle demeanour of the philosopher during his imprisonment had won upon this man; and used as he had been to the scenes of execration and horror within those walls, he was struck by the contrast in the case of Socrates, and bursting into tears as he gave his message, turned himself away, and retired. Socrates himself was touched by this demonstration of considerate feeling. He cordially returned the salutation, promising a ready compliance with the order. Then addressing the company, he observed, "How courteous the man is! through all the time he would come to me, and would converse with me sometimes, and was the best of men; and now how generously does he weep for me!" He then called for the poisoned cup. Crito's affection would still have delayed it, for he urged that the sun was not yet gone down, and that others on the like occasions had not used such despatch, but had supped and drunk beforehand as they pleased. Socrates answered that this might be reasonable for others; for him it was reasonable not to do so; and persisted in requiring the cup to be brought. The process of bruising the hemlock took some time; but at length the man who was to administer the poison came with it now ready for the draught. He calmly inquired what he was to do; and, being told that he was only to walk about after drinking it, until he found a heaviness in the legs, and then to lie down, he took the cup into his hand without the slightest change of colour or of countenance. But before he put it to his lips, partly, it seems, from religious feeling, and partly in humour, he further asked whether he might make a libation to any one from the cup. Nor did even his usual quaint manner of putting a question, which he knew would somewhat surprise the hearer, forsake him on this occasion; for he looked at the man, at the same time, with that peculiar glance usual to him, which his contemporaries jocosely designated by a word denoting its resemblance to the manner in which the bull glares around him with the head downward. Learning that the whole draught was not more than sufficient for the fatal purpose, he said, "At any rate one may, and ought to pray to the gods, that the migration hence to those regions may be prosperous; which indeed I do pray, and so may it be!" With these words, he drank off the poison with the most perfect composure and readiness.

At the sight of this, the bystanders could no longer command their emotions. Their tears flowed profusely. Some rose up from their seats,—Crito set the example,—and covered their faces, to give vent to their sorrow. Apollodorus sobbed aloud. He gently expostulated with them for this outbreak of grief, saying, "What are you doing, my friends, so strangely? I indeed sent away the women not least on this account, that they might not offend in such a way; for I have heard that one ought to die amidst auspicious sounds: I pray you, therefore, be tranquil, and bear up." This rebuke had the effect of repressing their tears. The heaviness which he had been led to expect from the working of the poison now began to come on, and he left off walking, and reclined, with his face upward, and covered over. The torpor gradually spread towards the upper regions of the body,—the lower parts becoming, one after the other, congealed, and insensible,—until it reached the heart. In this interval, he uncovered himself, and said, "Crito, we owe a cock to Esculapius; pay it, I pray you, and neglect it not;" intimating probably that now all the diseases of life were healed, and that he was restored to real and pure existence by the death of the body. These were his last words. Crito asked whether he had any thing more to say, but received no answer. There was no further indication of life, but a motion of the body. The executioner uncovered him, and they observed his eyes fixed; upon which Crito, faithful in the last respectful attentions to his beloved friend, the now departed philosopher, closed the mouth and the eyes.

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[1] Plato, Phædo, p. 63, d. *et sqq.*

[2] Ibid. p. 115, a. *et sqq.*

[3] Ibid.

Thus died Socrates, when he had now completed his seventieth year, B.C. 400, or 399, in the full vigour of a healthy old age; happy in his own estimation, and in that of his admiring disciples, in having terminated his life in so glorious a manner, with unimpaired faculties of mind and body, and after a defence sustained with so much truth, and justice, and fortitude.[1]

His death spread dismay at the moment among those who had been most conspicuous in their attachment to the philosopher, as they naturally dreaded the overflowings of that malignant spirit which had swept down their master. The chief of these appear to have fled to Megara, where they could reckon on finding a refuge from Athenian hostility, and a home with their fellow-disciple, the friendly Euclid. It is remarkable, however, that Isocrates, timid as he was by nature, should not have scrupled to remain at Athens, and to testify his affectionate regret for his master, by appearing the next day in public, clothed in mourning.[2] But with the fall of its great victim, the spirit of persecution was sated for a time. An act had been perpetrated, to which the eyes of all Greece would be intently turned; and the greatness of the sacrifice seems at the moment to have absorbed the attention of its agents and instruments, in the contemplation of it and its possible effects. If we may believe the representation of subsequent writers, shame and repentance soon followed the cruel act; and those who were most ostensibly involved in its guilt, were either banished or sentenced to death, or laid violent hands on themselves. Of the banishment of Anytus, and the death of Melitus, we are told by Laertius, that Antisthenes was the immediate cause. In what way he was instrumental to the death of Melitus, is not stated. But with regard to Anytus, Antisthenes is said to have occasioned his banishment, apparently without the intention of doing so, by a stroke of practical humour. For meeting with some young men from Pontus, inquiring for Socrates, whose fame had induced them to visit Athens, he conducted them to Anytus, who, as he observed to them, was "wiser than Socrates;" upon which, the indignation of the bystanders was excited, and they drove Anytus forth from the city.[3] He fled to Heraclea; but there found no peace, being forced by public proclamation to leave the city forthwith.[4] Though, however, these individuals soon after received the retribution due to their offence, it would not follow that they suffered from their countrymen on account of the part they had taken against Socrates. The ascendancy of another political faction, (and Athens was ever fluctuating between contending parties), would be quite sufficient to account for their overthrow and desperation. On the other hand, the testimony of Plutarch is explicit to the point, though he mentions no individuals by name, that the sycophants who had assailed Socrates became the objects of popular hatred to such a degree, that none would associate with them in any way, not even to return them an answer when addressed by them, and that at last they hanged themselves, being no longer able to endure the public execration.[5] His friends, indeed, performed the last obsequies to his remains; but his fellow-citizens afterwards concurred in honouring him, by erecting a brazen statue of him, the work of Lysippus, in the Pompeium, and expressing their sorrow, by closing the public gymnasia for a while.

This at any rate is certain, that persecution, as it ever does, overwrought its part in the case of Socrates. It oppressed, indeed, the individual, but it gave the seal of martyrdom to the cause in which he had been engaged. It produced a temporary intimidation, under which men would hear less of the name and teaching of Socrates openly avowed, but throughout which the admiration and love of the heroic philosopher would be cherished in secret, and his doctrine would be fostered in the shade, to appear in the sunshine of a future day. If the Athenians had desired to plant the root of philosophy in their city, they could not more effectually have done so, than by their violence against Socrates. Such, in fact, was the result. Philosophy henceforth obtained an Athenian naturalization and name; and the schools of Athens may date their period of nearly a thousand years from this memorable act, which, in its intent and spirit, fiercely but blindly endeavoured to extinguish there the very profession of philosophy.[6]

The cause, however, in which Socrates had been engaged, was too true, for any opposition to it, though conducted with the greatest prudence, to have been long successful. It had also already advanced too far, and interested too many persons in the maintenance of it, to be put down by a sudden blow. The burning of a book, or a formal condemnation of the opinions of a writer, are but futile means, as experience shews, of suppressing obnoxious doctrines. How much less could opposition avail, where, as in the case of Socrates, the offending doctrines had been scattered over, not the pages of a book, but the strenuous exertions of a long life,—already engraved in characters which no obliterating hand could reach, and doubtless so worked into many a mind, as not to be distinguishable from its own proper convictions,—doctrines too, so confirmed by the noble example of their teacher, in carrying them out to their full consequences by his death? For the death of Socrates, it should be observed, was not simply a test of his sincerity in his teaching. It was this, and still more. It was the ultimate and decisive opposition to those false principles, against which every action and discourse of his life had been directed. He had been all along exposing the presumptuousness and vanity of the principles on which men ordinarily judged and acted. He was now further to shew, that this opposition on his part was not to be daunted by those principles, when set in formidable array against his own life; and that, professing a low estimate of the present life, he would not disown or shrink from that profession at the moment of greatest trial.

If we inquire, accordingly, what was the substance of the positive teaching of Socrates, we must address ourselves to the contemplation of his active life, and his resigned patient death. He had no design of establishing philosophy as a literary pursuit or intellectual pastime; though he probably foresaw, that that taste for inquiry into truth which he was ever awakening, must soon lead to the formation of a philosophical literature at Athens. He already witnessed, indeed, the commencement of such a literature, the result of this excitement, if it be true that he had read the Lysis of Plato, and observed respecting it, "How much the young man makes me say that I never said!"[7] He wished rather to divert men from the vanity of setting themselves up as philosophers, and make them employ their thoughts in learning and investigating, instead of prematurely commencing at once as well-informed persons and teachers of others, with crude and superficial notions and principles.

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[1] Xenoph. Mem. iv. 8.—Apol. 32.—Plato, Phædo, ad fin.

[2] Pseudo-Plutarch. X Orat. Vit. Plutarch. Op. ix. p. 336.

[3] Diog. Laert. in vit. Antisth. vi. 4, 10.

[4] Ibid. in vit. Socr. ii. 5, 43.

[5] Plutarch. de Invid. et Od. Op. viii. p. 128.—Diodorus Siculus says, ὁ δῆμος μετεμελήθη . . . . καὶ τελος ἀκρίτους ἀπέκτεινε. xiv. 38; also Augustin. de Civ. Dei, viii. 3.

[6] The schools of Athens were closed in the reign of Justinian, A.C. 529.

[7] Diog. Laert. in vit. Plat. xxiv.

If we look, then, to the course of his practical teaching,—to the general tenor of his conversations and actions, and the example throughout of his life and death,—we shall find that his whole labour was directed to the establishment of true moral and religious principles, in opposition to the false and mischievous principles which, he observed, were commonly acted upon and avowed in the world. The excellence and supremacy of self-knowledge was what he was ever inculcating; and of self-knowledge, not as a matter of intellectual curiosity, or for its value as a science, but in order to self-government and to happiness. He found that this was the last kind of knowledge which men ever thought of acquiring; that they had, in fact, no concern about it; or that if they were reminded of its necessity, they presumed on their possession of it already. His first effort, then, was to open the minds of men to a perception of the value of this knowledge, and of their own need of it. The questions which he would put—the refutations which he addressed to the various propositions or conclusions elicited from others in the course of his conversations—the perplexities to which he would reduce them—and the unsatisfied state in which he would commonly leave them, after exciting their doubts—all had a direct tendency to convince men of the insufficiency of their intellectual acquirements, and of their want of some more adequate and availing information.[1] To the same purport was his disparagement of physical science, and of all merely speculative knowledge, in comparison with that which was useful for human life. For he was far from an utilitarian, in the modern sense of that term. He did not value particular studies, because they ministered to the necessities or conveniences of human life, or undervalue them because they had no such bearing. But he saw that his clever and ingenious countrymen were studious of intellectual refinement—that they delighted in the specious, and the admirable, and the subtile, more than in the solid and the unostentatious qualifications of the good member of a private family and the useful citizen. He was aware, too, from his own acquaintance with the existing physical philosophy, how imperfect that knowledge was, how entirely hypothetical, and incapable of practical application. We must make allowance, therefore, in estimating his objection to speculative science, for the polemical spirit in which he assailed a branch of knowledge then, at once, so barren, and so encroaching in its claims on public attention. We must regard him as preparing the way for the due cultivation of the other, the higher as well as more important knowledge, that of man's own nature, then so little thought of, and so neglected. This seems to be invariably his design on every occasion, whatever may be the immediate purport of his discourse.

When he came to direct the minds of men, once awakened to the importance of moral study, to the subject itself of human nature, he had to encounter on the very threshold the most perverse notions. All their maxims of life were based on the absolute importance of the present life. The body, and its present appetites and desires, were regarded as the whole of man. The tyrant, in the enjoyment of absolute power to gratify every passion without restriction or penalty, was considered as the apt representation of the highest human felicity. All men's plans of life accordingly were directed to the acquisition of power for themselves. They studied to improve their external circumstances, and not themselves. Then their religion was merely the fear of mysterious powers influencing the prosperous or adverse events of the present world, and which were therefore to be conciliated or appeased by offerings and vows. Socrates set himself strenuously to refute these vain presumptions. He argued the folly of supposing, that men really accomplished their own wishes in gratifying each prevailing inclination. He showed, that whilst they did what they pleased at the moment, they did not in fact attain that pleasure which they sought; and led them therefore to surmise, that there must be some end of human pursuit beyond the gratification of the passions, and further, some ultimate end to the whole sum of the active energies of the soul, beyond the present life, and distinct from all bodily associations. But he not only suggested such a thought by shewing the reasonings on the opposite view of human life to be inconsequential and absurd; he further practically refuted the prevailing fallacies on the subject, by his own example on the other side. He proved to the world, by divesting himself of all the worldly accessaries of happiness, and depending exclusively on the internal resources of his mind and character, and by his perpetual cheerfulness under those privations, that happiness did not result from externals, or from the body, but from the internal nature of man, nor from any thing positive and absolute in that nature, so much as from its state of discipline and command over the appetites of the body. Theories of morals were yet to be formed. It remained for Plato to erect the true and sublime standard of human conduct in the perfections of the Divinity, and for Aristotle afterwards to shew the application of the law of habits to the subject. Socrates has the merit of having prepared the way for these developments of the subject, by demonstrating the folly of seeking the ideal of happiness in any enjoyment of the body, or in any thing present.

So also as to religion, though he could not advance, in his conceptions of the retributive justice of the Divine Being, beyond the circle of darkness which limits the natural observation of man, he proved the absurdity of supposing that mere external punishment was the only suffering undergone for offences committed. Secret faults, as he pointed out, did not escape with impunity. He appealed to the remorses of conscience, to shew how surely, however invisibly, wrong doing was visited with its punishment; and whilst in his own mind he concluded that there would be a future state, in which each man would receive the merited consequences of his actions, he must also have excited, in the minds of his hearers, a strong though undefined apprehension of a period of general retribution after death in another world. At least they must have seen that it was not so certain, as they may have once supposed, that though a present punishment may have been evaded, punishment would not follow at a future day. In well-disposed minds, there would thus be a foundation laid of a doctrine of the immortality of the soul. Under the teaching of Socrates himself, this truth, perhaps, would scarcely assume the form of a doctrine, so distinctly as it is stated by Plato. It would be simply a practical conviction. And thus Socrates himself probably scarcely propounded it in formal terms, nor without those qualifying doubts which both his memorialists describe him as joining with its enunciation. But Plato, following him, took up the doctrine as a formal truth, and worked it up into a perfect theory, with the formal array of argument and didactic exposition.

There was nothing, indeed, of system in any part of the teaching of Socrates. In the "Memorabilia" of Xenophon, we have probably a very complete specimen of the substance of what he taught, and, in the desultory manner in which the subjects of the several conversations there given are introduced, of the actual way in which he would throw out his questions and reflections on different points, as they happened to suggest themselves on each occasion. There we find the various duties of the good man and the good citizen summarily sketched, without the formality of statement or systematic connexion. He inquires what is just, or pious, or temperate,—and he leads his hearers to consider the true definitions of the several virtues;[1] but it is chiefly with the view of laying open their mistakes and confusion of thought on the subject, and to divert them from sophistical disquisitions on virtue, to the discharge of virtue in all its parts, rather than to give any precise idea of it himself.[2]

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[1] Xenoph. Mem. iv. 3. 36. Ἀλλὰ ταῦτα μὲν, ἔφη ὁ Σωκρὰτης, ἴσως διὰ τὸ σφόδρα πιστεύειν εἰδέναι οὐδ᾽ ἔσκεψαι. . . . Ib. 39. φροντίζω, μὴ κράτιστον ᾖ μοι σιγᾷν· κινδυνεύω γὰρ ἁπλῶς ὀυδεν ἐιδέναι.

Certainly there are grave objections to the morality which he taught. It did not enjoin that perfect purity of sentiment and action, which, judging from its general excellence, we might perhaps have expected. It forbade *excesses* of licentiousness as evil, but it did not also forbid licentious indulgence as altogether vicious, or fix its stigma on those monstrous forms of vice which polluted Grecian society. Nor, again, did it give a right tone to the resentful feelings. It enjoined the requiting of ill to enemies,—placing retaliation as a duty on a par with the return of kindness to friends.[3] With these exceptions, the morality inculcated by Socrates, founded as it was on the indications in man's nature of a destiny beyond the present world, bears strongly the marks of the law written by the finger of God, and proves that the Creator has not left Himself without witness, where the light of his revelation has not shone. Supposing even that those great truths, thus taught, were the broken planks from the wreck of a primitive Faith, floated down on the stream of ages, we must yet believe a providential disposition, in the fact of that ready acceptance which they could obtain with one, brought up, as Socrates was, amidst the grossest corruptions of heathenism. His was an instance, how the unsophisticated heart responds to the notices of divine truth, when once they are duly presented to it; and how, wherever there is a sincere pursuit of right, the moral eye will be enabled to pierce the surrounding gloom, and to discern, for the most part, the true outline and form of right.

It is observable, however, that, whilst Socrates correctly perceived that the laws of religion and morality possessed a sacred importance, independently of all positive enactments of men, he yet appeals to the laws of the state for the particular rules of religious and moral duty. When instructing Euthydemus on the worship of the gods, he cites the Delphic oracle, which enjoined the law of the state as the rule of acceptable worship.[4] When asked by the sophist Hippias what is just, he answers, that it is what the laws prescribe. Such reference was perfectly natural in a Greek, accustomed as Greeks were to view every thing in subordination to politics, and to regard the duty of the citizen as paramount to every other duty. This feeling had its influence with Socrates, and induced him to regard the authority of the state as possessing in itself a moral force of obligation. The respect which he throughout shewed to the laws of his own state, was that of one who not only obeyed what they commanded, but strictly reverenced their authority.[5] We must not, however, suppose, that he thus intended to place positive and moral laws on the same footing. The reference which he gives to the written law of the state, as the directory on questions of religion and morals, is the substitute in his teaching for a systematic development of the moral and religious duties. The law of the state presented, to one who had no thought of systematizing the subject for himself, the best expression of those great truths which he was drawing forth from the higher source of man's eternal nature. He is content to point out to his hearers, in a general way, the wisest and readiest collection of rules for those cases which came under the great comprehensive duties of piety and justice. Evidently he is not treating the subject with the exactness of the theorist, in assigning this importance to the law of the state; but he is enforcing the use of the law of the state as an authoritative practical guide to right conduct.—His internal view of religion, for example, was founded on observation of the signs of benevolent design throughout the material and intellectual world; and he was thus led to the acknowledgment of a pure Theism. But in his conduct, he knew not how to realize the obligations which the perception of this truth imposed on him. With his reverence, accordingly, for the laws of his country, as well as under the influence of that superstition to which his piety habitually verged, he sought a direction to his religious sentiments from the authority of the state, and thus in practice was a polytheist.—His object was further to prevent men from trusting to the conceits of their own judgment in matters of conduct, and to recommend a proper deference to the wisdom and authority of their ancient laws, then so presumptuously slighted by each vain pretender to superior prudence and political sagacity.

In assailing, as Socrates did, the follies of his countrymen by the dexterity of an acute reason, he was ever exposing their ignorance. The impression on his own mind appears to have been, that men erred rather from the want of due information respecting their moral condition, than from the perverseness of their will,—from folly, rather than from vice. Himself an accurate observer of human life, and with a disposition to follow the path of duty wherever it might lead him, he had in his own case felt the importance of intellectual cultivation, in order to right conduct. From his own circumstances, accordingly, and a natural predilection for those exercises of the mind which were his habitual pursuit, he overrated this importance; and, instead of simply regarding the information of the mind as a necessary ingredient in moral improvement, he made it all in all. Thus, according to him, wisdom or philosophy was virtue, and ignorance and folly, vice. He carried this view of morals so far, as to place the knowledge of duty on a footing with the knowledge of arts. Nor was he even startled with the paradox, that if such were the case—if the knowledge of right were the whole of morality—there would be less immorality in intentional wrong conduct, than in unintentional done through ignorance.[6]

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[1] Xenoph. Mem. iv. 8, 11. Ἱκανὸς δὲ καὶ λόγῳ εἰπεῖν τε καὶ διορίσασθαι τὰ τοιαῦτα, κ.τ.λ.

[2] Xenoph. Mem. iv. 4, 9. Ἀλλὰ μὰ Δι', ἔφη, οὐκ ἀκούσῃ, πρίν γ' ἂν αὐτὸς ἀποφήνῃ, ὅ τι νομίζεις τὸ δίκαιον εἶναι. ἀρκεῖ γὰρ, ὅτι τῶν ἄλλων καταγελᾷς, ἐρωτῶν μεν καὶ ἐλέγχων πάντας, αὐτὸς δὲ οὐδενὶ θέλων ὑπέχειν λόγον οὐδὲ γνώμην ἀποφαίνεσθαι περὶ οὐδενὸς, κ.τ.λ.

[3] Xenoph. Mem. iv. 2, 16; ii. 6. 35. Aristot. Rhet. ii. 23.

[4] Ibid. iv. 3, 16. Also, i. 3, 1.

[5] See, in the "Crito" of Plato, a beautiful address, put into the mouth of Socrates, from the personified majesty of the laws.

[6] Xenoph. Mem. iv. 2, 20. Δοκεῖ δέ σοι μάθησις καὶ ἐπιστήμη τοῦ δικαίου εἶναι, ὥσπερ τῶν γραμμάτων, κ.τ.λ. Seneca, arguing also the need of moral information for the performance of duty, refers to the same illustration of morality from the arts, as that given by Xenophon, to shew that there is no real analogy between the two subjects. "Vis scire," he says, "quam dissimilis sit harum artium conditio et hujus? In illis excusatius est, voluntate peccare, quam casu: in hac maxima culpa est, sponte delinquere. Quod dico, tale est. Grammaticus non erubescit solecismum, si sciens facit: erubescit, si nesciens. Medicus, si deficere ægrum non intelligit, quantum ad artem, magis peccat, quam si se intelligere dissimulat. At in hac arte vivendi, turpior volentium culpa est." Ep. 95. 8. He seems to have had the argument of Socrates, as given by Xenophon, (Mem. iv. 2, 20.) in his view. So also Aristotle says: Καὶ ἐν μὲν τέχνῃ ὁ ἑκὼν ἁμαρτάνων αἱρετώτερος· περὶ δε φρόνησιν ἧττον, ὥσπερ καὶ περὶ τὰς ἀρετάς. Eth. Nic. vi. 5.

Thus vice was in no case, in the view of Socrates, an act of the will, but of the mistaken judgment. He did not mean by this to assert, that men did not act wrong wilfully in the particular instances of misconduct, so as not to deserve blame for their misconduct; but that the seat of vice was in the perverse understanding,—for that the will was invariably towards good. If, accordingly, vice may be regarded as seated in the understanding, and not in the heart, it would follow, that that man is less vicious in *principle*, who knows what is right and acts wrong, than one who acts wrong without knowing what is right. The former alternative, however, was impossible, according to his theory. For knowledge, by its intrinsic excellence, must prevail over every other principle. So far was Socrates led by the working of his method, and his observation of the ignorance and folly of men, to overlook facts, at least, as evident on the other side,—the plain instances of men acting wrong in spite of their better knowledge, and of greater blame assigned to wrong thus done in spite of knowledge. His error is further to be traced to a confusion of the ideas of right and happiness, in the term "good." That the will is, by the original constitution of man, invariably towards good, if we take good in the sense of real interest or happiness, is quite true; but it is far from true, if we include the notion of right in that of good. Men, when they take even perverted views of their happiness, may be regarded as unconsciously desiring the real happiness of their nature. The will, therefore, in this sense, may be said to be always towards good. But in the latter sense of the term "good,"—that in which it includes right,—the contrary rather is true. Men see the light, but love darkness rather than light; and the seat of vice is, accordingly, not in the understanding, but in the heart. But there is this justification of the language of Socrates on moral subjects, that the ignorance which he attacked, was, in truth, a vicious and blameable ignorance. Men did not take pains to inform themselves on moral subjects. They neglected themselves, pursuing and professing every other kind of knowledge but that which was most at hand for their acquisition, and most concerned them. Seeing, then, the moral errors into which men ran from this neglect, Socrates not unreasonably set his mark of reprobation no ignorance, as the source of immorality. Immediately, indeed, and ostensibly, he attacked the general ignorance of men, holding out philosophy as the remedy of vice and unhappiness. But the ultimate and real object of his attack all the while was, the immoral disposition, the self-neglect, and the irregular habits of life, from which the incapacity and ignorance of men on moral subjects commonly result. Then, further, it was the ignorance of self, chiefly, that he laboured to remove. He found conceit as to themselves, the prevailing fault of the men of his age and country. And he hoped, by exposing their ignorance on various subjects, to make them question their presumptions relating to their own nature, and character, and duties. Thus would he, in effect, be correcting moral error,—the folly of men persuading themselves and others that they knew what they had never cared to examine, much less to know.[1]

As the peculiar aspect under which he presented the subject of morals arose, in a great measure, from his manner of interrogating in conversation, so the general character of his philosophy is to be sought in its intimate connexion with the peculiar method which he pursued. His philosophy, being essentially colloquial, laid down no positive principles in any particular science, or even any general principles for the conduct of the understanding in scientific or moral inquiries. But it sought to rouse the understanding to a perception of its condition of weakness, and defects, and ignorance, previous to its interrogation of itself, and its acquisition of knowledge, and its strengthening by exercise and discipline. Like the great reformer of modern science, he found nothing duly ascertained in the field of philosophy; hypotheses assumed without examination, truth obscured and confounded under the plausible cover of general terms and vague analogies. Yet every one was fully satisfied with the state of knowledge; every one presumed that he was in possession of the truth. So, too, at this period, as at the time when Bacon proposed his new method, there was a dialectical science in use, available only for disputation and victory, and not reaching the truth of things, or imparting any real knowledge. And, in like manner, in the time of Socrates, as in that of Bacon, this imperfect dialectical science was regarded as the key to every kind of knowledge; and he who could discourse fluently on any given subject, was esteemed the accomplished philosopher. "Of nothing," as Bacon himself pointedly observes, "were men so scrupulous as lest they should seem to doubt on any subject."[2]

This state of things formed a strong barrier against any attempt to effect a moral reformation. The way to the heart had to be cleared through a mass of outworks thrown out by the intellect. It only remained, then, for him who would be the moral reformer of his countrymen, to work by means of that very dialectical science which opposed its ramparts and its arms to his progress.

But to have simply used the same method which his contemporaries employed, would have been to revolve in the same perpetual circle. Socrates, indeed, might, by a more skilful use of the same dialectical artifices, have confuted the sophists and others with whom he reasoned. He might have gained the victory in argument, by demonstrating the fallacy of their deductions, or proving the contradictory of their conclusions. But no advance would have been made by such a proceeding towards a detection of the source of the popular errors, the wrong principles themselves, on which men argued and acted. To accomplish this object, then,—to expose the fallacy of wrong principles,—he had to exalt the art of the dialectician to a higher function than that of merely eliciting consequences from given principles.

This attempt accordingly he made. Without instituting any formal method, or teaching any art of discourse,—without, it seems, having any such design in his thoughts,—he yet so far gave a new direction and impulse to dialectical science, as to render it in some measure at least subservient to the investigation of truth. In his hands, it served, if it did nothing more, to raise *doubts* as to the truth of erroneous principles which before had passed without question, and which the very practice of reasoning from them as axioms, had tended to confirm as fixed and indisputable standards of all other truths.

We must not suppose, that definition and induction were unknown as parts of dialectics before Socrates; or that Socrates was absolutely the first to discover and propound their nature and use. The expressions of Aristotle might suggest this supposition. For he says particularly, that there were two things which one might ascribe to Socrates, Definition, and Inductive Reasoning.[3] What Aristotle probably intends to say, is, that Socrates was the first to improve the existing method of dialectics, by employing definition and induction as the principal engines of discussion, and illustrating their nature and use more than ever had been done before him. He gave them, in fact, a body and a vitality, by applying them to the realities with which men had to do in their daily life.[1] Instead of employing them for the purpose of verbal distinction, or for the expression of some abstract and barren generality, he applied them to limit the vague notions entertained about matters of practical concern, and to bring opinions into harmony with ordinary experience. To the dialecticians before him, Definition and Induction were the commencement of their discussions. They unsuspectingly presumed on the logical processes involved in these instruments of discourse, as already sufficiently accomplished. They attempted, indeed, to define; but they took such definitions as they found at hand,—of course the most superficial.[2] General principles they scarcely though of establishing; but they assumed such as were the current maxims of the day. And the rest of their discourse proceeded from these crude and unscientific elements. But Socrates did not profess to give definitions, or to have arrived at any positive certain principles, from which, as data, other truths might be demonstrated.

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[1] Xenophon speaks of the refutations employed by Socrates, serving as chastisements of presumptuous folly, κολαστηρίου ἕνεκα. Mem. i. 4. 1.

[2] Nov. Org. i. 67.

[3] Aristot. Metaph. xiii. 4. Δύο γὰρ ἐστιν ἅ τις ἂν ἀποδῴη Σωκράτει δικαίως, τούς τ' ἐπακτικοὺς λόγους, καὶ τὸ ὁρίζεσθαι καθόλου. Ibid. i. 6. περὶ ὁρισμῶν ἐπιστήσαντος πρώτου τὴν διάνοιαν.

He disclaimed, as has been already pointed out, the design or the ability to teach. He was only an inquirer, himself *knowing nothing.* When pressed, as by the sophist Hippias, to give his own account of the particular subject about which he is importunately questioning, he evades the point, and recurs to his established way of proceeding by interrogatories.[3] He is constantly, that is, endeavouring to rise to a correct definition of the subject under discussion. He presents it as the end to be attained by the whole discussion; leading the person questioned from point to point, until he brings him close to the true and exact idea of the subject. So also does he employ Induction. He cites some instance,—commonly some coarse and very familiar one, from the workshop of the smith or the shoemaker, or from the culinary art, and the like,—as apposite to the point under debate; and thus brings the principle itself, on which the dispute turns, to the test of actual experience. This was so much his manner, that it was made a standing jest by those against whom he so triumphantly employed it. They complained of his ever repeating the same thing; ever talking of "carpenters, and smiths, and fullers, and cooks, and such like nonsense.[4]" But he was not deterred by the scoff, which in reality proved the point and force of his reasonings. He replied, that about the same things, he must persist in saying the same things; unless it could be shewn, that a person being asked, whether twice five were ten, should answer differently at different times.[5] Thus, he would continually recur to his well-known illustrations from common life, hackneyed as they were in his own use, and low and trifling as they might seem.

From this his constant practice of bringing men to the test of definition and familiar instance, on every subject discussed, he had been regarded by the Thirty as the teacher of an "art of discourse," and as therefore obnoxious to a law which they had made (chiefly with a view to him), forbidding the teaching of such an art.[6] Such a restriction, however, could not apply to Socrates; since, as we have seen, he professed no art; he imparted no method of argument; and, to have silenced him, they must, as he shewed them, have absolutely prevented his asking the most simple and familiar question. Here it was the point of an apt illustration that had provoked this sally of resentment from Critias and Charicles, two of the Thirty. It had been reported to them that he had drawn attention to their acts of violence, by asking, what would be thought of the herdsman under whose care an herd should be diminished. On this occasion, Charicles, after vainly remonstrating with him against the practice of his daily conversations, shewed the point of the illustration, by bidding him beware lest he also should make the number of the herd still less.[7]

So far, indeed, was Socrates from instituting any method either of argument or of investigation, that the very definitions and instances which he employed were of a popular character, adapted for refutation of error rather than for conviction of the truth,—such as to place difficulties in the way of a dogmatic opponent, rather than didactic illustrations of any particular subject. He was engaged in repelling dogmatism. And nothing is of more avail for this purpose than analogies; such instances, that is, as test the truth of an assumption in one case, by its application to another of the same kind. Direct instances, shewing experimentally the truth or falsehood of an assumption, may be difficult to be found; and, in their use, they require a particular acquaintance with the subject itself, in order that their application may be seen. For example, if it were desired to expose a false theory of government, some fact of history must be adduced, and its bearing on the theory in question must be distinctly pointed out. But an analogous instance does not require this intimate acquaintance with the subject itself, in illustration of which it is brought. It shews at once that a given hypothesis is either tenable, or not tenable,—that it is verified or not verified in some parallel case, and therefore may be granted or not, in the subject about which the argument is. Only it is necessary, for this purpose, that the analogous instance should be a familiar one,—that the exhibition of the principle in question should be clear and striking in the instances adduced. For example, to set forth the evil of tyranny, it would be quite enough to point out, as Socrates did, the case of a herdsman under whose keeping an herd should be deteriorated; and the inference would be immediate, that a career of confiscation and blood was no evidence of a good government. Again, whether it were wise to choose magistrates by lot, would be a difficult question to be decided by the direct evidence of facts bearing on the point. But when Socrates referred to the absurdity of appointing a steersman by lot, it was at once evident, that there were cases in which this mode of appointing important officers of the state would be mischievous. Such then was the kind of evidence which Socrates was constantly adducing from analogous instances to the point in question;—an evidence, not conveying any positive instruction in the theories of the subjects to which it was applied; but removing false impressions respecting them, and opening the mind to the reception of the truth. It was an admirable method of unteaching prejudices or vain assumptions, and of silencing the dogmatist,—a method, powerful at once for the refutation of error, and the conviction of ordinary minds incapable of being instructed by a more direct and positive evidence. Such, accordingly, was the method practised by Socrates. In pursuing any argument, "he would proceed," as Xenophon observes, "by the most admitted principles; considering this to be the sound basis of discussion. And therefore," adds Xenophon, "he, far beyond all I ever knew, when he spoke, carried conviction to his hearers;" and he would say, "that Homer had ascribed to Ulysses the merit of being a sound orator, on account of his ability to conduct a discussion, by reasoning from such principles as men acknowledged."[8]

It was seldom, however, if ever, that Socrates avowedly argued a point. Professing to know nothing himself, he constantly challenged others as to what they professed to know. He put his questions to each person with whom he conversed, very much as the skilful experimenter in these days does to nature, so as to lead to the affirmative or negative of a particular hypothesis whose truth he would investigate. Having obtained an answer, he proceeds analytically, to found on that another question, studiously directed, in like manner, to elicit the answer which might serve for further inquiry, and so on, until he has reduced the first proposition to some simple elements, clearly shewing the truth or falsehood of the original assumption. It was as truly an experimental process on men's minds, as that which the modern investigator performs on the subject which he examines. Those analogical instances in which he so much delighted, served the purpose of this analysis, no less than direct and proper instances, such as belong to him who investigates experimentally the nature of a particular subject. For analogies detect the state of the mind to which they are addressed. They at once call forth and illustrate its principles and habits of thought, and enable the experimenter to avail himself of the existing resources in that mind for effecting the desired conviction. They furnish him with a clue to the course which he should follow in carrying on his analysis. This was that midwifery of the mind which Socrates used sportively to describe as his peculiar occupation.

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[1] Xenoph. Mem. iii. 3. 11. Λέγεις, ἔφη, σὺ τὸν ἵππαρχον πρὸς τοῖς ἄλλοις ἐπιμελεῖσθαι δεῖν καὶ τοῦ λέγειν δύνασθαι; κ. τ. λ.

[2] Aristot. Metaph. i. 5. Καὶ περὶ τôυ τί ἐστιν ἤρξαντο μὲν λέγειν καὶ ὁρίζεσθαι, λίαν δ' ἁπλῶς ἐπραγματεύθησαν. ὡριζοντό τε γὰρ ἐπιπολαίως, κ. τ. λ.

[3] Xenoph. Mem. iv. 4, 9.

[4] Ibid. i. 2, 37. Plato, Gorgias, p. 491, a. t. iv. p. 96.

[5] Xenoph. Mem. iv. 4, 7. διὰ τῶν δοκούντων τοῖς 'ανθρώποις.

[6] Xenoph. Mem. i. 2. 31. 3.—Aristid. t. ii. p. 248.

Xenoph. Mem. i. 2. 37.

[8] Ibid. iv. 6. 15.

In his conversation, for example, with Euthydemus, who prided himself in having cultivated his mind by his own independent study of books, of which he had formed a large collection,—he first drew attention to the singularity of the young man's conceit, by representing him as coming before the public, with high professions of being self-taught, and putting the parallel case of a candidate for some medical office, who should announce that he had studiously avoided even the appearance of having *learned* the art of medicine, and ask for the office on the promise of endeavouring to learn the art by his future practice. Interest being excited by this illustration of the absurdity, he next led his hearers to see the absurdity of entering on political affairs without preparation, by referring to the fact of the severe application and discipline undergone by persons who seek reputation in such accomplishments as flute-playing or riding. Then, having gained over Euthydemus as a more willing listener, he proceeds to question him as to the use for which he had collected so many books. He throws out the presumption that they have been collected with a view to enrich the mind with virtue. Supposing this to be granted, he goes on to interrogate Euthydemus as to the particular excellence of which he is in quest. He enumerates several particulars; and these being rejected, he comes at last to excellence in the art of government, which the young man concedes to be the object of his desire. This gives an opening to inquire into the qualifications necessary for such excellence. He discovers, by the answers of Euthydemus, that he conceives himself master of those moral virtues which he is induced to admit are indispensable to the good citizen. By a series of questions, however, relating to particular actions, he forces Euthydemus to admit, that what is just in one case, is unjust in another, and to contradict himself in his successive statements as to the comparative criminality of voluntary and involuntary acts of injustice. What, then, triumphantly asks the philosopher, think you of a person who is so inconsistent with himself? The conclusion is inevitable; and Euthydemus is constrained to own, that " he knew not what he thought he knew." But Socrates, not yet satisfied, presses him further to explain his notion of that ignorance which he had thus displayed; and finds, that notwithstanding his confession of his want of right instruction, he yet presumes on his possession of self-knowledge. Another question forces him to abandon this position. The young man then asks to be only put in the way of self-examination. Here at once his false presumptions are exposed to the searching analysis of Socrates. The inquiry turns on a knowledge of the goods and evil of life. Euthydemus enumerates one thing after another as good; and Socrates immediately subjoins some counter evil as attending it; until Euthydemus at last gives up his confidence in his own opinion, and declares that he knows not now what he ought to pray for to the gods. Again, Socrates presents before him pointedly the evidence he had thus given of having been diverted from consideration of the subject by the strong presumption of his knowledge of it. But that he may leave no room for escape, he calls on him, in conclusion, to state his opinion as to the nature of democracy, which at least, he conceived, Enthydemus, as a candidate for public office in a popular state, must have studied. And in like manner, he extorts from his successive answers a further proof of his ignorance and incompetence to the duties for which he had designed himself.

The effect thus produced is what Plato compares to the numbing touch of the torpedo.[1] The mental powers of the individual thus tried were for the moment paralyzed. He found that he only committed himself further by renewed efforts; and " began to think," as Euthydemus says of himself at the close of the conversation to which we have just referred, " whether it were not best for him to be silent, as he ran the hazard of appearing absolutely to know nothing."

From the instance just given, it will appear that a current of irony pervaded these experimental argumentations of Socrates. There was irony mingled with earnest conviction, in that very disclaimer of all knowledge with which he set out. It was a mask, behind which he could hurl his weapons of assault on the boasted knowledge of others, whilst at the same time he expressed his serious view of the real ignorance of man, and the necessity of coming with a simple unprejudiced mind to the acquisition of truth. In the prosecution, however, of his method of analysis by interrogation, irony was indispensable for the success of his inquiry. For his object was to obtain the truth from the mouth of the person interrogated, not to state it himself; and where he did state it accordingly, it was necessary to put it in such a form as to try whether it was the opinion or not of that person,—whether he really thought so, or adopted it on the judgment of his questioner. An ironical statement answers this purpose. It conceals the teacher, and enables him to judge, according as the hearer applies it, what the state of the hearer's mind is, and to argue the point in question, not on premises laid down by himself, but the admissions of the other. The hearer, too, is taken by surprise. The air of seriousness which the ironical manner sets out with, and the absurdity involved, on second thought, in carrying out the supposition of a serious intent, in their united effect, provoke the smile of surprise, and win attention. As Socrates was engaged, too, in presenting unacceptable conclusions,—bringing home to the self-conceited evidences of their real ignorance,—it was necessary for him to disguise, as much as possible, the conclusion to which he was tending. He had to assume, therefore, the principles on which those with whom he conversed were reasoning and acting, and reduce these to an absurdity, by applying them as true to some evident case of ordinary experience. The skilful use made by Socrates of this irony was a powerful enforcement, in itself, of the convictions which he desired to leave on the minds of his hearers. He brought the aid of a delicate ridicule to the support of an argument, and thus exhibited the desired conclusion under a form, which, whilst it pleased the hearers, shamed them into an acknowledgment of its truth.

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[1] Plato, Meno., 80 a. t. iv. p. 348.

But this irony, and the analogical instances over which it was thrown, were but approaches to that end which Socrates appears always to have had in view in his conversations,—the ascent to accurate general notions of each object of thought. He was always working his way towards an exact definition of the idea on which the discussion turned. Each instance which he adduced was a step in this progress, diminishing by its light some portion of that obscurity and confusion of thought with which he found the subject invested. He did not, indeed, reach the point which he had in view. Dialectical science was in too rude a state at present for the attainment of its perfect end. Socrates rather set an admirable example of the perseverance and energy with which the end should be pursued, than a perfect model of the method of pursuing it. His very method, indeed, confesses its own imperfection, in stopping just at the point where the way seems to be opened, and leaving the subject negatively, rather than positively defined.

This constant pursuit of exact definition is an indication of the antisceptical bent of the mind of Socrates. The foundations of morals and of all science were shaken by the speculations of his sophistical predecessors. Opinion was exalted to the prerogative of knowledge. Socrates accordingly put opinion to the test. He explored it experimentally, as it existed in different minds; and he proved it deficient from the standard to which it had been vainly exalted. He found that it vanished before the light of investigation; and, in fact, that in proportion as the fancies and errors of opinion were cleared away, advances were made towards more stable and certain knowledge. This knowledge, accordingly, he continually sought after. He had probably but an indistinct conception of the realities towards which he directed his pursuit. Still he appears constantly to have assumed and fully believed their existence, by steadily proceeding, as we find him to have done, through the various opinions which he encounters in discussion, until he arrives at some more definite form of thought. What Socrates only indistinctly apprehended, Plato afterwards realized in his philosophical system, and endued with existence in his celebrated theory of Ideas. But in the view of his master that theory was but dimly seen in shadow. Socrates shaped his course towards it, as he more and more limited the extravagancies of popular opinion on the various subjects which he discussed, and excluded whatever was irrelevant and foreign to the real nature of the thing. He threw doubts on what was doubtful, that there might be the less doubt and uncertainty about what remained when the doubtful was removed from a subject.

What appears to have led Socrates into this sound method of proceeding, was, as Aristotle very justly intimates, the firm moral convictions which were the great elements of his mind and character.[1] He felt that there was a reality in the principles of piety, justice, benevolence, and other moral sentiments, which no sophistry could impugn. He not only felt their reality within himself, but he had observed, that however invisible to the outward eye, they produced real effects in the world; that they were not only evidenced in the constitution of nature, but also recognized in those unwritten laws which were found everywhere the same, independently of positive institution, as well as in the enactments of particular states.[2] He looked for the original of these sentiments to the perfect nature of the Divinity; and he held them accordingly to be invariable and true, as the Divinity is invariable and true. Hence he would allow no proper and adequate power of causation but moral design. Material or mechanical causes were in his view but of instrumental efficacy.[3] It was moral sentiment only, the love and pursuit of good, that possessed real power. This alone, he observed, subsisted unchanged and fixed, whilst every thing else was moved by it, and derived its existence from it. It was the neglect of this primary principle in the detail of the physical theory of Anaxagoras, which had offended him in the system of that philosopher. And agreeably to this, Plato tells us of his accounting for his remaining in his prison, from the simple cause of the moral feeling by which he was actuated.

Fixing his eye accordingly on these stable eternal principles, Socrates pressed forward in every discussion towards their attainment. He would never rest in vague general classifications, which involving also much that belonged not to the subject in question, left its nature as undefined as ever. But he proceeded to a further limitation of the generalities on each subject, obliging his hearer to distinguish the subordinate genera included in the more general idea first thrown out, and thus gradually to circumscribe the subject within its proper boundaries. This was the intimate connexion of his logic and ethics. He was engaged throughout in an endeavour to remove the vain presumptions of mere opinion, and to substitute for these a real knowledge, as far as it was attainable, of the subjects themselves. He conceived that if men went astray in their conduct, acting on what they mistakenly thought right, and good, and true, it was only necessary to make them *know* the truth, and they would then act on their *knowledge*, as before they acted on mere *opinion*, and by thus acting attain their happiness. This was but a short-sighted view of the origin of human misconduct and unhappiness, as it did not go beyond the fact of the erroneous judgment of men, to the moral perversion which was the primary cause of their failure in action. As the practical error of men arises from this perversion, it is evidently vain to think to improve their conduct, by merely substituting more correct notions of truth and duty; since this remedy does not reach the source of the malady. Such, however, was the view of Socrates. And hence he laboured, whatever might be the subject of his conversations, to lead men to contemplate the nature of the thing discussed, and to seek to define it to themselves; thus blending the perception of the right and the good in the intellectual apprehension of the truth. Xenophon accordingly remarks the importance attributed by Socrates to the ability of distributing things into genera, on the ground, that by means of this talent "men would become most virtuous, most formed for command, and most able in discourse."[4]

Though Socrates thus endeavoured to render his hearers accomplished in the art of discussion, by directing their attention to Definition, he, as might be expected, in that early state of logical science, did little more than point out the great importance of Definition, and mark the direction in which it should proceed. Were we to take our estimate of what Socrates accomplished in this way from the "Dialogues" of Plato, we must suppose Socrates to have been much more methodical in his discussions, than we should infer from the specimens given by Xenophon. Something perhaps should be allowed for the practical turn of Xenophon's mind, and his comparative inattention to the more abstract part of the discussions of his master, whilst his fellow-pupil, on the other hand, who had an eagle-eye for theory, however remote and dazzling, would seize every hint that dropped from the lips of Socrates for the indulgence of his speculative imagination. Still Xenophon may be regarded as having presented the most natural, as well as most exact, specimens of the method of Socrates. In the simplicity of his honest admiration and grateful recollection of the instructor and guide of his youth, he evidently records what had most impressed his own mind, both as to the substance and the manner of the conversations of Socrates, without any attempt either at dramatic or theoretic effect. From Xenophon we learn how Socrates appeared to the young Athenian, who, without any theories of his own, approached him, simply with the desire of hearing him, and applying what he might learn from the philosopher to his own improvement. Plato, on the other hand, whilst he also has given a faithful portrait of Socrates in the general outline, (and the faithfulness is shown by its close correspondence with that given by Xenophon,) studied to give effect, at the same time, to his own philosophic sketches, by placing the figure of Socrates in such a light as to harmonize with his own sublime and beautiful ideal of truth.

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[1] Aristot. Metaph. i. 6. *Σωκράτους δὲ περὶ μὲν τὰ ἠθικὰ πραγματευομένου, κ.τ.λ.*

[2] Xenoph. Mem. iv. 4.

[3] Aristotle gives an instance of the manner in which Anaxagoras lost sight of his theory of mind in working out his system. Anaxagoras, he tells us, said "that man was the most intelligent of animals, because he had hands; whereas he should have stated, that man had hands because he was the most intelligent of animals; for that hands were an instrument for taking hold." Aristot. de Part. Anim. iv. 10, p. 1034. *'Αναξαγόρας μὲν οὖν φησὶ, διὰ τὸ χεῖρας ἔχειν, φρονιμώτατον εἶναι τῶν ζώων τὸν ἄνθρωπον· εὔλογον δὲ, διὰ το φρονιμώτατον εἶναι τῶν ζώων, χεῖρας ἔχειν· τοῦ λαμβάνειν γὰρ χεῖρες ὀργανόν εἰσιν.* Ed. Duval.

[4] Xenoph. Mem. iv. 5. 12. *'Εκ τούτου γὰρ γίγνεσθαι ἄνδρας ἀρίστους τε κὰι ἡγεμονικωτάτους κὰι διαλεκτικωτάτους.*

Thus we see how Socrates was the founder of the moral and logical science of the schools of Athens. He taught nothing positively in either branch of philosophy, but he taught men to inquire, and set them on the right track of inquiry. He trained men to think for themselves, to accept no opinion which should be contradicted by the moral and intellectual principles of their own nature, and to rest in no opinion until they had traced it up to these principles.

An exact logic, and a sound ethical system, would in time naturally result from such a direction of men's minds.

In giving account to themselves of their opinions, men would be led to examine into the connexions and dependencies of their ideas. Observations would be made on the relations of ideas, and of words as their signs and representatives. And such observations methodically stated, would at length constitute a system of logic, such as that which Aristotle brought to light about half a century after the death of Socrates. In the mean time, however, the value of ideas in themselves, apart from their expression by words, would engage attention; and a metaphysical logic,—a logic having for its object the determination of the true notion or idea of a thing, and for its business the discussion of the probabilities or appearances of truth surrounding the matter in question,—would naturally be the first to succeed. Such was the Dialectic of Plato,—a science of discourse or discussion, as its name imports; not a particular science, like the logic which grew out of it, but as general in its comprehension as the method itself of Socrates, of which it was the formal development, and equivalent, therefore, to philosophy in the highest sense of that term, as being a search after the nature of things, or, according to him, a theory of Ideas.

Again, in giving account to themselves of their opinions, men would be led to trace the connexion of their moral sentiments and actions with an internal standard of right, independent of the variations of opinion. The examination of this relation would suggest, in process of time, a system of rules for bringing the variable—the sentiments and actions of the individual moral agent—into accordance with the invariable principles of his moral nature. The first ethics, identical, like the first logic, with philosophy in general, would be employed in carrying the views of men to those great principles themselves,—discussing and removing obstructions to the pure contemplation of the nature of virtue. But the more mature study of ethics, taking up the subject as a separate branch of philosophy, would develop the application of the doctrine of the fixed standard, by shewing throughout the field of man's moral nature, how every moral sentiment is strictly limited by its reference to such a standard. The former is the chief business of Plato's ethical philosophy; the latter, that of Aristotle's;—the first tending to a contemplative morality, to a love of the transcendent beauty and excellence of virtue,—the latter, to a theory of active virtue,—to a regulated state of the affections in all the offices of life;—both natural consequences in their order, of that awakening of the reason of men, of which Socrates had been the living instrument.

Socrates, at the same time, by the method which he pursued, taught men the beginning of an art of criticism. From an examination of existing opinions, the transition was natural to the systems of philosophers, and the records of the opinions of men of former days. And, in this respect, Socrates may be regarded as the father of the history of philosophy. Even had the criticism of the writings of philosophers formed no part of his conversations, still he must have prompted such an inquiry by his method of interrogating, and exacting from every one an account of his opinions. But he did more than this. Though not properly erudite, in that sense in which Plato and Aristotle were, he had yet acquainted himself with the doctrines of former philosophers. The chief part of his life was spent with his eye, not on books, but on men. Still, as we are informed by Xenophon, he had read, and had selected, in the course of his reading, whatever he thought valuable in the writings of those before him.[1] Plato, accordingly, has made great part of the conversation of Socrates consist of criticism of the theories of philosophers. Much of this criticism evidently belongs to the richly-various and elaborate learning of the disciple, rather than to the master from whose lips it proceeds. But that Plato is not gratuitously ascribing this kind of learning to Socrates, we see from the manner in which the less erudite disciple refers to the discussions by Socrates of the doctrines of former philosophers. Not only does Xenophon mention, in common with Plato, the comments of Socrates on the more recent system of Anaxagoras,[2] but he refers also to his examination of the great antagonist theories of the older schools, of Parmenides, Xenophanes, Melissus, and others, on the one hand; Heraclitus, Empedocles, and their followers, on the other; though without formally introducing their names.[3]

That various and discordant schools of philosophy should have arisen out of the excitement produced by the energetic call of Socrates to his countrymen, was in the natural course of things. Powerful minds, shaking off the yoke of sloth and indifference, and now at length roused to self-exertion, would, however generally docile to the guidance of a leader, be tempted to try their own powers, and strike out a path for themselves. We are not to wonder, then, that Aristippus, the advocate of pleasure, and Antisthenes, the austere cynic, should have been among the hearers of Socrates, or that Plato should have founded a contemplative mysticism on the sober homely philosophy of his master. Socrates, as we have all along shewn, did not propose any precise system of doctrine to his followers. His mission was accomplished in making them exert themselves. He did not desire that they should think alike, but that all should think and judge for themselves. It is no wonder, therefore, that some should have gone into extravagancies, and that, whilst general good resulted from the excitement, partial evil also should have accompanied it. An Aristippus, or an Antisthenes, could not have issued from the school of Pythagoras. But how much evil generally may have resulted from the abject submission to the authoritative opinions of Pythagoras, in the neglect of self-examination and self-knowledge, and disregard of personal responsibility, by those who implicitly received them?

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[1] Xenoph. Mem. i. 6. 14. Καὶ τοὺς θησαυροὺς τῶν πάλαι σοφῶν ἀνδρῶν, οὓς ἐκεῖνοι κατελιπον ἐν βιβλίοις γράψαντες, ἀνελιττων κοινῇ συν τοις φιλοις διερχομαι, κ.τ. λ.

[2] Xenoph. Mem. iv. 7.

[3] Ibid. i. 1. 1416.

But whilst we ascribe to Socrates the merit of having given at once the impulse and the character to Grecian philosophy, we must yet single out for special commendation, his admirable services in reviving the forgotten theory of natural religion among his countrymen. Of religion, indeed, as an external system of positive laws enforced by the state, they had, as we have before observed, more than enough. But religion, as a system of truth, was scarcely thought of. When Aristophanes[1] brings on the stage Demosthenes asking Nicias, well-known as Nicias was for his superstitious feeling; *ἐτὲον ἡγεῖ γὰρ θεούς*; "really, then, do you think there are gods?"[2] the allusion is evidently to the real irreligion, which the most rigid and scrupulous worship of the heathen but ill concealed. Resting their belief of a Divine agency in the world on tradition and authority, men omitted to explore the witness of God in their own nature, and in the world around them. Consequently, they were exposed to every objection which the ingenuity of theory, or the folly and wickedness of the world, might suggest to their uninformed credulity, against the positive truth of their religious system. As infidelity in these days finds its refuge in the belief of an infallible church, and is itself in its turn the miserable refuge from the despotism of the very infallibility before which it crouches in silence; so among the votaries of heathen superstition, the doubts and misgivings of the thoughtful intellect, and the troubled heart, were left to prey on themselves, shut up in abject submission to an external authority, and unprepared for their own defence and support. Socrates addressed a great portion of that practical information, which, in spite of his disclaimer of the office of a teacher, he was ever imparting to all around him, to the remedy of this distempered state of the religious feelings. He saw plainly enough that the vulgar theology could not be defended on the ground of rational evidence.[3] This, therefore, in his respect for the ancient laws and customs of his country, he was content to lean on the sanction of positive institution. A great reverence, he justly thought, was due to the wisdom embodied in ancient laws; and he would not encourage persons wantonly to abandon the presumptions of truth and right naturally belonging to established institutions. At least, he would not have men rashly set up their own notions against the presumptions in favour of the wisdom of other men and other days, recommended as these were by some experience of their stability and use, whilst each man's private opinions had no such sanction, or no equivalent sanction. But he felt also, that the internal sense of religion wanted other support,—that presumptions of human vanity and corruption were, and ever would be, brought to bear against this; and that such assaults could only be repelled by a well-informed reason prepared for the encounter. He therefore provided his hearer with a solid and impregnable argument in favour of the being and providence and moral government of the Deity. The argument was what is now familiarly known as the argument from final causes, or the evidences of almighty design in the fabric and course of nature. For this purpose, he gave an induction of instances from the world without, and from the intellectual and moral constitution of man himself, of admirable design in the adaptation of means to ends. He called upon men, with such evidences of divine benevolence around them, not to wait for any more palpable proof, such as judging from the analogy of nature they had no ground to expect, but to believe in the existence of invisible things from their effects, and from the good received to reverence the Deity its author. The language, indeed, attributed to him by Xenophon, is in remarkable correspondence with that of St. Paul, declaring, that "the invisible things of God are clearly seen, being understood by the things that are made, even his eternal power and Godhead;"[4] and the tenor of his argument throughout illustrates the inspired observation of the apostle. More particularly we may advert to his striking inculcation of the doctrine of the moral government of God. He refers to the sense of responsibility as in itself an evidence of the existence of a Divine Power to reward and punish;[5] and he points to the pleasure and pain, advantage and disadvantage, respectively consequent on virtuous and vicious conduct, in the course of things, as instances of a perfection of government beyond the power of human laws.[6] The stock of instances has been enlarged by the researches of modern science, and strength has been added to them by their arrangement and combination. But Socrates, after all, has the distinguished merit of having given the argument from final causes an explicit statement and due importance in the proof of natural religion.

When we think that truths of such high import and interest were sedulously propagated for so many years in the place of concourse of the civilized world, we naturally turn from the contemplation of the living philosopher, to ask, what was the result—what was the amount of beneficial influence on the people to whom his mission was addressed. We cannot doubt, that on the whole the influence was great,—that the serious errors of many in regard to the conduct of life were corrected,—their minds opened to consider the great purposes for which they had been born into the world, and to look for happiness, not from transitory sensual enjoyments, but from the sober and vigorous exertion of their powers of thought and action. In some conspicuous instances, indeed, his endeavours strikingly failed. Critias and Alcibiades were known wherever the name of Athens was heard. And their wild and guilty career presented to the public eye a splendid mirror, from which the most unjust censure was reflected on the philosopher himself. But the many instances which must have occurred in humbler life, of his success in the work of moral reformation, are passed over in silence. That there were such instances Xenophon has given us to understand, when he observes, in his simple manner, that Socrates dismissed those who resorted to him, improved by their intercourse with him.[7] To expect, however, any decisive and permanent public improvement from the teaching of the philosopher, would be to overlook the extent and the malignity of heathen corruption. The men of that day, as of the present, had the voice of God distinctly speaking within them, "their conscience bearing witness, and their thoughts accusing or excusing them," according to that just description of them which Scripture has set before us. But if they shut their ears, and hardened their hearts against this divine instruction, how would they listen to one who was ever upbraiding them with their dulness and inattention to its lessons and admonitions? Rather, they would feel towards him, according to that apposite illustration of Plato, as persons dozing towards one that should wake them up, and, after ridding themselves of his disturbance, think quietly to compose themselves to sleep again.[1] For he did not disguise that his mission to them was one of reproof and expostulation,—a mission, in fact, from the Deity; and that his real concern, accordingly, was not for himself, but for the success of his mission, lest they should incur the guilt of rejecting a divine gift.[2]

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[1] Aristoph. Eq. 32.

[2] Thucyd. ii. 53, v. 105. *Ἐς τὸ θεῖον νομίσεως*,—and *ἡγούμεθα τὸ θεῖον δόξῃ*,—are expressions of Thucydides, which shew the low ground on which religion was rested in Greece.

[3] Plato, Euthyphro, p. 6. a. *Ἀλλά μοι ἐιπὲ πρὸς φιλίου, σὺ ὡς ἀληθῶς ἡγῇ ταῦτα γεγονεναι ὄυτως*; κ.τ.λ. Op. i. 12.

[4] Xenoph. Mem. iv. 3. 14. *Ἃ χρὴ κατανοοῦντα μὴ καταφρονεῖν τῶν ἀοράτων, ἀλλ' ἐκ τῶν γιγνομένων τὴν δύναμιν ἀυτῶν καταμανθάνοντα τιμᾶν τὸ δαιμόνιον.*

[5] Ibid. i. 4. 16. *Οἴει δ' ἄν τοὺς θεοὺς τôις ἀνθρώποις δόξαν ἐμφῦσαι, ὡς ἱκανοί εἰσιν εὖ καὶ κακῶς ποιεῖν, ἐι μὴ δυνατοὶ ἦσαν*;

[6] Ibid. iv. 4. 24. *Νὴ τὸν Δία, ὦ Σώκρατες, ἔφη, θείοις τâυτα πάντα ἔοικε· τὸ γὰρ τοὺς νόμους αὐτοὺς τοῖς παραβαίνουσι τάς τιμωρίας ἔχειν, βελτίονος ἢ κατ' ἄνθρωπον νομοθέτου δοκεῖ μοι εἶναι.* So Bishop Butier, in his Analogy, part i. ch. 2, observes, "For if civil magistrates could make the sanctions of their laws take place, without interposing at all, after they had passed them, without a trial, and the formalities of an execution; if they were able to make the laws execute themselves, or every offender to execute them upon himself; we should be just in the same sense under their government then, as we are now; but in a much higher degree, and more perfect manner." P. 51.

[7] Xenoph. Mem. i. 2. 61. *βελτίους γὰρ ποιῶν τοὺς συγγιγνομένους ἀπέπεμπεν.* Also ib. 4. 19; iv. 5. 24.

And truly we may regard that energetic call which he was ever sounding in the ears of his countrymen, as a providential warning to the heathen world of the sin and misery of the natural man, trusting to his own imaginations,—how, "changing the truth of God into a lie," he "gives himself over unto lasciviousness, to work all uncleanness with greediness." As God sent his prophets to his chosen people, to tell them of their transgressions, and bid them "remember the law of Moses his servant;" so in his dealings with the nations of the world, He appears to have raised up, from time to time, individuals from among themselves, heathens still, yet gifted with a purity of moral vision beyond their contemporaries, to retrace the divine outline of their fallen nature, amidst its ruins, and to declare almost authoritatively the indelible but forgotten law of right. Israel rejected its prophets; but through all the perverseness of the people, those prophets prepared the way of the Lord. The heathen world, in like manner, refused to listen to its monitors, its legislators, and philosophers; but in spite of their general obduracy and indifference, we cannot but believe that the call was not utterly fruitless. To the original influence of Socrates especially, brought as this was to bear on the great centre of heathen civilization, it may have been in great measure owing, that the light of religious and moral truth was kept alive, however faintly burning, for successive generations, in many a dark abode of superstition; and that in a later day, the doctrine of grace and truth appealed not without effect to the Areopagite of Athens, the jailor of Philippi, and the Roman proconsul at Paphos. He certainly excited a spirit of eager curiosity on moral subjects; as was evidenced in the rise of the schools of philosophy to meet the demands of that spirit, and in the moral character of the disquisitions pursued in them. But this spirit could not have exhausted itself in mere literary discussion. There were doubtless the waverings of anxious minds beyond the precincts of the schools, to be settled; cravings after more safe direction of personal conduct than such as the world around them presented, to be satisfied. Such a state of things would keep men looking for gospel-truth. Some would feel, as Alcibiades is represented by Plato, after a conversation with Socrates, and Euthydemus by Xenophon, at a loss how to pray. And to such the answer of Socrates, as given by Plato, would very indistinctly perhaps, yet not without earnest hope, suggest the high thought, that they must wait until they could be informed by God himself, as to the proper disposition towards God and men; or until one should come to discipline them,—to remove the darkness from their eyes, and enable them to discern both good and evil.[3]

(J. J.)

SOCRATES was also the name of an ecclesiastical historian of the fifth century, born at Constantinople in the beginning of the reign of Theodosius: he professed the law and pleaded at the bar, whence he obtained the name of *Scholasticus*. He wrote an ecclesiastical history from the year 309, when Eusebius ended, down to the year 440; and wrote with great exactness and judgment. His work is to be found in different editions of Eusebius, Sozomenus, and the other Greek writers on the history of the church.

SODA, the name given by the French chemists to the mineral alkali, which is found native in many parts of the world.

SODERAH, a town of the province of Lahore, in the Seik territories, situated on the east side of the Chinaub, forty-eight miles N.N.W. from the city of Lahore. Long. 73. 30. E. Lat. 32. 27. N.

SODOM, formerly a town of Palestine in Asia, famous in Scripture for the wickedness of its inhabitants, and their destruction by fire from heaven on account of that wickedness. The place where it stood is now covered by the waters of the Dead Sea, or the lake Asphaltites.

SODOR, a name always conjoined with Man, in mentioning the bishop of Man's diocese. Concerning the origin and application of this word, very different opinions have been formed by the learned. Buchanan (lib. i. cap. 34.) says, that before his time the name of *Sodor* was given to a town in the isle of Man. In Gough's edition of Camden's Britannia (vol. iii. p. 701.) it is said, that after the isle of Man was annexed to the crown of England, this appellation was given to a small island within musket-shot of Man, in which the cathedral stands, called by the Norwegians the *Holm*, and by the inhabitants the *Peel*. In support of this opinion, a charter is quoted A.D. 1505, in which Thomas earl of Derby and lord of Man, confirms to Huan Hesketh, bishop of Sodor, all the lands, &c. anciently belonging to the bishops of Man. "Ecclesiam cathedralem sancti Germani in *Holm Sodor vel Pele* vocatam, ecclesiam Sancti Patricii ibidem, et locum præfatum in quo ecclesiæ præfatæ sitæ sunt." The truth of either, or perhaps of both, these accounts might be allowed; but neither of them is sufficient to account for the constant conjunction of Sodor and Man, in charters, registers, and histories. If Sodor was a small town or island belonging to Man, it cannot be conceived why it is always mentioned before it, or rather why it should be mentioned at all in speaking of a bishop's diocese. To speak of the bishopric of Sodor and Man in this case, would be as improper as it would be to call the bishopric of Durham the bishopric of Holy Island and Durham, or the bishopric of Darlington and Durham; the former being a small island, and the latter a town belonging to the county and diocese of Durham. Neither of these accounts, therefore, gives a satisfactory explanation of the original conjunction of Sodor and Man.

The island of Iona was the place where the bishop of the Isles resided, the cathedral church of which, it is said, was dedicated to our Saviour, in Greek *Soter*, hence *Sotorenses*, which might be corrupted into *Sodorenses*, a name frequently given by Danish writers to the western isles of Scotland. That we may be the more disposed to accede to this Grecian etymology, the advocates for this opinion tell us, that the name *Icolumkill*, which is often applied to this island, is also of Greek extraction, being derived from *columba*, "a pigeon," a meaning that exactly corresponds to the Celtic word *colum*, and the Hebrew word *iona*. We must confess, however, that we have very little faith in the conjectures of etymologists, and think, that upon no occasion they alone can establish any fact, though, when concurring with facts, they certainly tend to confirm and explain them. It is only from historical facts that we can know to what the name of Sodor was applied.

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[1] Plato, Apol. Socr. 31. a. Op. i. 72.

[2] Ibid. Πολλοῦ δεῶ ἐγὼ ὑπὲρ εμαυτοῦ ἀπολογεῖσθαι, ὥς τις ἂν οἴοιτο, ἀλλ᾽ ὑπὲρ ὑμῶν, μὴ ἐξαμάρτητε περὶ τὴν τοῦ θεοῦ δόσιν ὑμῖν, ἐμοῦ καταψηφισάμενοι. P. 71.

[3] Alcib. ii. p. 150, d. Πότε οὖν παρέσται ὁ χρόνος οὗτος, ὦ Σωκράτες; καὶ τίς ὁ παιδεύσων; ἥδιστα γὰρ ἂν μοι δοκῶ ἰδεῖν τόυτον τὸν ἄνθρωπον τίς ἐστιν· Σ. Οὗτος ἐστιν ᾧ μελει περὶ σοῦ, κ.τ.λ. Op. v. p. 160.

It appears from the history of the Orkneys compiled by an old Islandic writer, translated and enlarged by Torfæus, that the Æbudæ, or Western isles of Scotland, were divided into two clusters, Nordureys and Sudereys. The Nordureys, which were separated from the Sudereys by the point of Ardnamurchan, a promontory in Argyleshire, consisted of Muck, Egg, Rum, Canna, Skye, Rasay, Barra, South Uist, North Uist, Benbecula, and Lewis, including Harris, with a great number of small isles. The Sudereys were, Man, Arran, Bute, Cumra, Avon, Gid, Isla, Colonsay, Jura, Scarba, Mull, Iona, Tiree, Coll, Ulva, and other small islands. All these, when joined together, and subject to the same prince, made up the kingdom of Man and the Isles. In the Norwegian language, *Suder* and *Norder* signify southern and northern, and *ey* or *ay* an island. When the Hebrides were under one monarch, the seat of empire was fixed in the Sudereys, and the Nordureys were governed by deputies: hence the former are much oftener mentioned in history than the latter; hence, too, the Sudereys often comprehend the Nordureys, as in our days Scotland is sometimes comprehended under England. Sudereys, or Suder, when Anglicised, became Sodor; and all the Western isles of Scotland being included in one diocese under the Norwegian princes, the bishop appointed to superintend them was called the bishop of Man and the Isles, or the bishop of Sodor and Man. Since Man was conquered by Edward III. it has been separated from the other isles, and its bishops have exercised no jurisdiction over them. Should it now be asked, why then is the bishop of Man still called the bishop of Sodor and Man? we reply, that we have been able to discover no reason; but suppose the appellation to be continued in the same way, as the title king of France was retained by the kings of Great Britain, for several centuries after the English were entirely expelled from France.

SOEST, a city of Prussian Westphalia, in the government of Minden, the capital of a circle of the same name, which extends over 240 square miles, and has a population of 33,400 persons. It is situated on the Tosterbache, and is surrounded with old and lofty walls. In 1834 it had 1200 houses in narrow and crooked streets, and 7854 inhabitants, chiefly occupied in manufactures of various kinds. Lat. 51. 34. 5. Long. 8. 0. 1. E.

SOFALA, or SEPHALA, a kingdom of Africa, lying on the east coast near Zanguebar. The name Sofala denotes, in the Hebrew and Arabic languages, *low country*. It has been celebrated by the Arabian geographers for its golden treasures, but it is from the interior that this precious metal is brought. The soil is fertile, and the climate tolerable. Numberless reefs and banks of sand render the approach dangerous. Long. 35. 40. E. Lat. 20. 20. S.

SOFFITA, or SOFFIT, in *Architecture*, any timber ceiling formed of cross beams of flying cornices, the square compartments or pannels of which are enriched with sculpture, painting, or gilding; such are those in the palaces of Italy, and in the apartments of Luxembourg at Paris.

SOFFITA, or *Soffit*, is also used for the underside or face of an architrave; and more particularly for that of the corona or larmier, which the ancients called *lacunar*, the French *plafond*, and we usually the *drip*. It is enriched with compartments of roses; and in the Doric order has eighteen drops, disposed in three ranks, six in each, placed to the right of the guttæ, at the bottom of the triglyphs.

SOFIA, a city of Turkey in Europe, the ancient Sardica. It is situated in Romelia, and is the capital of a province of its own name. It is on an extensive plain, between the two rivers Iscar and Rissava. It is surrounded with walls flanked by towers, and defended by a citadel. It is the seat of a Greek and of a Catholic bishop; has twenty-three mosques, several Greek, Catholic, and Armenian churches, some Jewish synagogues, 8000 houses, with about 48,000 inhabitants. It is one of the most flourishing cities of the empire, depending chiefly on its manufactures. They consist of silk, woollen and linen goods, and various smaller articles. The general appearance of the town is somewhat imposing; but many of the houses are of wood, and look meanly, as there are few glass windows, and generally iron grating in their stead. Sofia was built by the emperor Justinian out of the ruins of the ancient Sardica, and fell under the power of the Turks in 1382.

SOHAGEPOOR, a town and small district of Hindustan, in the province of Gundwana. The province is situated between the 23° and 24° of N. lat. It is a barren, mountainous, and unproductive country, possessed by various savage chiefs. The town is situated eighty miles S. by E. from Rewah. Long. 81. 45. E. Lat. 23. 29. N.

SOHAM, a town of the hundred of Staplac, in the county of Cambridge, seventy-one miles from London. It is usually called Monks-Soham, to distinguish it from some villages of the same name near it, and from having been formerly the seat of a large Benedictine monastery. It has a charity school and a market on Saturday. The inhabitants were, in 1801, 2004; in 1811, 2386; in 1821, 2856; and in 1831, 3667.

SOHAUL, a town of Hindustan, province of Allahabad, thirty-five miles S.E. from Callinger. Long. 80. 52. E. Lat. 24. 40. N.

SOHNPOOR, a town of the province of Gundwana, in Hindustan, possessed by independent chiefs, situated on the Mahanuddy river, 127 miles S.E. from Ruttunpoor. Long. 83. 45. E. Lat. 20. 47. N.

SOIGNES, a city of the Netherlands, in the province of Hennegan, and arrondisement of Mons. It stands on the river Senne, which rises at the distance of about six miles. The population amounts to 4800 persons, who are chiefly employed in obtaining stone from some valuable quarries. Lat. 50. 32. Long. 3 59. E.

SOIL, the mould covering the surface of the earth, in which vegetables grow. It serves as a support for vegetables, and as a reservoir for receiving and communicating nourishment. See AGRICULTURE.

SOISSONS, an arrondisement of the department of the Aisne in France, which extends over 456 square miles, and is divided into six cantons and 167 communes, containing 68,761 inhabitants. The capital, a city of the same name, is situated in a fine valley on the river Aisne. It has a cathedral with two towers, only one of which has been completed. The town, in 1836, contained 8124 inhabitants, employed chiefly in making linens and leather, and in spinning cotton by machinery.

SOKOR ZOK, a town of Armenia, situated about midway between Bellis and Diarbekir, and governed by a powerful prince, who rules over many different tribes of Kurds and Turcomans. Population, 6000.

SOLANDER'S ISLAND, in the South Pacific, near the south coast of New Zealand, discovered by Captain Cook in 1770. It is of a craggy surface, of great height. Long. 192. 49. W. Lat. 46. 31. S.

SOLDER, SODDER, or *Soder*, a metallic or mineral composition used in soldering or joining together other metals. Solders are made of gold, silver, copper, tin, bismuth, and lead. In the composition there must commonly be some of the metal that is to be soldered mixed with some higher and finer metals. Goldsmiths usually make four kinds of solder, viz. solder of eight, where to seven parts of silver there is one of brass or copper; solder of six, where only a sixth part is copper; solder of four, and solder of three. It is the mixture of copper in the solder that makes raised plate come always cheaper than flat.

SOLDIER, a military man enlisted to serve a prince or state in consideration of a certain daily pay. See ARMY.

SOLDIN, a town of the government of Frankfurt on the Oder in Prussia. It is the capital of a circle of the same name, which extends over 404 square miles, and contains 26,600 inhabitants. The town, which is near the Soldin lake, is surrounded with walls, and contains 434 houses, with 2860 inhabitants.

SOLECISM in *Grammar*, a false manner of speaking, contrary to the rules of grammar, either in respect of declension, conjugation, or syntax. The word is Greek, σολοικισμὸς, derived from the *Soli*, a people of Attica, who being transplanted to Cilicia, lost the purity of their ancient tongue, and became ridiculous to the Athenians for the improprieties into which they fell.

SOLEURE. See SOLOTHURN.

SOLFA, (*Ital.*) a musical exercise for the voice when learning to sing, in which the syllables *do, re, mi, fa, sol, la, si,* are applied to their respective notes in the exercise.

SOLFAING, (Fr. *Solfier*, Ital. *Solfeggiare,*) means the performance of such an exercise; and also the singing of a piece of music at sight with these syllables. On this subject consult the large work on singing, published for the use of the French Conservatory of Music.

SOLFATARA, a lake in the Campagna of Rome, near to Tivoli. It is of small extent, but is remarkable for containing several floating islets formed of matted sedge and herbage, with a soil of dust and sand blown from the adjacent country, and cemented by the bitumen and sulphur with which the water of the lake is impregnated. Some of these islands are more than forty feet long, and will bear five or six persons, who, by means of a pole, may move to different parts of the lake. From this lake there issues a whitish stream, emitting a sulphureous vapour, until it reaches the small river Teverone, which discharges itself into the Tiber. The water of that rivulet is of a petrifying quality, which increases in strength the farther it flows from the lake. Fish are only to be found in the Teverone before it receives this impure stream.

SOLFATERRA, a mountain of Italy in the kingdom of Naples and Terra di Lavorro. This mountain appears evidently to have been a volcano in ancient times; and the soil is yet so hot, that the workmen employed there in making alum need nothing else besides the heat of the ground for evaporating their liquids.

SOLICITOR, a person employed to take care of and manage suits depending in the courts of law or equity. There is also a great officer of the law, next to the attorney-general, who is styled the king or queen's solicitor-general; who holds his office by patent during the sovereign's pleasure, assists the attorney in managing the law business of the crown, and has fees for pleading, besides other fees arising by patents, &c. He attends on the privy-council; and the attorney-general and he were anciently reckoned among the officers of the Exchequer. They have their audience, and come within the bar in all the courts.

SOLID, in *Philosophy*, a body whose parts are so firmly connected together, as not easily to give way or slip from each other; in which sense *solid* stands opposed to *fluid*. Geometricians define a solid to be the third species of magnitude, or that which has three dimensions, viz. length, breadth, and thickness or depth. Solids are commonly divided into regular and irregular. The regular solids are those terminated by regular and equal planes, and are only five in number, viz. the tetrahedron, which consists of four equal triangles; the cube or hexahedron, of six equal squares; the octahedron, of eight equal triangles; the dodecahedron, of twelve; and the icosahedron, of twenty equal triangles. The irregular solids are almost infinite, comprehending all such as do not come under the definition of regular solids; as the sphere, cylinder, cone, parallelogram, prism, parallelopiped, &c.

SOLIDITY, that property of matter, or body, by which it excludes all other bodies from the place which itself possesses; and as it would be absurd to suppose that two bodies could possess one and the same place at the same time, it follows, that the softest bodies are equally solid with the hardest.

Among geometricians, the solidity of a body denotes the quantity or space contained in it, and is called also its solid content. The solidity of a cube, prism, cylinder, or parallelopiped is had by multiplying its basis into its height. The solidity of a pyramid or cone is had by multiplying either the whole base into a third part of the height, or the whole height into a third part of the base.

SOLILOQUY, a reasoning or discourse which a man holds with himself; or, more properly, according to one account, it is a discourse by way of answer to a question which a man proposes to himself.

SOLIMAN II. emperor of the Turks, surnamed the *Magnificent*, was the only son of Selim I., whom he succeeded in 1520. He was educated in a manner very different from the Ottoman princes in general; for he was instructed in the maxims of politics and the secrets of government. He began his reign by restoring those persons their possessions whom his father had unjustly plundered. He re-established the authority of the tribunals, which was almost annihilated, and bestowed the government of provinces upon none but persons of wealth and probity. "I would have my viceroys," he used to say, "resemble those rivers that fertilize the field through which they pass, not those torrents which sweep every thing before them." After concluding a truce with Ishmael Sophy of Persia, and subduing Gozeli Bey, who had raised a rebellion in Syria, he turned his arms against Europe. Belgrade was taken in 1522, and Rhodes fell into his hands the year following, after an obstinate and enthusiastic defence. In 1526 he defeated and slew the king of Hungary in the famous battle of Mohatz. Three years afterwards he conquered Buda, and immediately laid siege to Vienna; but after continuing twenty days before that city, and assaulting it twenty times, he was obliged to retreat with the loss of 80,000 men. Some time after he was defeated by the Persians, and disappointed in his hopes of taking Malta. He succeeded, however, in dispossessing the Genoese of Chio, an island which had belonged to that republic for more than two hundred years. He died at the age of seventy-six, while he was besieging Sigeth, a town in Hungary, on the 30th August 1566.

SOLINGEN, a town of the Prussian government of Cleves, the capital of a circle of the same name. It has been long celebrated for the excellent temper of the sword blades and other cutting instruments fabricated in the town and district. The circle is small, including only forty-two square miles, but it contains 28,500 inhabitants, of whom about four thousand reside within the town. Lat. 51. 12. 31. Long. 7. 2. 20. E.

SOLIS, ANTONIO DE, a Spanish writer, of an ancient and illustrious family, was born at Placentia, in Old Castile, on the 18th of July 1610. He was intended for the law; but his inclination toward poetry prevailed, and he cultivated it with great success. Philip IV. of Spain made him one of his secretaries; and after the king's death, the queen-regent appointed him historiographer of the Indies, a place of great profit and honour. His history of the conquest of Mexico, shows that she could not have named a fitter person. "Historia de la Conquista de Mexico." Madrid, 1684, fol. He is better known by this history, than by his poetry and dramatic writings, though in these he was also distinguished. At the age of fifty-six he took orders. He died at Madrid on the 19th of April 1686.

SOLITARIES, a denomination of nuns of St. Peter of Alcantara, instituted in 1676. The design of the institution was to imitate the severe penitent life of that saint. Thus they were to keep a continual silence; never to open their mouths to a stranger; to employ their time wholly in spiritual exercises, and leave their temporal concerns to a number of maids, who had a particular superior in a separate part of the monastery. They were always to go barefooted, without sandals; gird themselves with a thick cord, and wear no linen.

SOLITARY Island, in the South Pacific ocean, discovered by Mendana in 1595. It is low, and surrounded with rocks. Long. 178. 20. W. Lat. 10. 4. S.

SOLITARY *Islands*, a cluster of small islands near the east coast of New Holland. Lat. 30. 8. S.

SOLO, or SAURA-CORTA, an inland town of Java, the capital of a district, and the residence of an emperor. It is large and populous, intersected with broad and shaded avenues or streets, running at right angles. The emperor's palace is very spacious, and comprises several palaces in its area. The European town and port are very neat. The resident's house is also a large and handsome building. A fine river, which flows near the town, and falls into the harbour of Grepie, affords in the rainy season a ready conveyance for the various productions of a large tract of country, in exchange for commodities which are sent up in boats from the coast.

SOLO, *(Ital.)* a term used in musical compositions of several parts, to mark those voices or instruments that are to perform alone or in a more prominent manner; as, *sofrano solo, violino solo*, &c. The plural is used when two or more voices or instruments of the same name are to perform alone. *Solo* is also a name given to a composition written for a single instrument, such as a violin, an oboe, a flute, &c., which is accompanied by a bass for the violoncello, or a thorough-bass for the pianoforte.

SOLOFRA, a city of Italy, in the Neapolitan province Ulteriore. It contains three churches and 6050 inhabitants, who are manufacturers of gold and silver articles, of leather and parchment, and are celebrated for their salted hams and bacon.

SOLLER, a town in Majorca, one of the Balearic islands in the Mediterranean, belonging to Spain. The valley in which it stands is productive of olives and oranges. It is situated in Lat. 39. 61., and contains 5614 inhabitants.

SOLOMBO, GREAT, a small island in the Eastern seas, of a moderate height. Long. 114. 45. E. Lat. 5. 36. S. Little Solombo is near the north-east coast of Great Solombo.

SOLOMON, the son of David king of Israel, renowned in Scripture for his wisdom, riches, and magnificent temple and other buildings. Towards the end of his life he sullied his former glory by his apostacy from God; from which cause vengeance was denounced against his house and nation. He died about 977 B.C.

SOLOMON'S *Islands*. This group is in the South Pacific ocean, situated chiefly between long. 155° and 160° E. lat. 5° and 12° S. Little is known of the precise situation or number of these islands. The longest are Ysabel, Guadalcanar, San Cristoval, and an island called New Georgia. The first two are affirmed by the Spaniards to be very large islands; the latter nearly seventy miles in extent. Georgia is still larger, and San Cristoval is not less than sixty. These islands were discovered in 1567.

Solon.

SOLON, one of the seven wise men of Greece, was born at Salamis, of Athenian parents, who were descended from Codrus. His father leaving little patrimony, he had recourse to merchandise for his subsistence. He had, however, a greater thirst after knowledge and fame than after riches, and made his mercantile voyages subservient to the increase of his intellectual treasures. He very early cultivated the art of poetry, and applied himself to the study of moral and civil wisdom. When the Athenians, tired out with a long and troublesome war with the Megarensians, for the recovery of the isle of Salamis, prohibited any one, under pain of death, to propose the renewal of their claim to that island, Solon thinking the prohibition dishonourable to the state, and finding many of the younger citizens desirous to revive the war, feigned himself mad, and took care to have the report of his insanity spread through the city. In the mean time he composed an elegy adapted to the state of public affairs, and committed it to memory. Every thing being thus prepared, he sallied forth into the market-place with the kind of cap on his head which was commonly worn by sick persons, and ascending the herald's stand, he delivered, to a numerous crowd, his lamentation for the desertion of Salamis. The verses were heard with general applause; Pisistratus seconded his advice, and urged the people to renew the war. The decree was immediately repealed; the claim to Salamis was resumed; and the conduct of the war was committed to Solon and Pisistratus, who by means of a stratagem defeated the Megarensians and recovered the island.

His popularity was extended through Greece in consequence of a successful alliance which he formed among the states in defence of the temple at Delphi against the Cirrhæans. When dissensions had arisen at Athens between the rich creditors and their poor debtors, Solon was created archon, with the united power of supreme legislator and magistrate. He soon restored harmony between the rich and poor. He cancelled the debts which had proved the occasion of so much oppression; and ordained that in future no creditor should be allowed to seize the body of the debtor for his security. He made a new distribution of the people, instituted new courts of judicature, and framed a judicious code of laws, which afterwards became the basis of the laws of the twelve Tables in Rome. Among his criminal laws are many wise and excellent regulations; but the code is necessarily defective with respect to those principles which must be derived from the knowledge of the true God, and of pure morality, as the certain foundations of national happiness. Two of them in particular were very exceptionable; the permission of a voluntary exile to persons that had been guilty of premeditated murder, and the appointment of a less severe punishment for a rape than for seduction. Those who wish to see accurately stated the comparative excellence of the laws of Moses, of Lycurgus, and Solon, may consult the prize Dissertations relative to natural and revealed religion, published by the Teylerian Society of Haarlem, vol. ix.

The interview which Solon is said to have had with Crœsus king of Lydia; the solid remarks of the sage after surveying the monarch's wealth; the recollection of those remarks by Crœsus when doomed to die, and the noble conduct of Cyrus on that occasion, are known to every schoolboy. Solon died in the island of Cyprus at a very advanced age. Statues were erected to his memory both at Athens and in Salamis. His thirst after knowledge continued to the last: "I grow old," said he, "learning many things." Among the apophthegms and precepts which have been ascribed to Solon, are the following: Laws are like cobwebs, that entangle the weak, but are broken by the strong. He who has learned to obey, will know how to command. In all things let reason be your guide. Diligently contemplate excellent things. In every thing that you do, consider the end.

The chronology of his life is involved in no small obscurity. His legislation may, with some degree of confidence, be referred to the year 594 before Christ; but, as a very learned and able chronologer has remarked, since both his age and the time of his death are doubtful, nothing can be with certainty affirmed of the year of his birth.[1] According to Laertius, he died at the age of eighty; but Lucian extends his life to one hundred years. Of the poems of Solon, an elaborate edition has recently been published by Bach, under the title of "Solonis Atheniensis Carminum quæ supersunt." Bonnæ, 1825, 8vo.

SOLOON, a small island in the Eastern seas, twenty-five miles from the island of Samar. Long. 125. 42. E. Lat. 10. 55. N.

SOLOR Isle, an island in the Eastern seas, separated from the island of Floris by the straits of Floris. It is about thirty miles in length, by fifteen in average breadth.

SOLOTHURN, a canton of Switzerland. It is bounded on the north by France and by Basel, on the east by Basel and Zurich, and on the south and west by Berne. It extends over two hundred and fifty-eight square miles, comprising two cities, one market-town, and one hundred and thirty-seven villages, with 59,122 inhabitants, of whom 54,000 are catholics, and the remainder protestants. The revenues amount to 180,000 francs, and the yearly expenditure to 164,000. It is bound to contribute 904 men, and 1365 francs to the general confederation. The mountains are a continuation of the Jura range, and none of them exceeds 3900 feet in height. The river Aar receives the smaller streams. There are no extensive lakes. The climate is temperate, and the soil produces good corn, hemp, flax, fruit, and wine. The chief employment is agriculture and cutting the extensive woods, which supply some fuel and building timber for exportation.

Solothurn, a city of Switzerland, the capital of the canton of that name. It stands at the foot of the Jura mountains, on both sides of the river Aar. It is surrounded with walls and defended by bastions, is well, but irregularly built, and contains 560 houses, with 4470 inhabitants. It has a college with five professors and a good public library. Solothurn contains several manufactories for making and printing cotton, and some other goods. Lat. 47. 12. Long. 7. 26. E.

SOLOTONOSCHA, a town of Russia, the capital of a circle of the same name, in the province of Pultowa, 947 miles from Petersburg. It stands at the point where the Solontschia falls into the Dneiper. It contains three churches, two monasteries, eight hundred houses, and 5650 inhabitants, chiefly employed in agriculture. Lat. 49. 58. Long. 31. 58. E.

SOLSTICE, in *Astronomy*, the time when the sun is in one of the solstitial points; that is, when he is at his greatest distance from the equator; thus called because he then appears to stand still, and not to change his distance from the equator for some time; an appearance owing to the obliquity of our sphere, and to which those living under the equator are strangers.

The solstices are two in each year; the æstival or summer solstice, and the hyemal or winter solstice. The summer solstice is when the sun seems to describe the tropic of cancer, which is on June 22, when he makes the longest day: the winter solstice is when the sun enters the first degree, or seems to describe the tropic of capricorn, which is on December 22, when he makes the shortest day. This is to be understood as in our northern hemisphere; for in the southern, the sun's entrance into capricorn makes the summer solstice, and that into cancer the winter solstice. The two points of the ecliptic, at which the sun's greatest ascent above the equator, and his descent below it, are terminated, are called the *solstitial points;* and a circle, supposed to pass through the poles of the world and these points, is called the *solstitial colure.* The summer solstitial point is in the beginning of the first degree of cancer, and is called the *æstival* or *summer point;* and the winter solstitial point is in the beginning of the first degree of capricorn, and is called the *winter point.* These two points are diametrically opposite to each other.

SOLYMANIA, called also Shehr Zaur, a town of Kurdistan, the residence of the Pacha. The town had fallen into decay, but was rebuilt by Solyman the Pacha, who, in 1810, having taken up arms against the Pacha of Bagdad, defeated him and put him to death. Population, 6000; fifty-four miles east of Kerkook.

SOMALPET, a town of Hindustan in the Nizam's province of Nandere, fifty-two miles N.N.E. from the town of Nandere.

SOMBOR, or Zombor, a city of the kingdom of Hungary, in the province of the hither Danube, in the circle of Kozep Jaras. It contains 2980 houses, with 14,860 inhabitants, whose chief trade is in corn and cattle. Lat. 48. 8. 32. Long. 21. 10. 33. E.

SOMERS, John Lord, high chancellor of England, was born at Worcester in 1652. He was educated at Oxford, and afterwards entered himself at the Middle-Temple, where he studied the law with great vigour. In 1688 he was one of the counsel for the seven bishops at their trial, and argued with great learning and eloquence against the dispensing power. In the convention which met by the prince of Orange's summons, January 22, 1689, he represented Worcester; and was one of the managers for the House of Commons, at a conference with the House of Lords upon the word *abdicated.* Soon after the accession of William and Mary to the throne, he was appointed solicitor-general, and received the honour of knighthood. In 1692 he was made attorney-general, and in 1693 advanced to the post of lord-keeper of the great seal of England. In 1695 he proposed an expedient to prevent the practice of clipping the coin. In 1697 he was created Lord Somers, baron of Evesham, and made lord high chancellor of England. In the beginning of 1700 he was removed from his post of lord chancellor, and the year after was impeached of high crimes and misdemeanours by the House of Commons, of which he was acquitted upon trial by the House of Lords. He then retired to a studious course of life, and was chosen president of the Royal Society. In 1706 he proposed a bill for the regulation of the law; and the same year was one of the principal managers for the union between England and Scotland. In 1708 he was made lord president of the council; from which post he was removed in 1710, upon the change of the ministry. In the latter end of Queen Anne's reign his lordship grew very infirm in his health; which is supposed to be the reason that he held no other post than a seat at the council-table, after the accession of King George I. He died of an apoplectic fit in 1716. Mr. Addison has drawn his character very beautifully in the Freeholder.

SOMERSETSHIRE, a maritime county of England, lying in a crescent-like form on the Bristol Channel, to which its north-western side is turned. It is bounded to the north-east by Gloucestershire, on the east by Wiltshire, on the south by Dorsetshire and part of Devonshire, and on the west by the latter county. Its greatest length, from east to west, is sixty-five miles, and its greatest breadth, from north to south, forty-five miles. Its boundary line has several considerable indentations. The whole area comprehends 1642 square statute miles, or 1,050,880 English acres; being in extent the seventh in the list of the English counties. The acreable value of the land, according to the late returns under the property-tax, exceeded that of any other county except Leicestershire, being, including the tithes, L.876 per square mile, or about 27s. per acre.

The civil divisions of this county are denominated the eastern and the western. The eastern division contains twenty hundreds and seven liberties, and the western twenty-two hundreds; but these divisions have become of less importance, since other divisions have been politically framed by the Reform act, as will be hereafter noticed. The whole county is in the diocese of Bath and Wells; and is ecclesiastically divided into three archdeaconries, under which are thirteen deans, who superintend 482 parishes. There are within the county two cities (besides a part of Bristol), seven boroughs sending members to Parliament, and twenty-nine market towns.

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[1] Clinton's Fasti Hellenici, vol. ii. p. 301.

The population of this county at the four decennial periods of enumeration, has been found to be as follows: In 1801, 273,750; in 1811, 303,180; in 1821, 355,314; and in 1831, 402,500.

In 1831, the occupiers of land employing labourers were	6,032
The occupiers of land not employing labourers	3,731
Labourers employed in agriculture	28,107
Labourers in manufactures	4,350
Labourers employed in retail trade or handicraft,	26,672
Capitalists, bankers, &c	4,676
Labourers not agricultural	12,183
Other labourers under twenty years of age	7,074
Males at and above twenty years of age	95,556
Male servants	2,801
Female servants	18,333

In the same year the number of families chiefly employed in agriculture was found to be 30,452; of those chiefly employed in trade, manufactures, and handicraft, 20,230, and of those not comprised in either of the preceding classes, 25,889. The number of inhabited houses was 71,325, occupied by 84,571 families; the uninhabited houses, 3,632, and those building, 939. The annual value of the real property of the county, as assessed in 1813, was L.1,900,651.

The towns whose population in 1831 exceeded 2000, were as follows:

Bath	38,063	North Petherton	3,566
Bedminster, a suburb of Bristol	13,130	Wedmore	3,557
Frome Selwood	12,240	Wivelscombe	3,047
Taunton	11,139	Ilminster	2,957
Bridgewater	7,807	Martoch	2,841
Wells	6,649	Glastonbury	2,500
Yeovil	5,921	Twerton, sub. of Bath	2,478
Shepton-Mallet	5,330	South Petherton	2,294
Chard	5,141	Milverton	2,233
Wellington	4,762	Keynsham	2,142
Bathwick, a suburb of Bath	4,033	Wincanton	2,123
Crewkerne	3,789	Nailsea	2,114
		Milborn Port	2,072
		Bruton	2,031

Few districts contain a greater variety of soil and situation than the county of Somerset. In the north-east corner, the range of the Mendip hills presents a lofty tract of country, of late improved on the surface, but chiefly valuable for the coal and other mines beneath it. On the western side are the Quantock hills, an extensive and sterile range, and beyond them the elevated bleak plain called the forest of Exmoor, the highest district in the western counties. One spot in this forest, called Dunkeny, is 1668 feet above the level of the sea; and from it a prospect over an extended and diversified country is displayed, terminating on one side in the Bristol, and on the other in the English Channel. These hilly, and somewhat barren portions of the county, however, bear but a small proportion to the whole; and between them are to be seen the richest meadows and arable lands, the value of which more than counterbalances the sterility of the hills. In the better parts of the county, it may rather be described as rich than beautiful. There is a deficiency of woods; the streams that run in the valleys are sluggish, and in summer nearly stagnant; but the extent of orchards, especially when in full bloom, produces a pleasing effect, and in some measure compensates for the want of woods.

The rivers of the county are the Avon, which enters it from Wiltshire, and becomes navigable at Bath, which city it nearly surrounds. It then passes, with many curvatures, to Bristol, and soon after is lost in the Severn. The Axe rises in the Mendip hills in two branches, one of which issues from a natural excavation, called Wookey Hole, resembling some of the Derbyshire caverns. Its course is short, and it empties itself through some marshes, below Axbridge, into the Bristol Channel. The Brue rises in Wiltshire, and also enters the Bristol Channel, being navigable not more than two miles from its mouth. The Parret rises at a village of the same name in Dorsetshire, becomes navigable at Langport, and in rainy seasons a few miles above that town. It is joined, at Boroughbridge, by the Thone or Tone, which proceeds from Taunton, and passing by Bridgewater, empties itself into the sea. The only navigable canal that has been completed is the Kennet and Avon, which unites together the two great rivers Thames and Severn. It commences near Bath, and soon enters Wiltshire. Other canals have been projected in different directions, but none of them has been prosecuted to completion; though on several of them large sums have been expended.

As Somersetshire contains, on the banks of its rivers, large tracts of the richest meadow lands, the most valuable branch of its rural economy is the fattening of cattle and the management of the numerous dairies. The oxen, bred chiefly in the less fertile pastures of Devonshire, when grazed in this county, afford the best beef, and furnish, in great numbers, the markets of the metropolis, as well as those of Bristol and Bath, in their immediate vicinity. The produce of the dairy is of the best kind. The cheese of Cheddar has obtained great celebrity, but that made in many other parts, and frequently sold as Gloucester, is equal to any in the world. The butter in the southern division of the county is excellent, and much of it, collected in the vicinity of Crewkerne, is sent to the London cheesemongers, who supply it to their customers under the denomination of Dorsetshire butter.

The next agricultural product is cider, which forms almost the universal beverage of the working classes. It is a more pure and yet a stronger liquor than the cider either of Herefordshire or Devonshire. The consumption of it within the county is very large, and some is sent to distant parts. Nature has been so bountiful in furnishing spontaneous productions, that to those agricultural pursuits which depend on skill and industry less attention is paid in this than in many other districts. Such is the abundance of natural grass, that the farmers do not find it necessary to grow a crop of clover, or other artificial grass, so uniformly between two corn crops as is necessary in other counties; nor is the practice of fallowing, or of introducing a rotation by commencing with turnips, much resorted to. Notwithstanding this, they grow good crops of corn, and in the hundred of Taunton Dean the wheat is of the very best quality. Barley is not very extensively cultivated, as the general use of cider causes but little consumption of malt. The barley crops are in general very good. Oats are extensively cultivated, but scarcely equal the demands of the county, and the easy intercourse with Ireland readily supplies any deficiency when it occurs. The soil is well calculated for the growth of flax, and it furnishes a large proportion of that used in the manufactures of the county. It is not unusual to rent land for half a year while a crop of flax is raised; after which it is taken again by the regular occupant, who finds the flax to be an excellent preparative for wheat, from the careful weeding necessary to its growth.

The rich loamy soil brings to maturity the best elm timber. Goose feathers were formerly produced in great abundance; but the draining and inclosing many of the richest marshy plains has rendered these capable of yielding more profit by other productions, and of late years the quantity of feathers is much diminished. The landed property of the county is much divided, no one proprietor or great family having such extensive possessions as to give a preponderant political influence. There is a great number of yeomen who share the lands, and many of them maintain the homely independence of the past generations.

The mineral products of this county are valuable. The hills of Mendip supply with coals their vicinity, the cities of Bath and Wells, and the towns of Frome and Shepton-Mallet. The other parts of the county use the coals of Newport, which are brought by sea to Bridgewater. Lead, of a quality superior to that of Derbyshire, is found in Mendip and on the Cheddar hills. Calamine is extensively produced, and supplies the brass manufacturers of Bristol. Copper is found near Stowey. Manganese, bole, and red ochre, are among the other products of Mendip.

This is a manufacturing district for various productions. The manufacture of fine woollen cloth is extensive, chiefly at Frome, where it employs 730 males upwards of twenty years of age; and at Road are employed 59, at Beckington 32, Charter Henton, 24, Twerton, near Bath, 284, Lyncombe and Wedcombe, 565, and at Freshford, 32 makers of fine cloths. In another part of the county, at Wellington and Milverton, are nearly 300 makers of cloth of an inferior description. About 300 men are employed in making sail-cloth, sacking, and girth-web, at Crewkerne and the parishes of East Coker, Merriot, West Hatch, and North Perrot. At Chard 478 men, and at Ilminston 21, are occupied in making silk and lace, or the machinery for those fabrics; and the same trades afford considerable occupation at Bruton and Taunton. At Yeovil, and some of the towns and villages near it, the chief trade is glove-making, which gives employment to more than 600 men, and a great number of females. Edge tools are made at Wells, employing 60 men, and also at Whately, Emborrow, and some other places. At Nailsea, 100 men are employed in the manufacture of glass; paper-making and tanning occupy 59 men at Cheddar; and at various places in the county are noticed manufactures of iron, calamine, copper, brass, paper, and snuff; and a variety of small articles is made at Bath.

The foreign commerce of Somersetshire passes chiefly through Bristol, which is the mart for such goods as are required in distant countries. Some of the woollen goods which are manufactured at Taunton and Wellington are shipped from Exeter. The far greater portion of the productions of the county are, however, destined to supply the demand for internal consumption. The cattle, butter, and cheese, are chiefly sent to London, and in time of war, to Portsmouth and Plymouth. The linen and woollen goods are distributed through the western and Welsh counties, and, in general, are destined more for the home than for foreign markets.

The titles derived from this county are those of the dukes of Somerset and Wellington; the marquises of Lansdowne, Bath, and Bristol; the earls of Bridgewater, Poulet, and Ilchester; and the barons Mendip and Glastonbury. By the reform bill the county has been politically formed into two divisions, the eastern and the western, and each division elects two members to the house of commons. The election for the first is held at Wells; and the other polling places are Bath, Shepton-Mallet, Bedminster, Axbridge, and Wincanton. The election for the second is held at Taunton; and the other polling places are Bridgewater, Ilchester, Williton, and Langport.

The seats of the nobility and gentry, especially of the latter, near Bath and Bristol, are numerous; and our limits allow only of noticing the most distinguished of them, viz. Longleet, the seat of the Marquis of Bath; Hinton, the seat of Earl Poulet; and the houses of the Earl of Carnarvon, Lord Hood, Mr. Miles, and Colonel Gore Langton.

Two members are chosen for each of the cities of Bath and Wells, and two for each of the boroughs, Taunton and Bridgewater. The boroughs of Minehead, Ilchester, and Milburn-Port, which chose two members each, have been disfranchised, and the town of Frome has been made a parliamentary borough, returning one member. Ilchester, from the elections being held there, and from its containing the gaol and county court, is usually considered the county town, although the assizes in the spring are held at Taunton, and in the summer at Wells and Bridgewater alternately.

SOMERTON, a town in the hundred of that name in the county of Somerset, 125 miles from London. It is pleasantly situated in a fertile country. The inhabitants were in 1801, 1145; in 1811, 1478; in 1821, 1643; and in 1831, 1786.

SOMMEANY, a town of Persia, in the province of Mekram, and the principal sea-port of Lus. It is situated on an elevated bank, at the mouth of the river Pooralee, which forms a bar about a mile from the town, with three fathoms depth at low water, and boats can anchor close to the shore. It is an inconsiderable place, and the inhabitants, with the exception of a few Hindu merchants, subsist by fishing.

SOMMEE, a town of Hindustan, in the province of Gujrat. It is a large place, but has a wretched appearance, and the wall by which it is surrounded is in many parts falling to pieces. It stands in a swamp, and is surrounded by numerous puddles, and in the rainy season is almost under water. It is situated to the south-east of Rahdunpoor.

SOMME, a department of the north of France. It has been formed out of those parts of the ancient Picardy known as Amienois, Ponthieu, Vimieux, and Santerre, and extends over 1,460,932 acres, or 2284 square miles. It is bounded on the north by the Pas de Calais; on the east by the departments of the North and of the Aisne; on the south by the Oise and the Lower Seine; and on the west by the British channel. It contains five arrondisements, with forty-one cantons, and 835 communes, and its population in 1836 amounted to 552,706. The surface is flat and level, but gradually slopes towards the sea on the western side. There are no mountains, but some hills of inconsiderable height rise on the eastern frontier. The Somme, which has its source in the department of the Aisne, is the chief river. The others are the Avre, the Noye, the Celle, and the Brisle. The soil is chalky, and naturally fruitful. The inhabitants cultivate to a great extent corn and hemp, and considerable quantities of corn are exported. Cattle and sheep are reared in large flocks. The country is almost destitute of wood, but the valleys abound in peat. The wine produced is small in quantity, and inferior in quality. Oleaginous seeds are extensively cultivated for the manufacture of oil. In this district are numerous and extensive establishments for the manufacture of woollen cloths and fine linen goods, such as cambrics, lenos, and lawns, carpets, hats, hosiery, leather, soap, cutlery, and other hardware. It is, on the whole, one of the most prosperous divisions of the kingdom, and contains, besides many towns and villages densely inhabited, the large cities Amiens (population, 46,129) and Abbeville, (population, 18,247), in which most of the commerce of the department is concentrated.

SOMNAMBULISM, or Sleep-walking. According to a report made to the Physical Society of Lausanne, by a committee appointed to examine a young man who was accustomed to walk in his sleep, the disposition to this singular habit seems to depend on a particular affection of the nerves, which both seizes and quits the patient during sleep. Under the influence of this affection, the imagination represents to him the objects which strike him while awake, with as much force as if they really affected his senses; but it does not make him perceive any of those which are actually presented to his senses, except in so far as they are connected with the dreams which engross him at the time.

If during this state the imagination has no determined purpose, he receives the impression of objects as if he were awake; only, however, when the imagination is excited to lend its attention towards them. The perceptions obtained in this state are very accurate; and when once received, the imagination renews them occasionally with as much force as if they were again acquired by means of the senses. But the impressions received during this state of the senses disappear entirely when the person awakes, and do not return till the return of the same disposition in the nervous system.

The remarks of this committee were made on a lad named Devaud, who was thirteen years and a half old, and who lived in the town of Vevey. He possessed a robust constitution; but his nervous system appeared to be organized with peculiar delicacy, and to discover marks of the greatest sensibility and irritability. His senses of smell, taste, and touch, were exquisite: he was subject to fits of immoderate and involuntary laughter; and he sometimes wept without any apparent cause. His sleep was at all times unquiet, but particularly when the fits were about to seize him. During his sleep, motions were observable in every part of his body, with starting and palpitations; he uttered broken words, sometimes sat up in his bed and lay down again. He then began to pronounce words more distinctly, and rising abruptly, acted as he was instigated by the dream which then possessed him.

From the facts which were brought under the observation of this committee, they inferred that the functions of the somnambulist, while under the influence of this affection, are not suspended, as to what he wishes to see, or the objects about which his imagination is occupied; that he may also be disposed to receive those impressions when his imagination has no other object at the time; that in order to see, he is obliged to open his eyes as much as he can, but when the impression is once made it remains; that objects may strike his sight without striking his imagination, if it is not interested in them; and that he is sometimes informed of the presence of objects without either seeing or touching them.

A great number of similar instances might very easily be accumulated. Such anomalous operations of the mind it is perhaps beyond the power of philosophy to explain; but a very small portion of philosophy, or even common sense, will enable us to dispose of another class of vagaries imputed to animal magnetism. The magnetisers are a sort of conjurers, who, according to their own account, are able to superinduce a state of sleep, and, while their patients are in that state, to exercise a marvellous influence over their volitions. Deleuze, in his *Histoire Critique du Magnétisme Animal*, furnishes these very edifying details: "When magnetism produces somnambulism, the being who finds himself in this state acquires a prodigious extension in the sense of feeling. Several of his exterior organs, usually those of sight and hearing, are rendered torpid, and all the sensations which depend on them are internally performed. There is in this state an infinite number of shades and varieties; but in order to form a correct judgment, it must be examined in its greatest remoteness from the state of waking, passing over in silence every thing that experience has not established. The somnambulist has his eyes closed, and does not see by the eyes nor hear by the ears; but he sees and hears better than a waking man. He sees and hears only those with whom he is in relation. He sees only that which he looks at, and he usually looks only at those objects to which his attention is directed. He is subject to the will of his magnetiser for every thing that cannot harm him, and for every thing that is not opposed to his ideas of justice and truth. He feels the will of his magnetiser; he perceives the magnetic fluid; he sees, or rather he feels, the interior of his own body, and those of others; but he usually remarks only the parts which are not in the natural state, and which disturb the harmony of the economy; he retraces in his memory the remembrance of things which he had forgotten while awake; he has pre-visions and pre-sensations, which may be erroneous in several circumstances, and which are limited in their extent; he expresses himself with a surprising facility; he is not exempt from vanity; he improves of himself, for a certain length of time, if he is wisely managed; he spoils if he is ill directed. When he re-enters into the natural state, he absolutely loses the recollection of all sensations, and of all ideas which he has had in the state of somnambulism; so that these two states are as unconnected with one another, as if the somnambulist and the waking man were two different beings." The simple enunciation of such absurdities as these, seems to preclude the necessity of all formal discussion.

In addition to their other attributes, some of the magnetic somnambulists are endowed with a miraculous skill in physic. "Those patients in crisis," says Cloquet, "who are named physicians, have a supernatural power, by which, on touching a patient who is presented to them, on carrying the hand even above the clothes, they feel what is the affected organ, the suffering part; they declare it, and mention nearly the suitable remedies. A singularity not less remarkable than all those which I have enumerated is, that those physicians who for several hours have touched patients, and have reasoned with them, remember nothing, absolutely nothing, when the master pleases to disenchant them, and to restore them to their natural state. The time which has elapsed from their entrance into the crisis to their coming out of it, is, so to speak, annihilated to such a degree, that if a covered table be presented to these sleeping physicians, they will eat and drink; and if, the table being uncovered, the master restores them to their natural state, they will have no recollection of having done so. The master has the power not only, as I have already said, to make himself be understood by these physicians in crisis, but I have repeatedly seen him present from a distance his finger to one of these physicians, always in crisis, and in a state of spasmodic sleep, make him to follow him where he pleased, or send him to a distance from himself, either to his house or to different places, which he mentally indicated without telling him."

Another phenomenon, equally worthy of admiration, is the power of reading without the aid of eyes. Pigeaire, a physician of Montpellier, is answerable for the following statement of his daughter's performances in this new department. "We made her read with her eyes closed by magnetic sleep, or covered with a handkerchief in the form of a bandage; she read with the greatest facility characters printed or written, not only in applying her fingers to the paper, but also with a plate of glass interposed between the book and her fingers. More than forty persons have been witnesses of this experiment, which we took care to perform before only a few persons at a time, in order not to disturb the little somnambulist. This experiment has never failed; once only it has been incomplete. The little girl, in the state of somnambulism, named certain objects enclosed in snuff-boxes; announced persons previously to their entrance into the room in which she was; and several times mentioned the hour and the minute on a hunting watch which she held in her hand." Those who are acquainted with the waking performances of Miss Macavoy of Liverpool, will experience no difficulty in understanding the sleeping performances of Miss Pigeaire of Montpellier.

SOMNER, William, an eminent English antiquary, was born at Canterbury in 1606. His first treatise was the Antiquities of Canterbury, which he dedicated to Archbishop Laud. He then applied himself to the study of the Saxon language; and having made himself master of it, he perceived that the old glossary prefixed to Sir Roger Twisden's edition of the laws of King Henry I. printed in 1644, was faulty in many places; he therefore added to that edition notes and observations valuable for their learning, with a very useful glossary. His Treatise of Gavelkind was finished about 1648, though not published till 1660. Somner was zealously attached to King Charles I.; and in 1648 he published a poem on his sufferings and death. His skill in the Saxon tongue led him to inquire into most of the European languages, ancient and modern. He assisted Dugdale and Dodsworth in compiling the *Monasticon Anglicanum*. His Saxon Dictionary was printed at Oxford in 1659. He died in 1669.

SOMPRE, a town of Hindustan, in the province of Cashmere, situated on the east side of the Jhylum river. Long. 73. 25. E. Lat. 34. 17. N.

SONATA (*Ital.*), a piece of music, consisting of various movements for a single instrument, with or without accompaniment. The name has sometimes been given to certain vocal compositions, in which all the voices are equally essential. Some of the most remarkable modern sonatas are for the pianoforte, such as those of Haydn, Mozart, Beethoven, Clementi, Dussek, &c. Formerly sonatas were classed as *sonate di camera* and *sonate di chiesa*, i. e. *chamber-sonatas* and *church-sonatas*, on account of their difference of style, and the place of performance.

SONATINA (*Ital.*), a short and easy sonata.

SONDERHAUSEN, the capital of the principality of Schwartzburg-Sonderhausen, in Germany, stands on the river Wipper, at the junction of the Bebra with that stream. It is well built, and the castle on which the prince resides is situated on a hill overlooking the city; it is a venerable object, with some pleasing promenades near to it. The city contains a gymnasium, two churches, and an orphan-house, 460 dwellings, and 3600 inhabitants. Long. 10. 45. 1. E. Lat. 51. 22. 33. N.

SONDRE Grund, or Bottomless, an island in the South Pacific Ocean, discovered by La Maire and Schouten in 1616. It is about twenty leagues in circumference. Long. 148. W. Lat. 15. S.

SONDRIO, a delegation of the Austrian kingdom of Lombardy, extending over 1139 square miles, is bounded on the north by Switzerland, on the east by the Tyrol, on the south by Bergamo, on the south-west by Como, and on the west by Switzerland. It comprehends an extensive valley, with lofty mountains on both sides, sometimes called the Valteline. It contains one city, six towns, and seventy-eight villages, with 91,600 inhabitants. The capital is a city of the same name, situated at the entrance of the valley, on the river Moller. It contains 3480 inhabitants.

SONEHUT, a small town and mud-fort of Hindustan, in the province of Gundwana. Long. 82. 33. E. Lat. 23. 33. N.

SONEPOUR, a town of Hindustan, in the province of Orissa, situated on the west bank of the Mahanuddy, at its confluence with the Taile river. Long. 83. 30. E. Lat. 20. 47. N.

SONG, in *Music*, in a general sense, applies to melody, whether vocal or instrumental. It is usually applied to an air adapted to the words of a short poem. Sometimes, with an adjunct, it means a particular form of melody, as *plain song* (Fr. *plain chant;* Ital. *canto piano*, or *canto fermo*). Among songs, the most characteristic and interesting are the national ones of various countries. To the influence of national song may be traced those remarkable changes and improvements in the style of melody, with regard to freedom and expression, that are so perceptible in the music of professed composers within the last two centuries.

Song of Birds. See Singing, and Philosophical Transactions, vol. lxiii.

SONGHUR, a town of Hindustan, in the Gujerat peninsula, situated in a wild country, twenty-five miles north-west from Wankaneer. Near it is a very ancient temple dedicated to the sun, and adorned with a variety of sculptures, in a style greatly superior to any modern works by the Hindus. In the interior of this temple is a male figure, three feet high, with uplifted hands, each holding an image of the sun; and on his two sides are two smaller idols of the same kind. There are also two other temples, one of which contains the figure of Bhavani standing on an animal resembling a tortoise, and surrounded by female attendants. There is no record concerning the time when these temples were built.

SONGI, a small river on the eastern coast of Malacca, falls into the China Sea. Lat. 2. 10. N.

SONGKIANG, a city of China, of the first rank, in the province of Kiangnan. It is situated on the great canal, very conveniently for trade, which is carried on to a considerable extent in calicoes and other cotton cloths. It has four large cities under its jurisdiction. It is 560 miles south of Pekin. Long. 120. 44. E. Lat. 31. N.

SONG-MEN-CHAN, a small island near the coast of the province Tchekiang, in China. Long. 121. 21. E. Lat. 31. N.

SONGOA, an island in the Straits of Malacca. It is about fifty miles in circumference. Long. 100. 30. E. Lat. 2. 18. N.

SOOLOO Isles. These isles, about sixty in number, derive their name from Sooloo, the principal island in the group. They form a chain which extends in a north-east and south-west direction, from the north-eastern extremity of Borneo to the western extremity of Magindanao, and from the 4th to the 7th degrees of north latitude. The island of Sooloo is about thirty miles in length by twelve in average breadth, and contains 60,000 inhabitants. It lies midway between the islands of Borneo and Magindanao, is well cultivated, and affords a fine prospect from the sea; nor has it any certain rainy seasons, like the other Malay islands. This is owing to the moderate height of the hills not intercepting the clouds in their passage from the sea. Most rain falls, however, during the south-west monsoon, and also at the change of the monsoon, especially the autumnal. But these changes are not followed by any storms, and very seldom at any other time, so that the island enjoys almost a perpetual summer. There are several good harbours among these islands, particularly at Bewabewa, Tavitave, Tappool, Secassee, between Boobooan and Tappeantana, south of Basselan. The harbour of Bewan, the capital of Sooloo, is not good, except during the south-west monsoon. This place is situated on the sea-coast, on the north-west part of the island, and is of considerable size. The houses are built after the manner of the Malays, elevated about four feet from the ground with bamboos, of which the floors also are made. The island of Sooloo being small in proportion to its population, habits of industry prevail, and great attention is paid to agriculture. Rice is planted; but it is a precarious crop, owing to the uncertainty of the rains. Many roots are in consequence cultivated in its stead, namely, the Spanish or sweet potatoe, and yams of different species. They have abundance and variety of every species of tropical fruit. The oranges are equal in quality to those in China: they have also a fruit called jack or nanka, durians, a kind of large custard apple, called madang, mangoes, mangustines, rambustines, and a fruit they call bolona, like a large plum or mangoe, white inside. The trees in the woods are loaded with fruits, which ripen well, and are not injured by too much moisture. The Sooloos, from the great number of the Chinese that are among them, have learned from them the art of gardening; and they ingraft and improve their fruits.

Wild elephants are to be found in the woods; which is a remarkable circumstance, considering that the island is small and populous. Spotted deer, goats, and black cattle, are also abundant. Wild hogs abound, and do much mischief; but the natives have few sheep. They have, however, a good breed of horses, which are trained to trot, but not to gallop. After harvest the inhabitants hunt both the elephants and the wild hogs, with a view to destroy them.

The island of Sooloo was formerly the centre of an extensive trade, and was frequented by ships from Japan, which imported silver, amber, silks, chests, cabinets, and other curiosities made of fragrant woods, besides great quantities of silks and porcelain from China. It was also visited by vessels from Java, Sumatra, Ceylon, and the coast of Coromandel, with valuable cargoes. This trade has greatly declined. The intercourse with China is now confined to two junks, which arrive annually from Amoy with cargoes of brass salvers, iron, sugar-candy, raw silk, black nankeen, white linen of a strong fabric, china ware, flowered silks, besides tea, cutlery and other hard ware, brass wire, gongs, beads of all colours, little swan-shot, fire-works, &c. In return they export to China biche de mer, black and white wax, pearl-oyster shells, bird-nests, and tortoise-shell; also a sea-weed used as gum or glue, and other articles, such as Carooang oil, clove-bark, black wood, ratans, sago, various barks for dyeing, cassia, pepper, native camphire, sandal-wood, curious shells for grottoes, pearls, and spices. These islands are also occasionally visited by country ships, which import articles of European manufacture, such as brasiery, cutlery, cloth, gunpowder, fire-arms, manufactures in glass, iron, opium, piece-goods, saltpetre, shot, swords, tin ware, watches, sugar, tobacco, &c. From Borneo are imported sago, biche de mer, cowries, and tortoise-shell. Rice is imported from Magindanao, and is paid for with Chinese goods. Cotton manufactures from Celebes complete the list of imports. There is a famous pearl-fishery at Sooloo and the neighbouring islands.

These islands are governed by a hereditary prince or sultan, whose power is, however, counterbalanced by the nobles. The Sooloos seldom venture from home in their own vessels, except for the purpose of predatory excursions to make slaves among the Philippine Islands. They are warlike in their habits, though they depend less on fire-arms than on the lance, sword, and dagger, in the use of which they are very dexterous. The inhabitants have reached a higher stage of civilization than is generally attained in the Asiatic islands. The women are not strictly confined, as in many Mahommedan countries. In their houses are domesticated many Philippine and some Spanish slaves, who are purchased from the Illanos and Magindanese cruisers. Notwithstanding their boasted civilization, murder is a crime extremely common among them, and occurs on the least provocation. In 1800 they treacherously assassinated the captain of a country ship, and his boat's crew; and afterwards made an attack on the ship, but were repulsed.

Of the early history of these islanders little is known. They assert, that they once formed a part of an ancient Bornean empire, founded by the Chinese. But the Magindanese assert that they were formerly subject to them. From the period when the Spaniards obtained possession of the Philippines, they have been engaged in a constant warfare with the Sooloos, but with little advantage to themselves, being always repelled in their attempts to obtain possession of these islands.

SOONDA, a town and district of Hindustan, in the province of North Canara. The district, which is small, is situated between the 14th and 15th degrees of north latitude, above the Western Ghauts. Formerly the country was well cultivated, and produced fine timber and pepper, betel nut, cardamoms, and plantains. Towards the eastern division of the country, the great object of agriculture is rice. Having been the seat of war between Hyder and the Mahrattas, it was greatly wasted by the former in 1763, and its rajah compelled to fly for protection to Goa; on which occasion he surrendered the whole of his territory below the Ghauts for a stipulated pension. In 1799 the Soonda district became the property of the British, with whom it remains. The capital, of the same name, was formerly an extensive and populous town, and was defended by strong fortifications, which were levelled by Hyder, who also nearly destroyed the town. Long. 74. 58. E. Lat. 14. 34. N.

SOONDIA, a town of Hindustan, in the province of Sinde, situated on the Indus, on the route from Tatta to Hyderabad. Lat. 24. 58. N.

SOONEL, a town of Hindustan, in the province of Malwah, belonging to the Mahrattas, 60 miles south by east from Kotah. It is regularly built, with streets at right angles, and is of considerable extent. Long. 76. 5. E. Lat. 24. 21. N.

SOONERGONG, or SUNERGONG, a town of Bengal, situated on one of the branches of the Brahmapootra. It was once a large city, the provincial capital of the eastern division of Bengal, and famous for its manufactures of muslin and other fine cottons. It is now reduced to a mere village, principally inhabited by weavers, and the city of Dacca has risen on its downfall. Long. 90. 43. E. Lat. 23. 39. N.

SOONGUR, a town of Hindustan, in the province of Gujerat, 39 miles east by south from Surat. Long. 73. 38. E. Lat. 21. 8. N.

SOONPUT, a small town of Hindustan, in the province of Delhi. To the north is a handsome mausoleum of Khizer Khan, an Afghan nobleman of the family of Shere Shah. The adjacent country was greatly benefited by the canal dug by Aly Merdan Khan. Orders have been given by the British government to repair the canal, which will aid the country to recover from the desolate state in which it has been for some years past. Long. 76. 53. E. Lat. 29. N.

SOONTABURDAR, in the East Indies, an attendant, who carries a silver bludgeon in his hand, about two or three feet long, and runs before the palanquin. He is inferior to the chubdar; the propriety of an Indian newaury requiring two soontaburdars for every chubdar in the train. The chubdar proclaims the approach of visitors, &c. He generally carries a large silver staff about five feet long in his hands; and among the nabobs he proclaims their praises aloud as he runs before their palanquins.

SOOPOOR, a town of Hindustan, in the Rajpoot territories, province of Ajmeer. It is the capital of a small principality, and is 65 miles north-east from Kotah. Long. 76. 45. E. Lat. 25. 43. N.

SOOROOTOO ISLE, a small island in the Eastern Seas, situated off the western coast of Borneo, and separated from the island of Carimatia by a narrow strait, through which a ship might run if compelled by necessity. Long. 108. 40. E. Lat. 1. 45. S.

SOOROPOOR, a town of Hindustan, in the province of Bejapoor, situated on the Krishna river, nearly 130 miles south-west from Hyderabad. Long. 77. E. Lat. 16. 15. N.

SOORY, a town of Bengal, district of Birbhoom, 50 miles south-west from Moorshedabad. Long. 87. 32. E. Lat. 23. 54. N.

SOOSNEER, a considerable town of Hindustan, in the province of Malwah, 57 miles north-north-east from Oojain. Long. 76. 10. E. Lat. 23. 55. N.

SOOSOO, a small town on the west coast of Sumatra, where pepper is sometimes exchanged for gold dust. Long. 97. 10. E. Lat. 3. 45. N.

SOOSOOHOONAN, a district in the island of Java, on the south coast, formerly extending to the north coast, and including the territories of Cheribon, and the greater part of the island. It is now much fallen from its ancient grandeur, and in the last century was divided into two parts. The prince, embarrassed by the rebellion of a powerful nobleman, made a cession of his territory to the Dutch, who in return granted him half back again, under the title of Sultan. Prior to 1740 this sovereign was proprietor of all the territory to the east of Cheribon; but he lost part of his dominions in a new contest with the Dutch. The dynasty, however, still continues; and in 1813 the capital was visited by Sir Stamford Raffles, the British governor, who was graciously received.

SOOT, a volatile matter arising from wood and other fuel along with the smoke; or rather it is the smoke itself condensed, and gathered to the sides of the chimney. Though once volatile, however, soot cannot be again resolved into vapour, but, if distilled by a strong fire, yields a volatile alkali and empyreumatic oil, a considerable quantity of fixed matter remaining at the bottom of the distilling vessel. If burnt in an open fire, it flames with a thick smoke, whence other soot is produced. It is used as a material for making sal ammoniac, and as a manure.

SOOTY, a town of Bengal, in the province of Raujeshy, where an action was fought in 1763, between the British troops and those of Meer Cossim, in which the latter were defeated. Long. 88. 2. E. Lat. 24. 36. N.

SOPHI, or SOFI, a title given to the emperor of Persia, importing as much as wise, sage, or philosopher.

SOPHIS, or SOFEES, a kind of religious order among the Mahommedans in Persia, answering to what are otherwise called *dervises*, and among the Arabs and Indians *faquirs*. Some writers suppose them to be called sophis from a kind of coarse camblet which they wear, called *souf*, from the city Souf in Syria, where it is principally manufactured. The more eminent of those sophis are complimented with the title *schiek*, that is, *reverend*, much as, in Romish countries, the religious are called *reverend fathers*. Schiek Sophi, who laid the foundation of the grandeur of the royal house of Persia, was the founder, or rather the restorer, of this order. Ishmael, who conquered Persia, was himself a sophi, and greatly valued himself on that character. He chose all the guards of his person from among the religious of this order, and would have all the great lords of his court sophis. The king of Persia is still grandmaster of the order, and men of rank continue to enter into it, though it be now fallen under some contempt.

SOPHISM, in *Logic*, a specious argument, having the appearance of truth, but leading to falsehood. Sophisms are reduced by Aristotle into eight classes, an arrangement so just and comprehensive, that it is equally proper in present as in former times. 1. *Ignoratio elenchi*, in which the sophist seems to determine the question, while he does it only in appearance. Thus the question, Whether the excess of wine be hurtful? seems to be determined by proving, that wine revives the spirits and gives a man courage; but the principal point is here kept out of sight, for still it may be hurtful to health, to fortune, and reputation. 2. *Petitio principii*, a begging of the question, or taking for granted that which remains to be proved; as if any one should undertake to prove that the soul is extended through all the parts of the body, because it resides in every member. This is affirming the same thing in different words. 3. Reasoning in a circle; as when the Romanists prove the Scriptures to be the word of God by the authority of the church, and the authority of the church from the Scriptures. 4. *Non causa pro causa*, or the assigning of a false cause to any effect. Thus the supposed principle, that nature abhors a vacuum, was applied to explain the rising of water in a pump, before Galileo discovered that it was owing to the pressure of the atmosphere. In this way the vulgar ascribe accidents to divine vengeance; and the heresies and infidelity of modern times are said to be owing to learning. 5. *Fallacia accidentis*, in which the sophist represents what is merely accidental as essential to the nature of the subject. 6. By deducing a universal assertion from what is true only in particular circumstances, and the reverse: thus, some men argue, "transcribers have committed many errors in copying the Scriptures, therefore they are not to be depended on." 7. By asserting any thing in a compound sense which is only true in a divided sense. So, when the Scriptures assure us that the worst of sinners may be saved, it does not mean that they shall be saved while they remain sinners, but that if they repent they may be saved. 8. By an abuse of the ambiguity of words. Hume reasons thus, in his Essay on Miracles: "Experience is our only guide in reasoning concerning matters of fact; now we know from experience, that the laws of nature are fixed and invariable. On the other hand, testimony is variable, and often false; therefore, since our evidence for the reality of miracles rests solely on testimony which is variable, and our evidence for the uniformity of the laws of nature is invariable, miracles are not to be believed." The sophistry of this reasoning depends on the ambiguity of the word *experience*, which in the first proposition signifies the maxims which we form from our own observation and reflection; in the second it is confounded with testimony; for it is by the testimony of others, as well as our own observation, that we learn whether the laws of nature are variable or invariable. The Essay on Miracles may be recommended to those who wish to see more examples of sophistry; as we believe most of the eight species of sophisms which we have mentioned are well illustrated by examples in that essay.

SOPHIST, an appellation assumed in the early periods of Grecian history, by those who devoted their time to the study of science. This appellation appearing too arrogant to Pythagoras, he declined it, and wished to be called a *philosopher;* declaring that, though he could not consider himself as a wise man, he was indeed a lover of wisdom. True wisdom and modesty are generally united. The example of Pythagoras was followed by every man of eminence, while the name *sophist* was retained only by those who with a pomp of words made a magnificent display of wisdom upon a very slight foundation of knowledge. Those men taught an artificial structure of language, and a false method of reasoning, by which, in argument, the worse might be made to appear the better reason. In Athens they were long held in high repute, and were supported, not only by contributions from their pupils, but by a regular salary from the state. They were among the bitterest enemies of the illustrious Socrates, because he embraced every opportunity of exposing to contempt and ridicule their vain pretensions to superior knowledge, and the pernicious influence of their doctrines upon the taste and morals of the Athenian youth.

SOPHOCLES, the famous tragic poet, was the son of Sophilus, an Athenian, and was born in the year 495 before Christ. Although the father was only a mechanic, the son enjoyed the advantage of a good education. Superior vigour and address in the exercises of the palæstra, and skill in music, were the great accomplishments of young men in the states of Greece. In these Sophocles excelled; nor was he less distinguished by the beauty of his person. He was also instructed in the noblest of all sciences, civil polity and religion: from the first of these he derived an unshaken love of his country, which he served in some embassies, and in high military command with Pericles; from the latter he was impressed with a pious reverence for the gods, manifested by the inviolable integrity of his life. But his studies were early devoted to the tragic muse; the spirit of Æschylus lent a fire to his genius, and excited that noble emulation which led him to contend with, and sometimes to bear away the prize from, his great master. He wrote forty-three tragedies, of which seven only have escaped the ravages of time. Having testified his love of his country by refusing to leave it, though invited by many kings, and having enjoyed the uninterrupted esteem and affection of his fellow-citizens, which neither the gallant actions and sublime genius of Æschylus, nor the tender spirit and philosophic virtue of Euripides, could secure to them, he died in the beginning of the year 405, at the very advanced age of ninety.[1] The burial-place of his ancestors was at Decelia, which the Lacedæmonians had at that time seized and fortified: but Lysander, the Spartan chief, permitted the Athenians to inter their deceased poet; and they paid him all the honours due to his love of his country, integrity of life, and high poetic excellence. Æschylus had at once seized the highest post of honour in the field of poetry, the true sublime: to that eminence his claim could not be disputed. Sophocles had a noble elevation of mind, but tempered with so fine a taste, and so chastened a judgment, that he never passed the bounds of propriety. Under his conduct the tragic muse appeared with the chaste dignity of some noble matron at a religious solemnity; harmony is in her voice, and grace in all her motions. From him the theatre received some additional embellishments; but his distinguished excellence is in the judicious disposition of the fable, and so nice a connection and dependence of the parts on each other, that they all conduce to make the event not only probable, but even necessary. This is peculiarly admirable in his King Œdipus; and in this important point he is far superior to every other dramatic writer of antiquity.

The ingratitude of the children of Sophocles is well known. They wished to become immediate masters of their father's possessions, and therefore, tired of his long life, they accused him before the Areopagus of insanity. The only defence the poet made, was to read his tragedy of Œdipus at Colonos, which he had lately finished; and he then asked his judges, whether the author of such a performance could be charged with insanity. The father upon this was acquitted, and the children returned home covered with shame and confusion.

The editions of Sophocles are very numerous, and some of them very elaborate, but we can only enumerate the more conspicuous. The *editio princeps* was published by Aldus, Venet. 1502, 8vo. This was followed by an edition published by the heirs of P. Junta, Florent. 1522, 4to; and another published by B. Junta, Florent. 1547, 4to. The text of Aldus was the basis of all the editions which preceded that of Turnebus, Paris. 1553, 4to. This is among the best of the early editions. We must not omit those of H. Stephanus, Paris. 1568, 4to, and of Canter, Antverp. 1579, 12mo. The text of Turnebus was chiefly adopted in all the succeeding editions till that of Brunck, Argent. 1786, 2 tom. 4to. This is a very elaborate as well as splendid edition, and strikingly displays the editor's acuteness and learning. The same able critic published two octavo editions, each in two volumes. We now descend to the edition of Erfurdt, Lips. 1802–11, 8 tom. 8vo. The tragedies of Sophocles have been translated into many different languages. An English version, which was favourably received, was published by Dr Francklin, Greek professor at Cambridge, Lond. 1759, 2 vols. 4to. Another was subsequently published by Mr Potter, Lond. 1788, 4to.

SOPING, a district or principality of the island of Celebes, formerly one of the most extensive in the country. In 1775 it was governed by its own king.

SOPRA, a river of Hindustan, which rises in the province of Malwah, and joins the Gilly Sinde river, after which their united streams fall into the Chumbul.

SORA, a city of Italy, in the Neapolitan province of Terra di Lavoro, the capital of a district of its own name. It stands on the banks of the river Garigliano, is the seat of a bishop, and, besides the cathedral, has five churches, and 7950 inhabitants.

SORAU, a circle of Prussia, in the government of Frankfurt, which extends over 513 square miles, with 46,400 inhabitants. The capital is the town of the same name. It stands on a large plain, is well built, and contains 430 houses, with 4060 inhabitants, who manufacture large quantities of cotton goods.

SORBONNE, or SORBON, the house or college of the faculty of theology established in the old university of Paris. It was founded in 1252, by St Louis, or rather by Robert de Sorbon his confessor and almoner, first canon of Cambray, and afterwards of the cathedral of Paris; who gave his own name to it, which he himself took from the village of Sorbon or Serbon, near Sens, where he was born. The foundation was laid in 1250; Queen Blanche, in the absence of her husband, furnishing him with a house which had formerly been the palace of Julian the apostate. The king afterwards gave him all the houses he had in the same place, in exchange for some others. The college was magnificently rebuilt by the Cardinal de Richelieu. The institution was designed for the use of poor students in divinity.

SORBONNE was also used in general for the whole faculty of theology at Paris, as the assemblies of the whole body were held in the house of the Sorbonne, and the bachelors of the other houses of the faculty came hither to hold their *sorbonnique*, or act for being admitted doctor of divinity.

SORCERY, or MAGIC, the power which some persons were formerly supposed to possess, of commanding the devil and the infernal spirits, by skill in charms and invocations, and of soothing them by fumigations. See MAGIC and APPARITIONS.

SORIA, one of the four departments into which the province of Old Castille, in Spain, is divided. Its extent is 341 square leagues, and its population amounts to 257,537 souls. It is in general a hilly district, and in some parts very mountainous. The plains are fertile, especially that of Rioja, and yield abundance of wheat and barley, and in some years it has a surplus of both these productions. Its wine is good, but not abundant; and it is deficient in a supply of oil, which is procured from the more southern provinces. This province furnishes to commerce a great proportion of the fine wool of the merinos. That of Soria is not equal in fineness to what is produced in Segovia, but is however of a good quality; and the quantity annually sent away amounts to about 2,250,000 pounds.

SORIA, a city of Spain, in New Castille, the capital of the department of that name. It is situated on the north bank of the river Duero, but too near its source to derive any benefit as to navigation. In the vicinity there are excellent pastures for sheep, with houses of various kinds to shelter them when the weather is more than usually inclement, or when they are shorn. It is not a large city, nor are the public buildings of a nature to merit a detailed description; but the extensive ruins of the ancient Numantia invite the notice of every lover of Roman antiquities. Soria contains thirteen churches, eleven monasteries, four hospitals, and 6000 inhabitants. The manufacture of silk stockings employs eighty-two looms. Some of the inhabitants are employed in soap-boiling, tanning, and in the manufacture of cloth. Lat. 41. 48. N.

SORIANG, a river of Celebes, on the west coast, which falls into the sea.

SORITES, in *Logic*, a species of reasoning, in which a great number of propositions are so linked together, that the predicate of the one becomes continually the subject of the next following, till at last a conclusion is formed by bringing together the subject of the first proposition and the predicate of the last. Such was that merry argument of Themistocles, to prove that his little son under ten years old governed the whole world: "My son governs his mother; his mother me; I the Athenians; the Athenians the Greeks; Greece commands Europe; Europe the whole world: therefore my son commands the whole world."

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[1] Clinton's Fasti Hellenici, vol. ii. p. 23, 57, 83.

SORRENTO, a city of Italy, in the province of Naples. It is finely situated among olive, citron, and pomegranate trees, and is the seat of an archbishop. It is on the sea-coast, and has some foreign trade. The chief occupation is collecting and spinning silk. It was the birth-place of the poet Tasso. The surrounding hills are chiefly composed of tufa, which was originally lava; and the doors and window-seats are generally formed of that substance. It contains 4240 inhabitants.

SORTILEGE (*Sortilegium*), a species of divination performed by means of *sortes* or lots. The *sortes Prænestinæ*, famous in antiquity, consisted in putting a number of letters, or even whole words, into an urn; and then, after shaking them together, they were thrown on the ground; and whatever sentences could be made out of them constituted the answer of the oracle. To this method of divination succeeded that which has been called the *sortes Homericæ* and *sortes Virgilianæ*; a mode of inquiring into futurity which undoubtedly took its rise from a general custom of the oracular priests of delivering their answers in verse. It subsisted a long time among the Greeks and Romans, and being from them adopted by the Christians, it was not till after a long succession of centuries that it became exploded. Among the Romans it consisted in opening some celebrated poet at random, and among the Christians the Scriptures, and drawing, from the first passage which presented itself to the eye, a prognostic of what would befall one's self or others, or direction for conduct when under any exigency. There is good evidence that this was none of the vulgar errors; the greatest persons, philosophers of the best repute, admitted this superstition. Socrates, when in prison, hearing this line of Homer,

> Within three days I Phthia's shore shall see,

immediately said, within three days I shall be out of the world; gathering it from the double meaning of the word *Phthia*, which in Greek is both the name of a country and signifies corruption or death.

SORTINO, a city of the island of Sicily, in the province of Noto. It stands on a healthy spot on a gentle elevation, the ancient Xuthinum, 130 miles from Palermo, and is watered by a small stream. It contains 7300 inhabitants.

SORTINSKOI, a village of Tobolsk, in Asiatic Russia, seventy-two miles south-south-west of Beresof.

SOSVA, the name of two considerable rivers in Asiatic Russia, in the government of Tobolsk. The first has a course of 160 miles. It rises in the Oural Mountains, about the sixty-fifth degree of north latitude, and running almost due east, falls into the Obi near Beresof, after receiving a smaller river of the same name, called the Little Sosva. The other river rises somewhat farther to the north, in the same chain of hills, and running southwards about 200 miles, joins the Sosva, where their united streams take the name of Tauda.

SOTERIA, in *Antiquity*, sacrifices offered to the gods for delivering a person from danger; as also poetical pieces composed for the same purpose.

SOUDAN, a kingdom of Africa, situated between 11° and 16° north latitude, and 26° and 30° east longitude. See Africa.

SOUERICK, a town of Armenia, in the pachalic of Ourfa, and on the road from Ourfa to Diarbekir. It contains about 500 inhabitants, with three mosques and a strong castle. It is sixty miles north-east of Ourfa.

SOUGH, among miners, denotes a passage dug under ground to convey off waters from mines.

SOUI-TCHEOU, a city of China, of the first rank, situated at the confluence of the rivers Yan and Kincha, in a fertile though mountainous country. Long. 104. 23. E. Lat. 28. 40. N.

SOUL, the principle of perception, memory, intelligence, and volition, in man; which, since the earliest era of philosophy, has furnished questions of difficult investigation, and materials of keen and important controversy.

SOUND. So many things relating to this subject have been already treated at considerable length under the article Acoustics, that what we now propose shall be chiefly confined to the propagation of sound in the atmosphere, which, as Laplace observes, affords the most important application which has yet been made of the theory of elastic fluids. In this we shall first give the results of the principal attempts which have been made with the view of determining the velocity of sound experimentally; and shall notice more particularly some of them which are of a later date, and were made with far greater precautions than any of those mentioned under the article just cited. We shall then advert to various important oversights and imperfections which still attach to this department of science, and to certain improvements of which it seems to be susceptible.

Results of Various Experiments on the Velocity of Sound.

Observers.	Date.	Country.	Distance in Feet.	Velocity.	Temperature.	
Florentine Academicians	1660	Italy	5,906	1148	...	Tentamina Acad. del Cimento.
Cassini, Huygens, &c.	...	France	9,239	1151	...	Hist. Acad. Royale, lib. ii.
Flamsteed and Halley	...	England	15,840	1142	...	Phil. Trans. 1708, 1709.
Derham	1704	England	5,280 to 63,360	1142	...	Ibid.
French Academicians	1738	France	18,744 to 102,824	1106	43° F.	Mém. de l'Acad. 1738, 1739.
Cassini and Lacaille	1739	France	144,124	1110	...	Ibid.
Bianconi	1740	Italy	78,740	1043	...	Comment. Bononiensis, vol. ii.
La Condamine	1740	Quito	67,400	1112	...	La Condamine, Introd. Hist. 1751.
La Condamine	1744	Cayenne	129,360	1175	...	Mém. de l'Acad. 1745.
T. F. Mayer	1778	Germany	3,412	1105	...	Mayer, Prakt. Geometrie, 1792.
G. E. Müller	1791	Germany	8,530	1109	...	Müller, Gelehrt Anzeige, 1791.
Espinoza and Bauza	1794	Chili	53,626 to 14,071	1222·3	74°·7	Ann. de Chimie, vii. 93.
Benzenberg	1809	Germany	29,764	1093	32	Gilbert's Annalen, N. Folge, b. v.
Goldingham	1821	India	13,932 to 29,547	1086·7	32	Phil. Trans. 1823, p. 96.
Myrbach	1822	Germany	32,615	1092·1	32	Mean of eighty-eight experiments.
Arago, Matthieu, &c.	1822	France	61,064	1086·1	32	Conn. des Tems, 1825.
Moll, Van Beek, &c.	1823	Holland	57,971·2	1089·5	32	Phil. Trans. 1824, p. 424.
Gregory	1823	England	2,700 to 13,460	1088·1	32	Phil. Magazine, June 1824.
Parry and Foster	1825	Polar Regions	12,892·9	1035·2	— 17·7	Phil. Trans. 1828, p. 97

The reduction of such results to 32° Fahrenheit is usually made conformably to the expansion of air given by Dalton, Gay Lussac, &c., which is nearly at the rate of 1·14 foot for each degree. The expansion of Rudberg, about to be noticed, being rather smaller, would slightly lessen the reduction.

From a close examination of the twenty-eight principal experiments made in Holland in 1823, Professor Miller has, in the Philosophical Magazine for July 1839, deduced the following as the correct means of the results. The mean interval of the time in which sound travelled 17,669·28 metres is 51·9873 seconds. The mean temperature during these experiments was 11°·01 cent. The mean pressures of the atmosphere, and of the vapour in it, were ·74618 and ·00889 metres at 0° cent. respectively. Now, from Rudberg's experiments (Poggendorff's *Annalen*, xli. 558 and xliv. 119), which perhaps require to be repeated by others, it appears that on heating dry air from 0° cent. to 100°, under a constant pressure, its volume was increased from 1 to 1·365; hence, at the temperature θ cent., the pressure of the atmosphere and of the vapour in it being p and f respectively, the velocity of sound in English feet per second will be

$$1090{\cdot}77\sqrt{\left(\frac{1+{\cdot}00365\theta}{1-{\cdot}375\frac{f}{p}}\right)}.$$

This, owing to its depending on a smaller rate of expansion, exceeds 1089·5, the number in the table; but it is chiefly to be regarded as a general expression for the experimental results. The theoretical formula will be found farther on.

Chro- metc emp ed.

With the exception of Benzenberg, who had long ago used the species of clock described below with a conical pendulum, the most of the experimenters were formerly very ill provided with any adequate means of accurately measuring the intervals of time which elapse between the flash and report of the guns, as observed at the opposite station. In 1822, the French academicians employed the stop-watch of Breguet and the chronograph of Ricussec, a species of watch, one of whose hands revolves in one second, and can, without needing to stop, be made to touch with its extremity the dial-plate at any instant, so as to leave there a dot of ink, merely by suddenly pressing a small lever. In the experiments made in Holland in 1823, a clock was used with a conical pendulum which revolved 69·433 times in a minute, and was supposed capable of determining intervals to the 100th of a second, by suddenly arresting the index without stopping the clock. By means of these machines it was supposed quite practicable to determine the interval between the sight of the flash and the arrival of the report of a gun, with such precision as to obviate all material error which might arise from this cause. The importance of this, if realized, is evident from the circumstance that each tenth of a second corresponds to 110 feet of distance.

Thei sults sory.

But there is too good reason to suspect that all such ideas of attaining great accuracy in any direct measurements of the intervals of time are perfectly illusory, and that observations made with these machines can scarcely be depended on within a tenth of a second. The machines themselves may be possessed of all the perfection ascribed to them; but it would seem that the man has yet to be made who would be competent to use them. In Holland, only one centrifugal clock being employed at each station, we have no means of judging of the correctness of the observations made with it. But whoever examines the tables of results given in the *Connaissance des Tems* for 1825 (pages 364–367) will find that three and as often four machines, with as many first-rate observers, were generally employed simultaneously in determining the interval for each shot; and that instead of their results agreeing within an inconsiderable fraction, as the above ideas of great correctness would imply, they often differ by three, sometimes by four, and in one case by five tenths of a second. Something farther illustrative of this will be found under the article Clock and Watch Work (vol. vi. p. 783), where a machine has been described for determining, by indirect means, but to almost any degree of exactness, the interval in which sound passes over a small distance. The principal part is a strong clock, without compensation or other refinement, and requiring no extraordinary sort of being to observe with it.

Influence of the wind.

Although many eminent philosophers have laboured much to improve and perfect the various reductions which it is considered necessary to make on the experimental results, there is still a mistake regarding the exact influence of the wind. It seems always to be supposed that the effects of a steady wind are entirely obviated or compensated by taking the mean of the velocities of such sounds as are simultaneously produced at the two opposite stations, and also reciprocally observed at these respectively. This is in effect the view of the matter taken by Professor Moll. (Philosophical Transactions for 1824, p. 426.) Many other philosophers express the same opinion, and in particular Sir John Herschel, who recommends that all experiments on the velocity of sound be made, if possible, either in calm weather or in a direction at right angles to that of the wind. But so far is the result under this last arrangement from being entirely unaffected by the wind, that the error to which we now allude is then a maximum; and indeed in every case in which the direction of the wind is inclined to the base line, there is still a small error, which cannot be obviated by the reciprocal method.

The earlier experimenters gave themselves no concern about the influence of the wind; but its effect was in some degree eliminated by the arrangements adopted by the French academicians in 1738, though in so imperfect a manner as to leave considerable doubt regarding the accuracy of their result. In order to clear up this point, the Marquis Laplace requested the board of longitude to repeat the experiments, with the precaution of exciting sounds more nearly at the same instant from both ends of the base, in the expectation that the effects of the wind would be thereby completely obviated. The experiments were accordingly repeated in June 1822, though with no greater precision in this respect than that the times of firing the opposite shots still differed about five minutes from being simultaneous. In the experiments made in Holland in 1823, matters were so much better arranged, that the difference in the times scarcely ever amounted to a second. However, M. Arago has remarked, that when the wind is very unsteady, or comes in sudden gusts, it may still affect the mean result, especially since a sudden gust may interfere with the one sound, and yet miss the other altogether. But even when the wind is perfectly steady, the reciprocal method cannot be quite correct, unless the wind also blows directly from the one station to the other. In every other case it is more or less inaccurate, owing to the circumstance that sound is not propagated in parallel lines, but issues from its source in lines which radiate or diverge to every side; so that the same sonorous ray which, during a calm, would pass directly from the one station to the other, will not reach the latter at all when deflected by the wind into a different direction. Had our limits permitted, we should have endeavoured to show that, by applying to this the well-known principles of the composition of forces, the mean of the velocities of the reciprocal sounds will, owing to the action of the wind, come short of the true velocity, by a quantity which will in all cases be nearly expressed by $\frac{W^2}{2S}\sin^2 A$; where W is the velocity of the wind, S that of sound in still air, and A the angle which the direction of the wind makes with the base line. This correction, though generally very small, may often be several times greater than some which are usually taken into account, especially that arising from the effect of the difference of latitude and of the height of the place above the sea, on the force of gravity. For such we beg to refer to the Philosophical Transactions for 1824, 1828, and 1830. The pendulum, however, seems a more certain means of determining the differences in the force of gravity, than any merely theoretical formula, which cannot be expected to provide for particular local attractions. Besides, we suspect that during experiments on the velocity of sound, attention has not always been paid to the velocity and direction of the wind; and still more rarely have these been registered and published, so as to afford data for applying the requisite correction.

In the Reports of the British Association for 1833 and 1836, we find two able and interesting articles by Professor Challis, on the mathematical theory of fluids. Among other things, he treats at considerable length on the theory of sound, giving an analysis and notices of various essays on that subject. But these the learned professor seems, after all, never to have thoroughly examined, otherwise he could not have failed to discover that, in the mathematical investigations employed in several of the papers on which he has bestowed the largest share of commendation, there are various fundamental errors and inconsistencies, which naturally enough have led their authors into results which, independently of every other consideration, are more or less erroneous, because palpably incompatible with each other and with the premises from which they are professedly deduced. Fallacies of the sort in question have been pointed out in the Edin. Phil. Journ. (for Oct. 1826, p. 335, and July 1827, p. 153), as also in various numbers of the Quarterly Journal of Science for 1829. Some of the same errors have been likewise noticed, though not so early as in the first-mentioned journal, by an eminent Italian philosopher, Mr Avogadro, in the *Memorie dell' Academia realle della Scienze di Torino* (vol. xxxiii. p. 237), and also in a separate tract of his. Several notable instances of the like sort have been discussed and exposed in the article HYGROMETRY; but it is only one or two examples which we can notice here.

Researches of Laplace and Poisson.

With the view of accounting for the excess of the actual velocity of sound over that given by Newton's formula, it was very ingeniously suggested, in a general way, by the Marquis Laplace, about the beginning of the present century, that, in the propagation of sound, the minute rises and falls of temperature occasioned by the alternate condensations and dilatations of the air, should tend to augment the disturbance in the equilibrium of the pressure, and consequently to accelerate the transmission of sound. He did not, however, till long after, assign the form or amount of the correction for such acceleration. The first attempt toward this seems to be that of Biot in 1802 (*Journal de Physique*, tome lv. p. 173). But M. Poisson both claims and gets the no small credit of having very considerably anticipated Laplace in giving the precise form of the correction. This he is alleged to have done in a formula for the velocity of sound, communicated to the Institute as early as the year 1807, and shortly after published in the *Journal de l'Ecole Polytechnique* (cahier xiv.), and which is meant to consist of Newton's formula multiplied by a constant factor $\sqrt{1+k}$. But whilst it must be admitted that no one has written to better purpose on the theory of sound than M. Poisson has done, there seems to be a very general mistake regarding that factor. The formula is

$$\sqrt{\frac{gh}{\mathrm{D}}\left(1+\frac{aw}{(1+\alpha\theta)\gamma}\right)}=\sqrt{\frac{gh}{\mathrm{D}}(1+k)}.$$

In this he defines g to represent the force of gravity; h the height of the barometer; D the ratio of the density of the air to that of mercury; θ the temperature of the air; w the augmentation of that temperature occasioned by a condensation γ, and so small as to be considered proportional to γ; also $a = \cdot 00375$ for the co-efficient of the dilatation of the gases. But these evidently cannot make k constant, as the sequel requires it to be. After introducing the same formula and explanation of symbols in another memoir inserted in *Annales de Chimie* for May 1823, he proceeds to show that the factor $1+\frac{aw}{(1+\alpha\theta)\gamma}$, which for greater brevity he there calls simply k, is equal to the ratio of the specific heat of air under a constant pressure to its specific heat under a constant volume; which would identify $\sqrt{k}$ with the above-mentioned correction given by Laplace himself, for the first time only, in the same *Annales* for November 1816, and even then without demonstration. But it is worthy of particular notice, that the reason why the factor k in this case comes to be a correct expression for the ratio of the specific heats, is entirely owing to M. Poisson's there using γ as proportional, not to w, as above defined, but to $\frac{aw}{1+\alpha\theta}$. This will be readily seen on examining the *Annales* for May 1823 (p. 8 and 14), where, having put $\gamma = \frac{d\varrho}{\varrho}$, and $w = d\theta$, he deduces $\frac{ad\theta}{1+a\theta} = (k-1)\frac{d\varrho}{\varrho}$; and hence $k = 1 + \frac{a\varrho d\theta}{(1+a\theta)d\varrho}$ $= 1 + \frac{aw}{(1+a\theta)\gamma}$. Indeed, otherwise, $\sqrt{k}$ could neither have been constant, nor coincided with the correction of Laplace.

The leading principle in these formulæ therefore is, that as long as the total heat in the air undergoes no change (which may safely be supposed to be the fact, during a much longer interval than the theory of sound requires), it is not γ and w, but the differentials of log. $(1+a\theta)$ and of log. ϱ which are always held to be proportional; and, consequently, any changes, whether great or small, in these two logarithms themselves, must also be proportional; so that the general expression for the ratio of the specific heats, whether the simultaneous changes of ϱ to ϱ', and of θ to θ', be great or small, will be

$$1+\frac{\log.(1+a\theta')-\log.(1+a\theta)}{\log.\varrho'-\log.\varrho}=k.$$

The above inconsistency seems to have sadly misled M. Poisson's readers, particularly Professor Challis, as already cited; but it is virtually included in a more serious oversight, about to be noticed, which originated in the *Mécanique Céleste*, and has been generally more or less adopted, with implicit confidence, into almost every subsequent essay on the theories of heat and sound. In particular, it forms a leading feature in the works of Poisson, in Professor Kelland's Theory of Heat, and in Mr Lubbock's recent essay On the Heat of Vapours, which seems to have been hastily compiled, or, at any rate, from very incongruous materials.

When reviewing the first four volumes of the *Mécanique Céleste*, Professor Playfair expressed great doubts if there were then a dozen of persons in Britain qualified to peruse them. But whatever may now be the number of those who are content with merely reading the ordinary letter-press of that celebrated work, it is certain that almost none give themselves the trouble of thoroughly sifting the mathematical investigations, otherwise the serious oversights and inconsistencies which occur in some of them would be better known and appreciated, particularly the inaccuracies which pervade the greater part of the long chapter devoted to the velocity of sound. Of these, however, we shall here, for brevity's sake, take only one instance, which is selected, not so much on its own account, but because it unfortunately lies at the foundation of many of the formulæ and results with which the seventeen quarto pages following it are chiefly occupied. In the passage referred to (tome v. p. 127), there occurs an equation of the form

$$\varrho\frac{dq}{d\varrho}+kp\frac{dq}{dp}=0,$$

where p is the pressure, ϱ the density, and q the difference between the total quantity of heat which a given mass of air may then contain, and that which it contains at a temperature and pressure chosen arbitrarily. Also k is still a constant, expressing the ratio of the specific heats. We here state the matter in something like the more simple language and notation of M. Poisson, who, in the *Annales de Chimie* for August 1823, has readily deduced that equation from the two leading principles employed for it by Laplace, and which alone are essential to it, viz. the law of Mariotte, and the *constancy* in the ratio of the specific heats.[1]

From integrating the preceding equation on general principles only, and without having regard to the subject in hand, it could only be inferred that q is some indeterminate or arbitrary function of $\frac{p^{\frac{1}{k}}}{\varrho}$. But such eminent mathematicians as Laplace and Poisson, instead of being content with this general view of the matter, ought to have perceived that the conditions of the question, particularly the two principles just specified, and with which they had set out for the purpose of finding q in terms of p and ϱ, necessarily required q to be of the form $\mathrm{A} + \mathrm{B}\left(\frac{1}{k}\log.p - \log.\varrho\right)$, where A and B are constants; because this expression, independently of its being the first to present itself in the integration, is the only form or function of the above general integral which would be free from inconsistency or compatible with those two leading principles. So far, however, were they from attending to or being aware of this circumstance, that supposing themselves perfectly at liberty to adopt any particular function of $\frac{p^{\frac{1}{k}}}{\varrho}$, they made choice of $q = \mathrm{A} + \mathrm{B}\,(266{\cdot}67 + \theta)\, p^{\frac{1}{k}-1}$; where A and B are arbitrary constants, and θ is the temperature, because ϱ has been eliminated by the law of Mariotte. This form was adopted by these philosophers, that it might agree, as they supposed, with the hypothesis that the expansions of air under a constant pressure are proportional to the corresponding increments of absolute heat. But it is easily shown that such a hypothesis is quite incompatible, not only with the two leading principles, but with that very form which was on its account purposely given to q, as was first pointed out in the Edinburgh Philosophical Journal (for October 1826, p. 335), and afterwards more explicitly in article HYGROMETRY (vol. xii. p. 113), where a similar question has been consistently solved by a far more simple process of reasoning.

The precise value of the above-mentioned ratio of the specific heats is considered an important element in the theory of sound. The experiments of Desormes and Clement give 1·354; those of Gay Lussac and Welter, 1·3748; and those described under the article HYGROMETRY, 1·3333; all of which seem to be smaller than what would reconcile the theory with the actual velocity of sound. But we shall afterwards see reason for supposing that there is still another source of acceleration, which has hitherto been overlooked. In the *Annales de Chimie* for June 1829, and *Mémoires de l'Academie* (tome x. p. 147), M. Dulong treats at considerable length on the specific heat of elastic fluids; and with the view of obtaining the ratio in question for each of them, he assumes as demonstrated, that the actual velocity of sound, in any elastic fluid whatever, has to the velocity computed by Newton's formula the subduplicate ratio of the specific heat of that fluid under a constant pressure to its specific heat under a constant volume. But since it is only in air that the velocity of sound can be obtained by direct means, Dulong availed himself of a method previously employed by others, though by no means with complete success, as is evident from the discordance of their results. It consists in determining the velocity of propagation from the musical note rendered by a given cylindrical tube, and from the measured distance between two consecutive nodal sections or positions of minimum vibration. The pitch of the note gives the number of vibrations in a given time, and consequently the time of propagation over the measured interval, and therefore the velocity of the sound. By following a particular process, Dulong was enabled to give great precision to this method, which he practised first on atmospheric air, with the view of testing the soundness of the scheme; and by many successive trials he obtained a series of results, each of which, instead of exceeding, fell short of the velocity determined by direct observation. On finding therefore that this method failed in affording quite so great a ratio as he had expected or wished, Dulong abandoned it altogether, and finally adopted 1·421 as the ratio for air. This he obtained merely from taking the mean of a great number of the direct experiments which have been made on the velocity of sound in the open atmosphere, though it is usually quoted by others as the result of Dulong's own experiments with the musical notes from tubes. The same empirical mode of determining the ratio, which, however, does nothing for clearing up the theory, has been prosecuted still more closely by Dr Simons, in the Philosophical Transactions for 1830. When the number thus obtained is substituted in the formula, it certainly answers admirably; and no wonder, for it is just obtained by reasoning in a circle, which is fit to reconcile every sort of discordance.

Probable source of discordance between theory and observation.

There can be no question that great ingenuity and superior analytical skill have frequently been displayed in theoretically investigating the velocity of sound; but an important oversight, and which probably is the principal source of the remaining discrepancy between the observed and the theoretical velocities, seems to attach to all the researches of this kind with which we are acquainted, in that they are conducted upon two assumptions which are so very incompatible with each other that both cannot be true, if indeed any of them is strictly so. In the first place, it is assumed that the particles of the air, at least during a calm, vibrate accurately in the direction in which the sound is propagated. Secondly, that the air, during these vibrations, preserves or acts strictly in its fluid character. That the investigations involve the first of these assumptions, is what no one will for a moment dispute; and that they also proceed upon the second, is evident from the circumstance that the pressure of the air in such researches is always taken as strictly proportional to some particular power of the density, viz. either to the simple density, as was done by Newton, or to some higher power of it, as was in effect done by Laplace and his followers. Now, such proportionality of the fluid pressure to any uniform power of the density, would obviously require the particles constantly to observe the same uniform arrangement during their vibrations, so as to have the like distances between the adjacent particles of any small portion of the air everywhere to vary inversely as the cube root of the density, with, perhaps, the mere exception of as much difference of arrangement as is unavoidably due to the density being different in different parts of a wave of air. But it is easy to see that the two assumptions are so inconsistent that only the one of them could be strictly true; because vibrations performed accurately in the direction of the sound necessarily imply that (abstracting from the very insignificant change of distance due to the sound's being propagated in lines which are slightly diverging, because radiating from the source of sound) the distances of the particles of the air, estimated perpendicularly to the direction of the sound, would not be altered by or during these vibrations; and consequently that the density of any minute volume of the air, instead of varying alike in all its three dimensions, would vary in only one of them, namely, in the direction alone in which the sound is propagated through it.

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[1] In the Philosophical Magazine for April 1827, it has been attempted to deduce the same equation from these two principles, incongruously coupled with a third, but with which they are utterly incompatible; and that is the needless assumption, that, under a constant pressure, the variations of absolute heat in air are proportional to those of its temperature by the common scale. But so much does the resulting equation savour of the incongruity of the data, that it has been accompanied with an admission of its being only true in one particular state of the variables, and therefore totally unfit for integration. All this might have been allowed to pass, had it not been done with the view of palming the same fatal defect upon the production of Laplace and Poisson, which however is of an essentially different character. For the equation which has been deduced from the two leading principles alone, by the accurate and consistent method of Poisson, as above cited, and also given in the Philosophical Magazine for November 1823, neither involves the needless assumption, nor has any dependence on a particular state of the variables, and so is equally true in every case. Nor was it till after having legitimately obtained that equation, that Poisson adopted any such assumption at all on this occasion, though, as we shall presently see, he unfortunately has done so in the sequel of his memoir, and thereby introduced all manner of inconsistencies.

But, independently of the incompatibility of the two assumptions, the extreme rapidity or short duration of the vibrations, whilst it gives some probability to the first, throws as much doubt on the second. Nay, any thing like a strict fulfilment of the second assumption seems, on this and various other accounts, to be extremely improbable, particularly because, in order to preserve a uniform arrangement, it would require the most of the particles, notwithstanding the rapidity of their vibrations, to describe lines deviating so much and in all manner of ways from the direction in which a clear sound is understood to be propagated, that, granting such interwoven vibrations to be possible, they could be expected to produce nothing but a very confused noise. Nor is it easy to conceive how, on that supposition, two different sounds could ever cross each other's paths without seriously interfering, which does not appear to be the fact. On the other hand, if we may not strictly adhere to the first assumption, yet, by taking a mean between the two, it would follow that the increase of the repulsion due to condensation, and the diminution of it due to dilatation, being both of them principally if not entirely confined to the direction of the sound, they would both be so much the greater in that direction; and by thus constituting an increased disturbance in the equilibrium of the repulsion reckoned in that same direction, they would have a precisely similar effect on the result, as if the pressure of the air in its otherwise supposed strictly fluid character had followed the ratio of a higher power of the density than it really does. Now, such an effect would obviously tend to shorten the duration of the vibrations, or to increase the theoretical velocity of sound, which is just the thing required in order to make it agree with observation.

The preceding remarks become far more striking with respect to the attempt which Poisson has always been considered to have made successfully (*Journal Polytechnique*, tome vii. p. 364), to show that the velocity of sound would still be the same, although the vibrations were considerable, and confined to a single straight line.

Doubts have been started if the air really consists of particles, and whether it may not rather have some undefinable constitution; but such vague considerations cannot materially alter the case, whilst there can be no question that the air, like all other matter, has inertia when at rest, and momentum when in motion; and also that as long as it is considered to preserve or act strictly in its fluid character, the matter of which any minute volume of it consists must be uniformly distributed. For it is upon properties essentially the same with these that the above remarks are founded. (E. E. E.)

Sound, in *Geography*, denotes in general any strait or inlet of the sea between two headlands. The name is given by way of eminence to the strait between Sweden and Denmark, joining the German Ocean to the Baltic, being about three miles over.

Sound-Board, the principal part of an organ, and that which makes the whole machine play. It is a reservoir, into which the wind, drawn in by the bellows, is conducted by a port-vent, and thence distributed into the pipes placed over the holes of its upper part. The wind enters them by valves, which open by pressing on the keys, after the registers are drawn, by which the air is prevented from passing into any of the other pipes besides those in which it is required.

Sound-Board also denotes a thin broad board placed over the head of a public speaker, to enlarge or extend and strengthen his voice. Sound-boards are found by experience to be of no use in theatres, as their distance from the speaker is too great to be impressed with sufficient force. But sound-boards over a pulpit have frequently a good effect, when the case is constructed of a proper thickness, and according to particular principles.

SOUNDS, Musical. See Music.

SOUNDING, the operation of trying the depth of the sea and the nature of the bottom, by means of a plummet sunk from a ship to the bottom. There are two plummets used for this purpose; one of which is called the *hand-lead*, weighing about eight or nine pounds; and the other the *deep-sea lead*, which weighs from twenty-five to thirty pounds; and both are shaped like the frustum of a cone or pyramid. The former is used in shallow waters, and the latter at a great distance from the shore, particularly on approaching the land after a sea-voyage. Accordingly the lines employed for this purpose are called the *deep-sea lead line*, and the *hand-lead-line*. The hand-lead line, which is usually twenty fathoms in length, is marked at every two or three fathoms; so that the depth of the water may be ascertained either in the day or night. At the depth of two or three fathoms there are marks of black leather; at five fathoms, there is a white rag; at seven, a red rag; at ten, black leather; at thirteen, black leather; at fifteen, a white rag; and at seventeen, a red rag.

Sounding with the hand-lead, which by seamen is called *heaving the lead*, is generally performed by a man who stands in the main chains to windward. Having the line quite ready to run out without interruption, he holds it nearly at the distance of a fathom from the plummet; and having swung the latter backwards and forwards three or four times, in order to acquire the greater velocity, he swings it round his head, and thence as far forward as is necessary; so that by the lead's sinking while the ship advances, the line may be almost perpendicular when it reaches the bottom. The person sounding then proclaims the depth of the water, in a kind of song resembling the cries of hawkers in a city. Thus, if the mark of five fathoms is close to the surface of the water, he calls, "By the mark five;" and as there is no mark at four, six, eight, &c. he estimates those numbers, and calls, "By the dip four," &c. If he judges it to be a quarter or an half more than any particular number, he calls, "And a quarter five, and a half four," &c. If he conceives the depth to be three more than a particular number, he calls it a quarter less than the next: thus, at four fathoms and three fourths he calls, "A quarter less five."

The deep-sea lead is marked with two knots at twenty fathoms, three at thirty, and four at forty, and so on to the end. It is also marked with a single knot in the middle of each interval, as at twenty-five, thirty-five, forty-five fathoms, &c. To use this lead more effectually at sea, or in deep water on the sea-coast, it is usual previously to bring to the ship, in order to retard her course: the lead is then thrown as far as possible from the ship on the line of her drift, so that, as it sinks, the ship drives more perpendicularly over it. The pilot, feeling the lead strike the bottom, readily discovers the depth of the water by the mark on the line nearest its surface. The bottom of the lead being also well rubbed over with tallow, retains the distinguishing marks of the bottom, as shells, ooze, gravel, &c. which naturally adhere to it. The depth of the water, and the nature of the ground, which is called the *soundings*, are carefully marked in the log-book, as well to determine the distance of the place from the shore, as to correct the observations of former pilots.

SOURABAYA, a large and flourishing town of Java, on the north-eastern coast, and capital of a government of the same name, subordinate to that of Java. It is situated at the mouth of a river, navigable for vessels of 100 tons one mile and a half from the sea-shore. The harbour is one of the most convenient in the island; it is broad and spacious, secure against the violence of the sea and wind; and it is mentioned by Sir Stamford Raffles, that it may be rendered impregnable to any hostile attack.[1] It is formed by the approaching extremities of the islands of Java and Madura, which in some places are not above eighty-three fathoms distance for about ten or fifteen miles. This strait is not of easy navigation, but it is marked all along by buoys; and is, besides, defended by strong batteries. One of these, a circular battery, has a commanding sweep across the Strait of Madura, which is narrowest there, being opposite to the south-west end of the island of that name. The eastern entrance being impassable for large ships, the batteries are still incomplete on that side; but the north-western entrance is defended by Fort Ludowyk, distant from Gressie about six, and from Point Panka about five miles. It presents, low on the water, a hundred pieces of the finest ordnance, mounted on traversing carriages, besides some heavy mortars. The European part of the town is separated from the Chinese part, and from the native quarter, by the river; but is connected with it by a fine drawbridge. The houses are very good, some of them elegant, particularly the newly erected country-seats of private individuals. The house of the British resident at Simpang is a fine large building, close to the river; and near it the general hospital is unequalled in elegance and commodiousness. Sourabaya has been greatly improved within these few years, in proportion as the neighbouring town of Gressie has fallen into decay. A fine arsenal, and other extensive works, calculated for equipments on a very large scale, were formed by General Daendels at this place. Vessels are built and equipped at Sourabaya. Abundance of timber is procured from the adjoining forests, which is floated down the river that takes its rise from a large inland lake encircled with high mountains. Here is also a mint, from which silver and copper coins are issued. A new government-house was begun at Sourabaya, and was designed to be a splendid edifice; but the foundation of the front range having sunk, and endangered the building, the plan was abandoned, and that part which continued firm was converted into store-rooms. Ships from Batavia bound to China or the Philippines generally touch for refreshments at this place, especially during the north-west monsoon. The surrounding country is fertile, and shaded by thickets of bamboos, bananas, and other shrubs. The adjacent country is remarkably populous; and the villages of the Javanese, Malays, and Chinese are so populous that they appear to be a continuation of the town. Long. 112. 55. E. Lat. 7. 14½. S.

SOURERA, a town of Hindustan, province of the Circars, and district of Ganjam. Long. 84. 37. E. Lat. 19. 53. N.

SOURGOUTE, a small town of Asiatic Russia, situated on the Obi, in a climate so severe that no grain can be raised in the neighbourhood. The town consists of 168 houses, and contains two churches. It is the residence of a commissary, who collects an annual tribute of furs from the Ostiaks, the inhabitants of the country.

SOURGOUTE, a river of Tobolsk, in Asiatic Russia, which falls into the Obi near the town of the same name, after a course of 100 miles.

SOUTCHEOUFOU, a large city of China, and capital of the province of Kiangnan, situated on the great canal, not far from its southern termination at Hangtcheoufou. It is one of the finest cities in China, noted for the beauty of its site, which is intersected by rivers and canals, and is compared by Europeans to Venice. This city is celebrated as an emporium of pleasure, and supplies the country with the choicest rope-dancers, jugglers, and the best actors; is famed for the beauty of its females; and is, in consequence, the residence of great numbers of the rich and voluptuous Chinese. The walls are more than four leagues in compass; and the suburbs extend along the canal, which is everywhere crowded with large barks, that afford a permanent residence to many of the inhabitants. It has an extensive manufacture of brocade and embroidery; and, from the continual bustle and crowds in the streets, it has the appearance of a great centre of trade. Long. 120. E. Lat. 31. 22. N.

SOUTH, one of the four cardinal points from which the winds blow.

SOUTH, *Robert*, an eminent divine, was the son of William South, a merchant of London, and was born at Hackney, near that city, in 1633. He was educated at Westminster school, and afterwards in Christ-Church College, Oxford. In 1654, he wrote a copy of Latin verses to congratulate Cromwell upon the peace concluded with the Dutch; and the next year a Latin poem, entitled *Musica Incantans*. In 1660, he was elected public orator of the university; and the following year became domestic chaplain to Edward earl of Clarendon, lord high chancellor of England. In 1663 he was installed prebendary of Westminster, admitted to the degree of D. D., and had a sinecure in Wales bestowed on him by his patron, the earl of Clarendon; after whose retirement into France in 1667, he became chaplain to the duke of York. In 1670 he was installed canon of Christ-Church; and in 1676 attended as chaplain to Laurence Hyde, Esq. ambassador extraordinary to the king of Poland. In 1678 he was presented to the rectory of Islip in Oxfordshire; and in 1680 rebuilt the chancel of that church, as he afterwards did the rectory-house belonging to it. After the revolution he took the oath of allegiance to King William and Queen Mary, though he excused himself from accepting a great dignity in the church, vacated by the personal refusal of that oath. His health began to decline several years before his death, which happened in 1716. He was interred in Westminster Abbey, where a monument is erected to his memory. He published, 1. Animadversions on Dr Sherlock's Vindication of the Holy and ever Blessed Trinity; 2. A Defence of his Animadversions; 3. Sermons, 8 vols. 8vo. And after his decease were published his *Opera Posthuma Latina*, and his posthumous English Works. Dr South was remarkable for his wit, which abounds in all his writings, and particularly in his sermons; but at the same time they equally abound in ill humour, spleen, and satire. He was remarkable for being a time-server. During the life of Cromwell he was a staunch Presbyterian, and then railed against the Independents; at the Restoration he exerted his pulpit-eloquence against the Presbyterians; and in the reign of Queen Anne was a warm advocate for Sacheverel.

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[1] Raffles's History of Java, vol. i. p. 12.

South Cape, at the southern extremity of New Holland. Long. 146. 56. E. Lat. 43. 47. S.

South-east Islands, a group of islands, forming part of Recherche Archipelago, on the south coast of New Holland. Lat. 33. 53. S.

South Island, a small island in the Eastern Seas, near the south-west coast of the island of Boutton. Long. 122. 50. E. Lat. 5. 42. S. This is also the name of a small island in the Indian Sea, near the eastern coast of Madagascar. Long. 50. 20. E. Lat. 17. S. There is another small island of this name near the south coast of the island of Celebes. Long. 120. 51. E. Lat. 5. 45. S.

South of India, a division of Hindustan, which is of a triangular figure, and has the Krishna river for its base, Cape Comorin the apex, while the sides are formed by the coasts of Coromandel and Malabar. It is 600 miles in length from Cape Comorin to the Krishna, and 500 miles in breadth where broadest. The great feature of this extensive region is the central table-land, from 3000 to 5000 feet above the level of the sea, separated by a wild, abrupt, and mountainous country, from the low plains to the east and west, which form a belt of small but unequal breadth between the hills and the sea. In this division of India may be seen the Hindu manners in their primitive simplicity, especially in Tinnevelly and the adjacent districts. The Mahommedans are few in comparison with the native Hindus, over whom twenty centuries have passed without making any change in their habits. Southern India has suffered grievously from the devastations of war, and fully as much from the cruel extortion of its rulers. The territories comprehended in this division of the country are, a small portion of the Bejapoor province, the Balaghaut ceded districts; the Carnatic, Northern, Central, and Southern; Mysore, Canara, Malabar, Barramahal, Coimbetoor, Dindigul, Salem and Kistnagherry, Cochin and Travancore; a detailed description of which will be found under their respective appellations.

South Sea, or *Pacific Ocean*, is that vast body of water interposed between Asia and America. It does not, however, strictly speaking, reach quite to the continent of Asia, excepting to the northward of the peninsula of Malacca; for the water interposed between the eastern coast of Africa and the peninsula just mentioned has the name of the *Indian Ocean*. The South Sea, then, is bounded on one side by the western coast of America, through its whole extent, from the unknown regions in the north to the Straits of Magellan and Terra del Fuego, where it communicates with the southern part of the Atlantic. On the other side, it is bounded by the coast of Asia, from the northern promontory of Tschukotskoi Noss, to the peninsula of Malacca already mentioned. Thence it is bounded to the southward by the northern coasts of Borneo, Celebes, Macassar, New Guinea, New Holland, and the other islands in that quarter, which divide it from the Indian Ocean. Then, washing the eastern coast of the great island of New Holland, it communicates with that vast body of water encompassing the whole southern part of the globe, and which has the general name of the *Southern Ocean*. Thus does this vast ocean occupy almost the semicircumference of the globe, reaching nearly from one pole to the other, and about the equatorial parts extending almost 180° in longitude, or 12,500 of our miles. The northern parts of the Pacific Ocean are entirely destitute of land, not a single island having yet been discovered in it from the latitude of 40° north and upwards, excepting such as are very near the coast either of Asia or America; but in the southern part the islands are very numerous. See Polynesia.

South-west Cape, on the south coast of New Holland, in the South Pacific Ocean, north-west of South Cape. Long. 146. 7. E. Lat. 43. 32. S.

South-west Isles, a group of islands, seven in number, dependent on the Banda Islands. Kissier is the chief, which lies to the south-west of them all. They are low, and surrounded by shoals and rocks, and are inhabited by a ferocious and perfidious race, resembling those of New Guinea, who seem to have sprung from the Papuas or aborigines of that country, and the Caffres of Africa. They produce sandal-wood. The Dutch had a commercial establishment here. Population 36,266.

SOUTHAM, a small town of the hundred of Knightlow, in the county of Warwick, eighty-three miles from London. It has little or no trade. The inhabitants amounted in 1801 to 935, in 1811 to 1007, in 1821 to 1161, and in 1831 to 1256.

SOUTHAMPTON, a town of Hampshire, seventy-seven miles from London. It is finely situated at the junction of the river Test with the Itchen; these form an expanse of water, by which vessels may approach the town. It was anciently fortified, and the remains of its walls and castle still exist. It is one of the best-built towns of England. The High Street is broad and well paved. Southampton contains five parish churches, several alms-houses, a grammar school, some convenient bathing-houses, public rooms, and an elegant theatre. The borough was incorporated by Charles I., and is governed by a mayor, recorder, bailiffs, sheriff, and common-council men. It returns two members to parliament. It is in fact a county of itself, having its own magistrates, of whom the bishop of Winchester is one. This town has long been a place of great trade with Portugal, chiefly for the importation of port-wine and fruit. It has also some trade with France, with the islands of Guernsey, Jersey, Alderney, and especially with the Isle of Wight, to which place packet-boats are constantly sailing. The mildness of the air, the facility of making excursions by water as well as by land, the vicinity of the Isle of Wight and of New Forest, contribute to render the town a desirable place for either a temporary or a permanent residence, which is further recommended by the excellent supplies of fish, fruit, meat, and other necessaries. The railway which connects Southampton with the metropolis will greatly tend to promote its prosperity. The inhabitants amounted in 1801 to 7629, in 1811 to 9258, in 1821 to 13,913, and in 1831 to 19,324.

SOUTHEND, a hamlet in the parish of Prittlewell, in the hundred of Rochford and county of Essex, forty-two miles from London. It stands at the mouth of the Thames, opposite to Sheerness; and from its easy communication with the metropolis, it has of late years been resorted to by considerable numbers for sea-bathing.

SOUTHERNE, Thomas, an eminent dramatic writer, was born at Dublin in 1660, and received his education in Trinity College. He came young to London to study law; but instead of that, devoted himself to poetry and the writing of plays. His Persian Prince, or Loyal Brother, was introduced in 1682, when the Tory interest was triumphant in England; and the character of the Loyal Brother being intended to compliment James duke of York, he rewarded the author when he came to the throne with a commission in the army. On the Revolution taking place, he retired to his studies, and wrote several plays, from which he is supposed to have derived a very handsome subsistence, being the first who raised the advantage of play-writing to a second and third night. The most finished of all his plays are the Fatal Marriage, or the Innocent Adultery; and Oroonoko, or the Royal Slave, which is built on a true story related in one of Mrs Behn's novels.

Mr Southerne died in 1746, in the eighty-sixth year of his age; the latter part of which he spent in a peaceful serenity, having, by his commission as a soldier, and the profits of his dramatic works, acquired a handsome fortune, and being an exact economist, he improved what fortune he gained to the best advantage. He enjoyed the longest life of all our poets, and died the richest of them, a very few excepted. His plays are printed in three volumes 12mo. See the Biographia Dramatica, vol. i. p. 680.

SOUTH-MOULTON, a market-town, in the hundred of the same name, in the north part of the county of Devon, 179 miles from London, and twelve miles from Barnstaple. It stands on the river Moule, and contains many good houses, a large and handsome church, a commodious guild-hall, and a free grammar-school. The population amounted in 1821 to 3314, and in 1831 to 3826.

SOUTHWARK, a borough in the county of Surrey, but one of the suburbs of London, being only separated from it by the river Thames. The means of access have been greatly increased by a new bridge, and by the rebuilding of London Bridge. It contains six parishes, and, as to its police, is in a great degree under the control of the magistracy of the city. As it in fact forms a district of the capital, it is described under the head LONDON.

SOUTHWELL, a town of the hundred of Thurgarton, in the county of Nottingham, 139 miles from London. It is situated on a pleasing elevation above the plain watered by the river Trent. The parish church is collegiate, and well endowed, having sixteen prebendaries, besides choristers and singing boys. The chapter has jurisdiction over twenty-eight parishes. Its house was erected in 1377, and its library rebuilt in 1784. There are remains of an old palace belonging to the archbishops of York, with a beautiful walk on the north side of the church. There is a well-endowed and well-conducted free grammar-school, and a good market on Saturday. The inhabitants amounted in 1801 to 2305, in 1811 to 2674, in 1821 to 3051, and in 1831 to 3834.

SOUTHWOLD, a seaport town of the hundred of Blything, in the county of Suffolk, 105 miles from London. It is situated on the river Blythe. It is connected with the port of Yarmouth, but has a corporation of its own. The herring-fishery is extensively carried on in it, and of late years it has been resorted to for sea-bathing. The inhabitants amounted in 1821 to 1676, and in 1831 to 1875.

SOVEREIGN, in matters of government, is applied to the supreme magistrate or magistrates of an independent government or state; because their authority is only bounded by the laws of God and the laws of the state: such are kings, princes, &c.

SOVEREIGN POWER, or *Sovereignty*, is the power of making or sanctioning laws; for wherever that power resides, all others must conform to it, and be directed by it, whatever appearance the outward form and administration of the government may assume. For it is at any time in the option of the legislature to alter that form and administration by a new edict or rule, and to put the execution of the laws into whatever hands it pleases; and all the other powers of the state must obey the legislative power in the execution of their several functions, or else the constitution is at an end. In our constitution the law ascribes to the king the attribute of sovereignty; but that is to be understood in a qualified sense; that is, he is supreme magistrate, not sole legislator, as the legislative power is vested in the king, lords, and commons, not in any of the three estates alone.

SOZOMENUS, HERMIAS, an ecclesiastical historian of the fifth century, was born at Gaza or Bethelia, in Palestine. He was educated for the law, and became a pleader at Constantinople. He wrote an abridgment of Ecclesiastical History, in two books, from the ascension of our Saviour to the year 323. This compendium is lost; but a continuation of it in nine books, written at greater length, down to the year 439, is still extant. He seems to have copied Socrates, who wrote a history of the same period. The style of Sozomenus is perhaps more elegant; but in other respects he falls far short of that writer, displaying throughout his whole book an amazing credulity, and a superstitious attachment to monks and the monastic life. His work, with those of Eusebius and Socrates, was published by R. Stephanus in 1544, by H. Valesius at Paris in 1668, and by Reading at Cambridge in 1720. All these editions are in folio. Several others have likewise appeared.

SPA, a town of the Netherlands, in the province of Liege and arrondissement of Verviers. It is one of the oldest, and was the most frequented, of the continental watering places. Its name has become generic for similar springs. It is situated in a narrow valley watered by a rapid and clear brook. The town consists of detached houses of all sizes, appropriate to the circumstances of the several classes of visitors.

The most remarkable waters are, 1. The Pouhon, situated in the middle of the town, which is more strongly impregnated with steel than the others; 2. The Sauveniere, a mile and a half east from it; 3. Groisbeck, near to the Sauveniere; 4. Tonnelet, situated a little to the left of the road which leads to the Sauveniere; 5. Geronstere, two miles south from Spa; 6. Wartroz, near to the Tonnelet; 7. Sarts or Niveset, in the district of Sarts; 8. Chevron or Bru, in the principality of Slavelot; 9. Couve; 10. Beverse; 11. Sige; 12. Geremont. These four last are near Malmedy.

Dr Brownrigg was the first person who discovered that carbonic acid gas forms a principal ingredient in the composition of the Spa waters, and actually separated a quantity of this elastic fluid, by exposing it to different degrees of heat from 110° to 170° of Fahrenheit. From twenty ounces seven drams and fourteen grains apothecaries' weight of the Pouhon water, he obtained eight ounces two drams and fifty grains.

The Spa waters are diuretic, and sometimes purgative. They exhilarate the spirits; and are more cooling, and allay thirst more effectually, than common water. They are found beneficial in cases of weakness and relaxation, either partial or universal; in nervous disorders; in obstructions of the liver and spleen; in cases where the blood is too thin and putrescent; in cases of excessive discharges proceeding from weakness; in the gravel and stone; and in most cases where a strengthening remedy is wanted. But they are hurtful in confirmed obstructions attended with fever, where there is no free outlet to the matter, as in ulcerations of the lungs. They are also injurious to bilious and plethoric constitutions, when used before the body is cooled by proper evacuations.

Spa was more fashionable formerly than it is at present. There are in it manufactures of iron, wood, and gilt toys. The resident inhabitants are about 3300.

SPACAFORNO, a city of the island of Sicily, in the province of Noto. It stands in a healthy situation on a hill, near the seaports of La Marza, and Santa Maria. It contains 8100 inhabitants, employed in various trades. Near to it is the Troglodyte town of Ispica, where the houses are excavated in calcareous rocks on both sides of a narrow valley.

SPAGIRIC ART, a name given by old authors to that species of chemistry which works on metals, and is employed in the search of the philosopher's stone.

SPAHIS, horsemen in the Ottoman army, chiefly raised in Asia. The great strength of the grand signior's army formerly consisted in the janisaries, who were the foot, and the spahis, who were the cavalry.

SPAIN.

History.

The kingdoms of Spain and Portugal together form what is called the Pyrenean Peninsula, the most southerly, and at the same time the most westerly, portion of Europe. Except on the north-east, where it is connected with the rest of Europe by an isthmus about one hundred miles in breadth, this peninsula is wholly surrounded by the ocean. Spain, which occupies by far the greater part of it, has for its boundaries on the south and south-east the Mediterranean Sea; on the west, partly the long and narrow territory of Portugal, partly the Atlantic Ocean; on the north, the Bay of Biscay; and on the north-east the Pyrenees, a chain holding the second rank among the mountains of Europe, and forming a well-defined line of separation between France and Spain.

That the Peninsula was peopled at a very early period seems abundantly certain, but by whom it would be vain to inquire. The traditions which ascribe its colonization to Tubal, the grandson of Noah, may be allowed to repose undisturbed in the obscurity of the chronicles in which they are embodied. The earliest inhabitants whom history makes known to us were the Iberians, a race probably of Asiatic origin. At some period lost in the depths of antiquity, the Celts, amid their wide-spread migrations, penetrated into the Peninsula; but we are still ignorant how they entered the country, and whence they came, although these subjects have been matter of keen disputation. The two nations appear at first to have contended for the sovereignty of the soil, but finally to have amalgamated, to have shared the country between them, and, as a united people, to have assumed the compound name of Celtiberians. They were split into numerous tribes or clans, each of which occupied its own particular territory.

The delightful climate which Spain enjoys, the fertility of its soil, and the mines of gold, silver, and iron, by which it is enriched, proved powerful attractions to the Rhodians and Phœnicians, who established colonies in the country at a very early period. But the Carthaginians were the people who obtained the firmest footing in it. Availing themselves of the pretext of commerce, they frequented the coast of Cadiz, where they succeeded in erecting fortresses, dwelling-houses, temples, and buildings where business was transacted; and pushing their conquests into the interior as well as along the coast, they at length made themselves masters of the whole of Bætica or Andalusia, employing force when artifice failed. The Spaniards were roused to make resistance, but it was too late. Hamilcar, father of Hannibal, succeeded in overrunning a considerable part of the country, and bringing it, at least nominally, under subjection to Carthage, 238 years before the birth of Christ. He extended his conquests towards Murcia, Valencia, and Catalonia, in the latter of which provinces he founded the city of Barcelona. This conqueror having perished in a battle fought with some of the native tribes, was succeeded by his son-in-law Asdrubal, who built the port of New Carthage, now called Carthagena. The rapid strides which the Carthaginians had made towards the total subjugation of the Peninsula, aroused the fears of the Greek colonies situated on the coast of Catalonia and Valencia, and alarmed those tribes in the interior who still stoutly maintained their independence. Too weak to make head against Carthage themselves, they applied to the Romans for assistance. This great nation had long regarded with a jealous eye the growing prosperity of its rival Carthage, and eagerly embraced the cause of the discontented states. In the character of ally and protector, Rome sent a deputation to Carthage, and obtained from its senate two important concessions; that the Carthaginians should not extend their conquests beyond the Ebro; and that they should not disturb the Saguntines and the other Greek colonies. But these conditions, although agreed to, did not correspond with the gigantic designs which Asdrubal had formed. The Romans, fully aware of the vast riches which the Carthaginians drew from Spain, and of the immense value of such a country to themselves in prosecuting their own ambitious schemes of foreign conquest, had entered into close alliance with some of the discontented tribes, no doubt with the ulterior view of subjecting them to their own domination. Saguntum, one of the most flourishing cities of the Peninsula, was one of these allies of Rome; and Asdrubal, in the prosecution of his design of subduing the whole of Spain before Rome could send succours to the confederates, collected a considerable force and marched against this city. On his way, however, he was assassinated by a slave; but the chief command passed into still abler hands, those of the renowned Hannibal. This famous Carthaginian was then in his twenty-fifth year, and greatly esteemed for his valour and his talents. After having conquered the kingdom of Toledo, he besieged Saguntum with his whole force, which is said to have amounted to 150,000 men. The Romans lost much time in fruitless attempts at negociation, and failed to send prompt succour to its faithful ally. The consequence was, that after a vigorous defence, the Saguntines were so reduced by hunger and fatigue, that they retired from the walls into the centre of the city, where they amassed all their valuable effects, and every thing combustible, into one vast pile. Placing their wives and children around it, they themselves issued from the gates and plunged sword in hand into the midst of the Carthaginians. The slaughter was prodigious on both sides, but in the end the Saguntines were cut off almost to a man. No sooner was their fate known in the city than their wives set fire to the pile, and precipitated themselves and their children into the devouring element. Thus perished Saguntum, one of the largest and most flourishing cities of Spain; and its destruction may be regarded as the opening of the second Punic war. Of the contests carried on between the Carthaginians and the Romans, till the final subjugation of the former, and the consequent incorporation of its territories with the Roman empire, an account will be found under the articles CARTHAGE and ROMAN HISTORY. We shall only in this place notice such leading events as are necessary to give clearness and connection to our narrative.

Two centuries were required by Rome to effect the total subjugation of Spain, that is, from the first invasion of the country by Cneus Cornelius Scipio in the year 218 B. C., till the last tribes, the Cantabrians and Asturians, laid down their arms to Augustus in the year 19 B. C. No other conquest had cost Rome so much. The numbers who perished in the field of battle, and the amount of treasure sacrificed, are not to be calculated. At the same time, scarcely any other acquisition was productive of so much advantage to the state, from the inexhaustible riches of the country. After the destruction of the Carthaginian power in Spain, this country was regarded as a Roman province, received the name of Hispania, and was divided by the senate into Citerior and Ulterior, or Hither and Farther; the Ebro serving as a boundary between the two. Each of these was governed by a prætor, annually appointed by Rome. The extortions of these functionaries very soon became so oppressive to the natives, that they at last resolved on attempting to rid themselves of their unprincipled rulers. Viriathus, a native of Lusitania, the most remarkable man in the ancient history of Spain, collected a considerable body of malcontents, and took the field against the Romans. Not only by stratagems and sudden surprises, but in regular pitched battles, he succeeded in foiling the most valiant officers of the Roman legions. For above eleven years he bade defiance to the formidable hosts of the invader. To subdue him by force of arms was found impossible, and the base spirit of Q. Servilius Cæpio had recourse to treachery. The offer of a magnificent recompense stimulated three of the followers of Viriathus to assassinate him, which bloody deed they accomplished whilst he lay asleep. It is some consolation to record, that the murderers were disappointed of their reward, and dismissed from the Roman camp with insults and contempt. The indomitable spirit of independence which animated the Spaniards was not, however, broken by the death of their great leader. The Numantians, in particular, still remained fiercely hostile to the Romans, and the destruction of Numantia was decreed by the senate. Scipio Æmilianus, the conqueror of Carthage, was appointed to the command of the legions destined for this service, and the city was closely invested by a powerful army. While food was left to the besieged, they defied all the efforts of the Romans to take their city. Famine however humbled them into submission, and they sued for mercy, but in vain. Driven to desperation, the wretched remains of the defenders issued from the gates, and fell with fury upon the Roman intrenchments; but they were forced back within the walls. Æmilianus had formed the cruel resolution of starving them into an unconditional surrender. Rather than yield to this, the Numantians determined, in imitation of the Saguntines, to make a sacrifice of themselves, and of all that was valuable which they possessed. This resolution they carried into effect under circumstances even more shocking than those which accompanied the destruction of Saguntum. When the victor entered the city, not a human being remained alive to grace his triumph; nothing met his eyes but smouldering ruins and a horrible solitude. This event took place in the year 133 B. C.

After the destruction of Numantia, three fourths of the Peninsula submitted to Rome; and nothing very remarkable occurs in its history till the time of the civil war between Marius and Sylla. The latter having crushed the Marian faction, proscribed those who had taken a part in it, whom he could not immediately destroy. Among these was Sertorius, who had previously served in Spain as a tribune; a man of great bodily and mental endowments, of consummate valour, and experience in the art of war, but whose ambition was equal to his nobler gifts. Having escaped to Spain, he there succeeded in gaining over to his interest several of the native tribes, raised a considerable army, and routed the Roman legions in repeated engagements. He introduced a strict order of discipline among his troops, founded public schools, constituted a senate in imitation of that of Rome, and attempted to establish in Spain a rival sovereignty to that of Italy. But, in the midst of these brilliant though ambitious undertakings, Sertorius was basely assassinated by his subaltern Perpenna, in the year 73 B. C. With the death of this great captain expired the last faint glimmer of national independence. Pompey, and afterwards Julius Cæsar, reduced most of the native tribes to subjection. After the fall of Pompey in Africa, his eldest son selected Spain as the fittest scene for opposing the dreaded dictator. For the fourth time, Cæsar hastened to the Peninsula, and, on the plains of Munda, gained a bloody but decisive victory over the younger Pompey, who was slain in attempting to effect his escape from the country. Augustus, the successor of Cæsar, effectually secured the dominion of Rome over Spain, having reduced the Asturians, Galicians, and Cantabrians, the bravest and most warlike of the native tribes. Spain now began to rest from the continual wars with which it had been devastated from the period of the Carthaginian conquest, and quietly submitted to the domination of Rome, from which it received its religion, its laws, its manners, and its language.

It has already been noticed that the country was at first divided into two provinces, Citerior and Ulterior, between which flowed the Ebro as the natural boundary. With the advance of the Romans the size of the provinces increased, but it is impossible to define their exact limits before the time of Augustus. This emperor, less desirous of effecting new conquests than of securing the old, made arrangements for improving the condition of the whole peninsula. Out of the two provinces he formed three, and gave them the names of Tarraco, Lusitania, and Bætica. Under the pretext of saving time and trouble to the senate, but really for the purpose of retaining power over the whole army in his own hands, he undertook the management of two of the provinces, in which, on account of the pretended insecurity of their situation, a considerable number of troops was maintained. Only Bætica came under the direct control of the senate. A proconsul, who had his seat at Hispalis, was installed governor of this province, but without any military power; whilst in the imperial provinces, a legatus Augustalis in Emerita, and a legatus proconsularis in Tarraco, exercised complete civil and military authority. Subsequently the province conceded to the senate fell entirely under the sway of the emperor, when the governor received the name of præses or president. The districts being very extensive, it was found necessary to appoint inferior officers; under the legate of Lusitania was placed a vice-legatus militaris, and there were three placed under the consular legates of Tarraco. A legate and a quæstor were subject to the proconsul of Bætica. In this manner the country as a whole was divided. Let us now take a glance of the constitution and condition of the towns.

After the complete subjugation of the Peninsula, the cohorts, composed principally of the natives of the country, were transplanted to the most distant parts of the empire, while Roman legions were sent into Spain to supply their place. No arrangement could have been made that was better calculated to give a Roman impress to the character of the people, and to their manners, customs, and establishments. In the interior of the country, towns purely Roman sprung up, small tracts of country having been conferred on soldiers as a reward for their services. Thus the town of Leon is indebted for its name and origin to the seventh legion, which settled there; and in the same manner arose Emerita Augusta (Merida), Pax Julia (Beja), Cæsar Augusta (Saragossa), and many others. Originally, most of the cities managed their own affairs; but when Caracalla declared all his subjects throughout his vast empire Roman citizens, the constitutions of the cities of Spain were made uniform with those of the other cities of the empire. Rome, the capital, was the great type to which they all conformed. For purposes of general police, and for the superintendence of public works, fortresses, entertainments, and the like, ædiles were appointed in provincial towns, whose office, however, was one more of pomp and honour than emolument. The affairs of the cities were universally administered by a council or curia, the members of which, called *decuriones*, were chosen from among the richest and most respectable of the inhabitants. As advocates or defenders of the people, there were the *defensores civitatum*, who neither belonged to the body of the decurions nor to the army, but formed rather a sort of check upon these, and resisted the encroachments of power on the rights of the citizens. We pass over a number of other subordinate functionaries, whose duties are either imperfectly known, or, where known, of minor importance.

All matters not cognizable by the legal tribunals, nor af-

History.

fecting the interest of the emperor, were discussed in the assembly of the decurions. For all important affairs, such as those affecting the welfare of the whole district, the decurions of the principal city of a province could call a general assembly, *concilium*, to which the other towns sent plenipotentiaries. Long after the comitia had ceased to exist in Rome, the province enjoyed the privilege of calling together such meetings; and they served at the same time as a means of making known their wants to the emperor.

Of all the provinces incorporated with the Roman empire, there was not one productive of so much gain, not one in which such inexhaustible sources of wealth were discovered, as the Pyrenean Peninsula. Mines, rich in the precious metals,[1] satisfied the thirst of the Romans for gold; and a soil nowhere surpassed in productiveness filled their granaries with corn. During the republic the Peninsula was laid under the obligation of supplying the capital of the empire with the twentieth part of its corn harvests. The price paid for the grain was fixed by the Roman senate itself, a convenient way of obtaining cheap provisions.

While Spain continued to be ravaged by war, the Romans did not in general bind themselves to a regular system of taxation, but only drew as much from the Peninsula as it was convenient for it to pay at the time; but when the conquest of the country was completed, a fixed rate of taxation was introduced. Consequently, after Augustus had divided Spain in the manner which we have described, the senate sent quæstors into the provinces to collect the taxes. In those provinces placed under the immediate control of the emperor, there were procurators employed; and functionaries of this class were also appointed to look after the monies received by the officers of the senate, the application of the whole being under the entire management of the emperor. These procurators were likewise extremely useful in preventing the subordinates from defrauding the emperor. By degrees their number increased, so that ultimately there came to be procurators, not only for the collective income of a province, but for separate branches of the taxes.

In Spain, as well as throughout the whole Roman empire, the taxes consisted of a capitation and a land tax; but by degrees, more from the extravagance of the emperors than from the necessities of the state, the people came to be burdened with a multitude of other imposts. The towns had their own particular estates and incomes, independent of those of the government, and which were managed by the civic authorities themselves. These served to defray the expenses of erecting public establishments, building fortresses, and instituting games. The contribution to the state taxes paid by the towns was levied by the magistrates from the inhabitants, in exact proportion to their wealth; hence the taxes, although they continued to rise, did not press with unequal and crushing weight upon individuals and classes. Never was Spain so wealthy, so populous, and so industrious, as during the first centuries of the empire. Aqueducts, bridges, amphitheatres, and other magnificent structures, even the ruins of some of which posterity surveys with wonder, still bear testimony to the flourishing condition of the country during that period.

When Constantine the Great assumed the purple, important changes were introduced into the empire. From the province of Tarraco he separated the governments of Carthagena and Galicia, thus making five provinces in the Peninsula, viz. Tarraco, Carthagena, Galicia, Lusitania, and Bætica. Theodosius the Great erected the Balearic Isles into a province, and the African district of Tingitania was also reckoned another, so that there were seven in all. The principal cities of these provinces were as follow: of Bætica, Hispalis; of Lusitania, Emerita; of Galicia, Bracara; of Tarraco, Cæsar Augusta; of Carthagena, New Carthage; of the Balearic Isles, Palma; and of Tingitania, Tingis. The first three were placed under consuls, and the others under presidents (*præsides*). Spain was subject to the prefecture of Gaul, and over these local governors was placed a vicar (*vicarius*), whose administration was chiefly confined to civil affairs, and the count (*comes*), whose functions were of a military nature. Sometimes, however, both the civil and military departments fell to the vicar. We have yet to mention one important event connected with the Roman conquest of Spain, namely, the introduction of Christianity into the Peninsula. This took place so early that the unanimous voice of tradition has ascribed it to St James the elder; and from the same authority we also learn that St Paul preached "Christ crucified" to the idolaters of Spain. Of course little or no reliance is to be placed on such statements; but whether the apostles or their successors propagated the gospel in these regions, certain it is that Spain can adduce her martyrs as early as the second century. There is abundant evidence to prove the antiquity of the persecutions sustained by the Christians of Spain, but our limits prevent us from entering into details.

The prosperity of the Peninsula began to decline after the death of Constantine, A. D. 337. A species of tax introduced by Diocletian, which was made to fall with paralysing weight on the middle or industrious classes, proved so pernicious in its operation, that in a short time the country presented the melancholy picture of deserted towns, fields lying waste, fruit-trees uprooted from the soil, that the possessors of the ground might lessen the value of their property, and thus escape the taxes; trade and manufactures at a stand; in short, nothing but desolation, poverty, and misery, everywhere presented themselves. It only required a strong impulse from without to overwhelm the whole country in ruins. The last day of the year 406 marks the passage of the Vandals, Alans, Suevi, and other Germanic tribes, across the Rhine. From this river to the Pyrenees, terror and dismay announced their approach, death and destruction marked their progress. For a time this great barrier of nature and of nations restrained the roving bands, and the mountain-passes were at first well guarded. But the prolific fields and wealthy mines of Spain were too rich a prey not to be reached at all hazards. Finding an opportunity, when negligence had weakened the line of defence (409), they burst like a torrent through the Pyrenean chain, and poured the tide of destruction from its base to the Pillars of Hercules. Native historians of the Peninsula describe the ravages committed by these barbarians as dreadful and revolting almost beyond parallel. The very wild beasts quitted their lairs to prey upon the human species, too emaciated by famine and pestilence to drive them back. In a word, the country was turned into a desert; and, satiated with carnage and rapine, the barbarians sat down amidst its ruins and divided it by lot. Bætica fell to the Vandals, Lusitania to the Alans, and Galicia, with a great portion of Leon and Castille, to the Suevi. Tarraco alone seems still to have been retained by the Romans.

But a fourth people, more formidable than all the rest combined, came to disturb the new settlers in their possessions. These were the Goths under Ataulphus, to whom Honorius, the Roman emperor, had ceded the fertile provinces of Southern Gaul and the Peninsula. The Gothic monarch espoused Placidia, the emperor's sister, in 414, and immediately proceeded to Barcelona, where, however, he was shortly afterwards assassinated. His successor, Sigeric, a detestable monster, shared the same fate; and the election of the Goths now fell upon Wallia, a chief every way worthy of their choice. Peace being made with Rome, hostilities were vigorously commenced against the kindred barbarians (418). The result of the war was the subjugation of the Suevi, the total destruction of the Alans, and the expulsion of the Vandals from Spain (427). But the restless and powerful Suevi were scotched, not killed. During the reign of Theodoric, Wallia's successor, they became formidable alike to the Romans and the Goths, and made many important conquests in the neighbouring provinces. Theodoric might easily have subdued them had he not been summoned to encounter a far more terrible antagonist, the renowned Attila, with his half million of mounted Huns. The death of the Gothic monarch on the plains of Chalons (451), the elevation of his son Thorismund to the vacant throne, his assassination by his brothers, and the elevation of the elder of the fratricides, Theodoric, were events which closely followed each other. The reign of the last-named prince was diversified by alternate success and disaster. The Peninsula, become one great battle-field to three contending hosts, the Goths, Romans, and Suevi, was plunged in misery, and, from the Pyrenees to the sea of Africa, was overspread with innumerable swarms, which, like so many locusts, utterly destroyed the spots on which they settled. While Theodoric was preparing to conduct an army across the Pyrenees against Remismund, king of the Suevi, he was assassinated by his brother Euric, in his capital of Toulouse (466).

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[1] Gibbon very justly observes, "Spain, by a very singular fatality, was the Peru and Mexico of the old world. The discovery of the rich western continent by the Phœnicians, and the oppression of the simple natives, who were compelled to labour in their mines for the benefit of strangers, form an exact type of the more recent history of Spanish America." Chap. vi.

The reign of Euric was unusually brilliant and successful. He rendered himself absolute lord of the country, by extinguishing the dominion of Rome in it, and completely subjecting the Suevi. Euric was the first legislator of his nation, and the founder of the Gothic kingdom of Spain; for hitherto the country had rather been overrun than subdued. This prince died at Arles, the capital of his empire, A. D. 483. He was succeeded by his son Alaric, a weak sovereign, who, after submitting pusillanimously to many indignities, was overthrown in battle, and slain by Clovis, king of the Franks (506). Amalaric, the son of Alaric, being a minor, was for a time superseded by his natural brother Gensaleic, but ultimately ascended the throne (522). He was the first Gothic king who established his court in Spain. He fixed on the city of Seville. From the death of this prince (531) till Recared I. became king of the Goths (587), a few obscure royal names occur, regarding whom it would be a mere waste of space to enter into details. The chief act of this sovereign was to reclaim his subjects from the heresy of Arianism to orthodox Catholicism. He died in 601. Of eleven monarchs who followed, occupying a period of seventy years, none is in any way remarkable. In 673, Wamba, a man distinguished alike for wisdom, valour, and virtue, was raised, by the unanimous voice of the Gothic electors, to the throne, left vacant by the death of Receswind (672). The early part of his reign was spent in quelling intestine war. During the latter part of it he successfully cultivated the arts of peace, and built a fleet for the protection of the coast; a very wise precaution, for the Saracens had already begun to swarm all over the sea of Africa. Had Wamba been succeeded by monarchs of equal prudence and activity, the scourge of Saracenic domination, the greatest perhaps that ever afflicted any people, would probably have been for ever averted from Spain. In consequence of having sunk into a death-like trance, in which state he was apparelled in the garments of the grave, Wamba was compelled to relinquish the crown (680).

One of the most celebrated names in the line of Gothic princes is that of Roderick, who ascended the throne in 709. He owed his elevation to a party which rose against his predecessor Witiza, whose two sons, with their relations, Count Julian, governor of the Gothic possessions in Africa, and Oppas, an archbishop, are supposed to have aided the Saracens in their design of conquering the Peninsula. At all events, the party which they formed against Roderick weakened the Gothic monarchy, and thus gave encouragement to the Moors to make a descent on the country, which they effected in 711. Roderick marshalled a large army, amounting, it is said, to 90,000 men, and advanced against the audacious infidel. The hosts met upon the plains of Xeres, where was fought a battle, so bravely contested on either side that it seems scarcely unworthy to have decided the fate of a kingdom. For three days, from sunrise to sunset, the embattled squadrons fought with equal ardour and obstinacy, till victory at last declared for the Mahommedans. Roderick himself is believed to have perished in the conflict, as he was never heard of more. By this decisive battle the Moors made themselves masters of nearly the whole of Spain. The wretched remains of the Goths retired into the mountainous parts of Asturias, Burgos, and Biscay, where they maintained their independence, and perpetuated their monarchy. In a few years their power began to revive under the renowned Pelagio or Pelayo, a prince of the royal blood. But before noticing the exploits of this warrior, we shall take a brief view of the political, civil, and religious condition of the people subject to the Gothic monarchy.

The local divisions of Spain, as already laid down, underwent little or no change until some time after the descent of the Mahommedans. The power possessed by the Gothic kings was considerable; but its exercise was greatly controlled by the nobles, in general a fierce, turbulent, and haughty body. The jurisdiction of the monarch was not confined to affairs purely temporal. He nominated bishops, presided, if he chose, at ecclesiastical tribunals, convoked national councils, and regulated the discipline of the church. Next to the king in civil dignity were the dukes, who appear to have been governors of provinces. After them came the counts, whose jurisdiction is supposed to have been confined to particular cities. A number of other functionaries were subordinate to these; and besides the officers of the crown, each city or town had its municipal council. Of course there were regular courts of law instituted throughout the country, where justice was administered; the forms of procedure in these tribunals being much the same as those practised in the Spanish courts at the present day, but less tedious. There was a Visigoth code of laws, partly of Gothic, partly of Roman origin. If we pass from the civil to the military state of the country, we find that the Goths were a nation of soldiers, the obligation of service being imperative on all freemen. After the Gothic power was established in Spain, the constitution of the church underwent important changes. The pope was acknowledged as supreme head, and metropolitan sees were formed, which exercised an ecclesiastical jurisdiction over the suffragan bishops. The bishops possessed an irresponsible power over the rectors, displacing or removing them at pleasure. The cathedrals and parish churches were in general well endowed; lay patronage existed, and monasteries were introduced. As in other countries, the ecclesiastical councils were of a threefold description, diocesan, provincial, and national, convoked respectively by the bishop, the metropolitan, and the king. The Goths present nothing of literature worthy of particular notice. If we pass to the domestic arts, we find still less to admire; in every thing they consulted the useful in preference to the beautiful or magnificent. It is therefore to be concluded, that however devout, temperate, honest, and sincere the Goths might have been, as many historians attest, yet Spain under their dominion made little advancement in civilization and the elegant arts.

The Moors under Tarik and Musa subdued the fairest portion of Spain, including the largest and strongest cities of the kingdom, with a rapidity which shows how completely the power of the Goths was broken. Still many of them preferred independence under severe privations amidst the wild rocks of the Asturias, to abundance and plenty on the fertile plains of Murcia. At the head of those who sought a refuge in this mountain sanctuary was Pelayo, a prince of royal Gothic blood, and who is recognised by Spanish historians as having acceded to the throne in 718; Theodomir, the legitimate monarch, having ingloriously submitted to the yoke of the infidel. Numbers of his countrymen flocked to his standard, and his force became at length so formidable as to create alarm in the Saracens. A large army was despatched to the Asturias to crush the rising insurrection; but in attempting to gain the position where Pelayo and his resolute followers were strongly posted, the Moors were repulsed with a slaughter so terrible, that for some years they showed no inclination to assail their formidable neighbours. Various successes followed, and the Asturias, now left in the undisturbed possession of Pelayo and his band, became the asylum of the liberty and the religion of the Christians in Spain. It formed the nucleus of a kingdom, which was destined slowly but surely to increase in size from century to century, until the invaders were finally expelled from the Peninsula. Little more is known of Pelayo, than that he gained repeated victories over the Moors, and died in peace in 737. He was succeeded by his son Favila, whose reign was brief and his end tragical, he having been killed by a wild boar in 739. The subsequent history of Spain is rendered so confused by the numerous kingdoms established by Christians and Moors, that some chronological guide is necessary to render it intelligible. We shall therefore present a chronological list of the various sovereigns who reigned over different parts of the country, which had been erected into distinct and independent sovereignties. The dates given mark the years in which the sovereigns acceded to the throne; the intervening periods, of course, indicate the duration of their respective reigns. We shall commence with the Mahommedan succession, as during the earlier centuries the greater part of Spain was subject to the Moors.

MAHOMMEDAN RULERS OF SPAIN.—CORDOVA.

1. *Emirs.*—Tarik ben Zeyad and Musa ben Nozeir, 711. Abdelasis ben Musa, 714. Ayub ben Habib and Alhaur ben Abderahman, 715. Alsama ben Melic, 721. Abderahman ben Abdalla, 722. Ambisa ben Sohim, 724. Hodeira ben Abdalla and Yahia ben Zulema, 726. Othman ben Abi Neza, Hodeira ben Alhaus, and Alhaitam ben Obeid, 727. Mohammed ben Abdalla, 728. Abderahman ben Abdalla (second time), 729. Abdelmelic ben Cotan, 733. Ocba ben Albegag, 736. Abdelmelic ben Cotan again, 741. Baleg ben Bakir, and Thalaba ben Sulema, 742. Husam ben Dhizar, 743. Thueba el Ameli, 744. Yussuf el Fehri, 746.

2. *Kings.*—Abderahman I. ben Moawia, 755. Hixem I. Abderahman, 787. Alhakem ben Hixem, 796. Abderahman II. ben Alhakem, 821. Mohammed I. ben Abderahman, 852. Almonahir ben Mohammed, 886. Abdalla, brother of the former, 888. Abderahman III. grandson of Abdalla, 912. Alhakem, II. son of Abderahman III. 961. Hixem II. ben Alhakem II., dethroned to make way for his cousin Mohammed, but restored in 1010; in 1012 finally removed, 976. Suleyman, 1012. Ali ben Hamud, 1015. Abderahman IV. 1017. Alcassim ben Hamud, brother of Ali, 1018. Abderahman V., and Mohammed II. cousin of Hixem II., 1023. Hixem III. brother of Abderahman IV. 1026. Gewahr ben Mohammed, 1031. Mohammed ben Gewahr, 1044. Mohammed Almoateded, 1060. Mohammed Almosstadir, 1069. *Dynasty of the Almoravides.*—Yussef ben Taxfin, 1094. Ali ben Yussef, 1107. Taxfin ben Ali, 1144. *Dynasty of the Almohades.*—Abdelmumen, 1147. Yussef Abu Yacub, son of Abdelmumen, 1163. Yacub ben Yussef, 1178. Mohammed, son of Yacub, 1199. Abu Yacub, 1213. Abulmelic, and Abdelwahid son of Yacub, 1223. Almamon and Abu Ali, 1225.

KINGDOM OF GRANADA.

Mohammed I. Aben Alhamar, founder of the kingdom, 1238. Mohammed II. ben Mohammed, 1273. Mohammed III. Abu Abdalla, 1302. Nassir Abul Giux, brother of the preceding, 1309. Ismail ben Ferag, nephew of Nassir, 1313. Mohammed IV. ben Ismail, 1325. Yussef Abul Hagiag, brother of the former, 1333. Mohammed V. ben Yussef, 1354. Ismail II. brother of Mohammed, 1359. Abu Said, brother-in-law of Ismail II. 1360. Yussef II. Abu Abdalla, son of Mohammed V. 1391. Mohammed VI. son of Yussef II. 1396. Yussef, brother of Mohammed VI. 1408. Muley Mohammed VII. son of Yussef III. 1423. Mohammed VIII. cousin of Muley Mohammed VII. 1427. Mohammed VII. restored, 1429. Yussef IV. Aben Alhamar. Mohammed VII. restored a second time, 1432. Mohammed IX. Aben Osmin (nephew of Mohammed VII.), 1445. Mohammed X. nephew of Mohammed VII. 1454. Muley Ali Abul Hassan, son of Mohammed X. 1463. Abu Abdalla, son of Abul Hassan, 1483. Abdalla el Zagal, brother of Abul Hassan, 1484. Both princes survived the fall of Granada, which took place in 1491.

KINGDOM OF THE ASTURIAS AND LEON.

Pelayo, 718. Favila, son of Pelayo, 737. Alfonso, son-in-law of Pelayo, 739. Fruela I. son of Alfonso, 757. Aurelio, nephew of Alfonso, 768. Mauregato, bastard of Alfonso, 774. Bermudo I. nephew of Alfonso, 788. Alfonso II. son of Fruela, 791. Ramiro I. son of Bermudo, 842. Ordoño I. son of Ramiro, 850. Alfonso III. son of Ordoño, 866. Garcia, son of Alfonso III. 910. Ordoño II. brother of Garcia, 914. Fruela II. son of Alfonso III. 923. Alfonso IV. son of Ordoño II. 925. Ramiro II. brother of the same Alfonso, 930. Ordoño III. son of Ramiro II. 950. Sancho I. brother of the same Ordoño, 955. Ramiro III. son of Sancho I. 967. Bermuda II. grandson of Fruela II. 982. Alfonso V. son of Bermudo II. 999. Bermudo III. son of Alfonso V. 1027. With this sovereign the male line of the house of Leon terminated. Leon and Castille now formed separate kingdoms, the contemporaneous sovereigns of which were:—

Leon.	Castille.
	1026. Sancho el Mayor, king of Navarre; first king of Castille in right of his wife.
	1035. Fernando I. son of Sancho.
1037. Fernando I. king of Castille; king of Leon in right of his wife.	
1065. Alfonso VI. son of Ferdinando I.	1065. Sancho II. son of Ferdinando I.
	1072. Alfonso I. son of Ferdinando I. (also VI. of Leon).
	1109. Urraca, daughter of Ferdinando I., and Alfonso VII. (also sovereign of Leon).
1126. Alfonso VIII. (the emperor), son of Urraca.	1126. Alfonso II. (the emperor), son of Urraca.
1157. Fernando II. son of Alfonso the emperor.	1157. Sancho III. son of Alfonso the emperor.
	1158. Alfonso III. son of Sancho III.
1188. Alfonso IX. son of Ferdinando II.	
	1214. Enrique I. son of Alfonso III.
	1217. Fernando III. son of Alfonso IX. of Leon (afterwards king of Leon).
1230. Ferdinando III. son of Alfonso IX. (also king of Castille).	

KINGDOM OF LEON AND CASTILLE UNITED.

Alfonso X. son of Fernando III. 1252. Sancho IV. son of Alfonso X. 1284. Ferdinando IV. son of Sancho IV. 1295. Alfonso XI. son of Ferdinando IV. 1312. Pedro the Cruel, son of Alfonso XI. 1350. Enrique II. bastard son of Alfonso XI. 1369. Juan I. son of the former, 1379. Enrique III. son of the former, 1390. Juan II. son of the former, 1406. Enrique IV. son of the former, 1454. Isabel, daughter of Juan II. and her husband Ferdinando V. (the II. of Aragon), 1474. Juana, daughter of Fernando and Isabel, and Philip I. of Austria, 1504.

KINGDOM OF NAVARRE.

The first independent count of Navarre was Sancho Inigo, 873. The kings reported to have reigned prior to this period are entirely fabulous. Garcia I. (Iniguez), son of Count Sancho, and the first king, 885. Sancho I. (Garces Abarca), son of Garcia I. 905. Garcia II. (el Trembloso), son of Sancho I. 924. Sancho II. (el Mayor), son or grandson of Garcia II. 970. Garcia III. son of Sancho, 1035. Sancho III. son of Garcia III. 1054. Sancho IV. (also I. of Aragon), 1076. Pedro I. son of Sancho IV. (also king of Aragon), 1094. Alfonso I. brother of Pedro (also king of Aragon), 1104. Garcia IV. 1134. Sancho V. son of Garcia IV. 1150. Sancho VI. son of Sancho V. 1194. Thibault I. nephew of Sancho VI. 1234. Thibault II. son of the former, 1253. Henri, in right of his wife, who was daughter of Thibault II. 1270. Jeanne, queen of Philip IV. king of France, 1274. Louis Hutin (king of France), son of Jeanne, 1305. Philip, brother of Louis (also king of France), 1316. Charles I. brother of Philip (also king of France), 1322. Jeanne II. daughter of Louis Hutin, married to Philip count of Evreux, 1328. Charles II. son of Jeanne, 1349. Charles III. son of the former, 1387. Blanche, daughter of Charles III. and Juan her husband, son of Ferdinando I. king of Aragon, 1425. François Phœbus de Foix, in right of his grandmother, daughter of Juan, 1479. Catherine de Foix, sister of Phœbus, and her husband, Jean d'Albret, 1483. This kingdom united with Castille in 1512.

KINGDOM OF ARAGON.

Aragonese independence is to be dated from 1035, when Sancho el Mayor, king of Navarre and Castille, divided his states among his sons. Aragon fell to the lot of Ramiro I. 1035. Sancho I. (afterwards IV. of Navarre), son of Ramiro I. 1063. Pedro I. son of Sancho I. (also king of Navarre), 1094. Alfonso I. brother of Pedro (also king of Navarre), 1104. Ramiro II. brother of Alfonso, 1134. Petronilla, daughter of Ramiro II. 1137. Alfonso II. son of Petronilla, 1163. Pedro II. son of Alfonso II. 1196. Jayme I. son of Pedro II. 1213. Pedro III. son of Jayme I. 1276. Alfonso III. son of Pedro III. 1285. Jayme II. brother of Alfonso, 1291. Alfonso IV. son of Jayme II. 1327. Pedro IV. son of Alfonso IV. 1336. Juan I. son of Pedro IV. 1387. Martin, brother of Juan I. 1395. Fernando I. brother of Enrique III. king of Castille, elected 1412. Alfonso V. son of Ferdinando I. 1416. Juan II. (also king of Navarre), brother of Alfonso V. 1458. Fernando II. (the V. of Castille), son of Juan II. 1497. This kingdom united with Castille in 1516.

COUNTS OF BARCELONA.

During the early period of Mahommedan domination in Spain, Barcelona and all Catalonia were subject to it. In the year 801, however, the Moors were expelled from Barcelona, and a count named Bera, a native of Gothic Gaul, was nominated head of the independency. The names of his successors, eleven in number, are too insignificant to require mention individually. Alfonso Raymond, the last count, acceded to power in 1131. On his death, Barcelona was united with Aragon.

To give a connected history of these various sovereignties is quite incompatible with our limits. We can only briefly describe those more important transactions affecting the whole country, in which the Christians, by wresting portions of soil from the Moors, compelled them to retire within narrower limits, and thus circumscribed their power. Alfonso and Fruela, the sovereigns who immediately succeeded Pelayo's son, inflicted several severe blows on the Moors, and overran a considerable portion of the flat country. But what proved a more effectual check upon the Saracens than the arms of the Christians, were their own domestic quarrels. So mutable had been the government, that in the space of only forty years from the period of their first landing in Spain, no less than twenty emirs had been called, or had raised themselves, to the seat of power. On the establishment of a monarchy under Abderahman, intestine revolt was quelled for a time; but a more formidable foe from without made his appearance. This was no other than the celebrated Charlemagne, who poured his legions over the Pyrenees into the valleys of Catalonia. We shall not discuss the much agitated question as to the motives which brought this emperor into Spain. He appears to have received an invitation from some discontented Moorish governors; and in acceding to their request, he probably also listened to the dictates of his own ambition. Certain it is that he entered Spain with a powerful army, and, if we can trust his historian Eginhard, subjected the country from the Pyrenees to the Iberus. But he was soon recalled from the Peninsula by the revolt of the Saxons. In his passage through the mountain defiles, the rear of his army was attacked by the Navarrese, and cut to pieces.

It seems certain, that from the period when Charlemagne poured his legions into Navarre, he considered the country as a fief of his crown, and thus gave great umbrage to the Asturian kings. But the inhabitants of the province, averse to the sway of either, longed for independence, and this they succeeded in achieving about the year 885. The rise of this kingdom was another blow to the Saracens. So signal were the successes gained over them by the Christians of Navarre, that in the year 920 not a Mahommedan remained in the whole kingdom north of the Ebro. The kings of Asturias and Leon also rapidly extended their dominions. Ordoño II. invaded the Mahommedan possessions, and gained many advantages. In 932, Ramiro II. made an irruption into the states of the enemy, and ruined Madrid. Arabian writers boast of terrible reprisals having been made on the Christians, and assert that Ramiro himself was defeated. The Saracens having invested Zamora, Ramiro approached with a formidable army. The combatants met, and a battle ensued, more obstinately contested and bloody than any that had been fought since the days of Roderick. There can be no doubt that victory shone on the banners of the Christians, but the success was less splendid than their writers assert it to be. The accounts of all the battles fought between the Moors and the Christians in Spain are to be received with caution. The Arabian writers, to exalt the prowess of their countrymen, exaggerate mere skirmishes into great battles, and temporary and partial checks into decisive victories. In equivocal cases, they seem invariably to claim the advantage; and where they were defeated, they either obscurely hint the fact, or diminish the loss which they sustained. It is to be feared, that in many instances Christian chroniclers are chargeable with similar partiality.

The reign of Abderahman III. (912) has been extolled as the most brilliant period in the history of the Spanish Arabs. Commerce flourished, and riches were accumulated to an unexampled extent. A powerful navy was formed, and maintained in full activity; the arts and sciences were cultivated with ardour, because their professors were rewarded with princely liberality; many splendid works were undertaken in the towns of Mahommedan Spain; and the king himself was the friend of industry and of merit. Still none of the territories which had been lost in previous reigns was recovered, and the Christians were gradually becoming more and more formidable to the Moors, when Mohammed, better known as Almanzor, appeared to restore the glory of the Saracen arms. He was an eminent general, an enlightened statesman, and a patron of the liberal arts. His campaigns against the Christians proved most fatal to them. The towns were ruined, the open country was ravaged, and once more the mountains of Asturias became the inaccessible asylum of the native monarchy. At length the three powers, Navarre, Castille, and Leon, entered into a confederacy to repel the common foe. The armies met at a place situated between Soria and Medina Celi, where a drawn battle was fought. This check, and the fearful loss which he had sustained, so mortified Almanzor, that he sunk under the weight of his despair, and died, some assert by voluntary abstinence from food, in the year 1001. An event of some importance to the Christian cause was the erection of Castille into a distinct kingdom, by Sancho el Mayor, king of Navarre, the most powerful prince of his age and country. Besides Sobrarve, he held the lordship of Aragon; and in 1026, in right of his wife, a princess of Castille, he became king of that country. By his conquests he considerably extended his dominions; and the marriage of his son Fernando to the heiress of Leon gave him influence in the affairs of that kingdom; so that at the period of his death, in 1035, he was virtually master of all Christian Spain except Catalonia. Before his death he divided his states among his sons, and Aragon fell to the share of Ramiro. The independence of Aragon as a separate kingdom is therefore to be dated from 1035, the year in which Ramiro I. obtained possession of the throne.

About the middle of the eleventh century Spain may be said to have been divided into two unequal parts, by a straight line drawn from east to west, from the coasts of Valencia to a little below the mouth of the Duero. The country north of this belonged to the Christians, who as yet had the smallest and least valuable portion, while all the rest belonged to the Moors. In point of wealth and real power, both by land and sea, the latter were much superior to the former; but their perpetual dissensions materially weakened them, and every day facilitated the progress of the Christians. Indeed, had either party been united, the other must soon have been quelled; but the Christians, although they did not constantly make war upon each other like the Moors, continued from time to time to be so embroiled by domestic feuds, as to be unprepared for striking a decisive blow with the combined armies of all the kingdoms; while the same evils, existing to a still greater extent amongst the Mahommedans, rendered it impossible for their monarchs to take advantage of the untoward state of the affairs of the Christians. Among the Moors almost every city was a kingdom; and as these petty sovereignties supported one another very indifferently, they, one after another, fell a prey to their enemies. The rapidity with which the kingdom of Cordova fell to pieces has few examples in history. Alfonso I. king of Aragon, also of Navarre, and for some time of Castille and Leon, is reckoned among the most valiant princes of Spain. From his warlike habits he was surnamed *El Batallador*. He conquered Tudela, Saragossa, Tarragona, Calatayud, Daroca, Mequinencia, and much of the country south of the Ebro. Since the conquest by the Arabs, he was the first who carried the Christian ensigns into Andalusia. In 1134, however, he lost a great battle, and either perished in the conflict or died of grief shortly afterwards. This was a misfortune, but the misfortunes of the Christians were in general soon repaired, although for nearly a century their conquests were less brilliant than those achieved by *El Batallador*. At the commencement of the thirteenth century, indeed, the Moors gained some decided advantages, and reduced several important towns. But the balance was restored on the celebrated plains of Tolosa, where an enormous army of Moors from Africa was nearly annihilated. Alfonso of Castille having made some destructive inroads into Andalusia, Mohammed Abu Abdalla, emperor of Barbary, prepared to punish his audacity. It is related, on credible authority, that one of the five divisions of the army which he assembled mustered 160,000 combatants. To meet this overwhelming host, the Christian kings, fortunately at this juncture brought to terms of amity with one another, united their armies at Toledo, where they were joined by numerous volunteers from Portugal and France. On the 16th of July 1212 the Christian army descended the mountainous chain which divides New Castille from Andalusia into the plains of Tolosa, where the Mahommedan army was drawn up in battle array. The conflict which ensued was obstinate and bloody, but victory at length declared for the Christians, and its immediate consequences involved the ruin of the Mahommedan empire in Spain. The thirteenth century is distinguished by other important advantages gained by the Christians. Ferdinand III. king of Leon, afterwards of Castille, by his numerous victories made himself lord of Spain, from the Bay of Biscay to the vicinity of the Guadalquivir, and from the confines of Portugal to those of Aragon and Valencia. In 1233 he triumphed over Aben Hud, king of Murcia, Granada, Cordova, Merida, and Seville; and from that year to 1248 he successively obtained possession of Toledo, Cordova, the whole of Murcia, Jaen, and Seville. The loss of the city of Cordova, which in the eyes of the Mahommedans was sacred alike from its magnificent mosque, and from its having been so long the seat of their caliphs, was a severe blow to their power. About the same time King Jayme, the greatest name in the ancient history of Aragon, and surnamed the conqueror on account of his victories, reduced the Balearic Isles, and obtained other important victories. At this period Mahommedan Spain obeyed three sovereigns, who hated each other as cordially as they were all detested by the Christians. Mohammed, who ruled in Jaen, was the least powerful, but the most successful, of these petty kings. He successively got rid of his two contemporaries, and fixed his court in Granada, resolving if possible to extend, or at the worst to preserve, his new states against the independent walis or local governors on the one hand, and the Christians on the other. Thus the celebrated kingdom of Granada was founded in the year 1238, for that of Cordova no longer existed. During two centuries and a half, this Mahommedan state withstood the hostile attacks of its Christian neighbours, and only fell when all Spain became united under one sceptre, and was consequently rendered irresistibly superior to the kingdom of the Moors.

The first king of Granada was equally valiant in war and wise in council, but he was not in a condition to contend with Ferdinand of Castille. He submitted to do homage to him as his vassal; and during the lifetime of Ferdinand a good understanding subsisted between him and Mohammed. But in succeeding reigns war again broke out between the Moors and Christians. In 1303 the strong fort of Gibraltar was reduced by Ferdinand IV. king of Castille and Leon. But the reign of this prince was mostly one of disaster. An iniquitous league was formed by two native princes, who proposed to share the kingdom between them. The kings of France, Portugal, and Granada, were not ashamed to sanction this unhallowed compact. The king of Portugal invaded Castille, the king of Granada spread his ravages into Andalusia, and the fate of Ferdinand seemed on the point of being sealed, and his kingdom partitioned among the combined robbers. But dissensions among the confederates, and the want of money, dissolved the league, and saved Spain. The greatest battle which had been fought between the Moors and Christians since the mighty African host was destroyed on the plains of Tolosa, took place in October 1340, on the banks of the small river Salado. The Christians under Alfonso of Castille were a very small band compared with the enormous host led by the king of Granada; but the former gained a brilliant victory, the loss of the Moors having been immense. The consequence was the surrender of several fortresses; and in the following year the destruction of the Mahommedan fleet was effected by the Christians.

It is now necessary to mention some circumstances in the history of Navarre, relative to the intimate connection which so long subsisted between that kingdom and France, and which had a material influence on the destinies of Spain. The male line of the house of Sancho Inigo, founder of the sovereignty, having ended in Sancho VI., who died in 1234, leaving no issue, the Navarrese elected as their future king, Thibault, a French prince, and nephew to the deceased Sancho. Of this monarch we know little beyond an expedition to Palestine, which he undertook along with several princes of France. His two sons, who successively occupied the throne of Navarre, espoused French princesses, and thus an intimate connection with France was established. The relationship between the two kingdoms became still more close when Queen Jeanne gave her hand to Philip the Fair of France. In short, Navarre became a province of France, and for four reigns has no distinct history. In 1328, however, the kingdoms were again separated, though the sovereigns of Navarre were closely related to those of France. Charles II. surnamed the Wicked, ascended the Navarrese throne in 1349, and shortly afterwards married Jeanne, daughter of King John of France. His reign is one of perfidy, intrigue, and dishonourable alliances. Events which belong more immediately to the history of France, led to the arrest of Charles by the French monarch, and his detention in prison for several years. He effected his escape, and again resumed his old practice of intriguing, particularly against the king of France. In 1366 he entered into a league with the celebrated Black Prince of England, for the restoration of Pedro, surnamed the Cruel, who had been driven from the throne of Castille on account of his many enormities. The expulsion of this detestable monster was the act of an indignant nation, which immediately elevated his bastard brother Enrique, or Henry, count of Trastamara, to the throne of Castille. The exiled king himself appealed in person to the generosity of the English hero, and the consequence was that the Black Prince led a powerful force across the Pyrenees. In his combined army of English and Normans were some of the flower of English chivalry. Henry made every disposition in his power, resolving to hazard all in a battle. The recollection of the cruelties and oppressions of Pedro's government were a strong stimulus to his followers, and might have insured success had he only been opposed by Pedro the Cruel and Charles the Wicked; but he had to contend with the victor of Cressy and Poictiers. The battle which decided the fate of the two kings was fought near Logroño, a few miles south of the Ebro, on the 3d of April 1367. Henry nobly contested the day, as also did his antagonist, who was as brave as he was cruel. The conflict was for a short time desperate, but it terminated in the complete discomfiture of Henry, an event followed by the immediate restoration of Pedro to the Castillian throne. His gallant ally had soon reason to regret his connection with a prince equally perfidious, debauched, and bloody. Edward quitted him in disgust, without receiving payment of the sum promised to the English troops. Pedro, no longer overawed by the Black Prince, who was as humane as he was valiant, immediately set about punishing those whom he either knew or suspected of having been zealous in the cause of Henry. His late disgrace had sharpened his naturally keen appetite for blood; but we pass over the revolting details of the enormities which he committed. They produced their usual effects, the complete alienation of the minds of his subjects from him, and then a conspiracy to put an end to such barbarous tyranny. Henry, who had fled to France, entered Spain with a small force, which, however, soon became augmented to an army. Tyrants have few friends in the hour of adversity, and those who have been bribed by gold or overawed by authority to become their pliant tools, are too easily seduced from their allegiance to be trusted when the day of trial comes. Mohammed V., king of Granada, was induced to take the field in behalf of Pedro; but it was less to aid his ally than to take advantage of the confusion of the times. Pedro's army gradually melted away, and he himself, compelled to flee for shelter to a fortress, and nearly deserted by his followers, was there shortly afterwards slain by the hand of Henry. Although, as we have already noticed, this prince was a bastard, yet he quietly ascended the Castillian throne, which he bequeathed to his posterity.

For nearly a century after these events took place, the history of Spain presents little or nothing that is remarkable. The continued and petty hostilities between the native princes, or between any or all of them and the Moors, merit but slight attention. Henry IV. surnamed the Impotent, ascended the throne of Castille in 1454. The misconduct of this prince, a frivolous and contemptible debauchee, produced a conspiracy amongst his turbulent nobles, to resist his weak and flagitious administration. He was formally deposed at Avila, in a very extraordinary manner; an effigy which represented him being solemnly degraded from the royal dignities, while at the same time his brother Alfonso was proclaimed king of Castille and Leon. Henry was naturally anxious to punish the rebels, but they assumed an attitude too formidable for him. Civil war produced a total relaxation of the laws, and let loose bands of robbers, who pillaged the open country, and not unfrequently attacked and plundered the towns. In the midst of these troubles the Infante Alfonso died, an event for the present highly favourable to the king. Some attempts to raise the Infanta Isabella, his sister, to the throne, proved at first abortive; but she was the person upon whom the nobles had set their eyes as the only legitimate successor to Henry. In 1469 was laid the foundation of a union which was to prove of such unbounded advantage to Spain. Juan II. of Aragon solicited the hand of Isabella of Castille for his son and heir Don Ferdinand, king of Sicily. By distributing largesses amongst the Castillian nobles, and firmly attaching the archbishop of Toledo to his interest, Juan succeeded in his object. On the 25th of October 1469, the royal pair received the nuptial benediction in the cathedral of Valladolid. The negociations had been secretly conducted, and the whole affair was brought to a conclusion without the knowledge of Henry or his queen, a princess as licentious as himself. She had borne a daughter, the Infanta Juana, whom the whole kingdom supposed, on pretty good grounds, to be the fruit of her intrigue with Don Beltran de la Cueva, count of Ledesma, one of Henry's favourites. No sooner was Henry made acquainted with this precipitate marriage, than he resolved to leave no measure untried for securing the crown to Juana. He caused her to be proclaimed heiress of his dominions, and in his last will declared her his successor. But popular opinion is too strong even for princes. The country believed her illegitimate, and on the death of Henry in 1474, Ferdinand V. and Isabella were elevated to the throne of Castille and Leon, it being stipulated that the king and queen should reign conjointly. The king of Portugal at first espoused the cause of Juana; but the alliance was productive of no event of importance, and peace was restored between Castille and Portugal in 1479. The very same year, Ferdinand, by the death of his father, Juan II., was called to the throne of Aragon. Having received the homage of his Aragonese subjects at Saragossa, of the Catalonians at Barcelona, and of the Valencians in the capital of that province, he returned into Castille.

The reign of Ferdinand and Isabella is distinguished by great events, events of the highest importance, not only to Spain, but to mankind. It was under their auspices that Columbus brought a new world to light, and it was by their arms that the power of the Mahommedans was for ever extinguished in the Peninsula. Their first object was the regulation of the government and the enforcement of the laws, which, from the license of preceding reigns, had fallen into desuetude, or were openly defied. The king and queen were noted for a rigid administration of justice; neither for money nor favour would they spare the guilty; and there was too much to punish and correct not to give their administration a character of severity, which would have had no existence had the country not fallen into a state of civil and political disorganization almost unprecedented. The local judges were overawed by the nobles, and extraordinary judges or corregidors were appointed to see that they did their duty. This not being found sufficient to eradicate an evil which had existed for centuries, the aid of the Holy Brotherhood was sought and obtained. This association, which had existed since the middle of the thirteenth century, consisted of a number of confederated cities and towns, which maintained a considerable body of troops, in order to protect travellers and pursue criminals, and took cognizance of all violent offences against the laws, appointing courts and judges in various parts of the kingdom. New powers were reposed in this association, so that it became a powerful instrument in the hands of government, and alike terrible to robber and rebel. By this means the territorial jurisdiction of the seignoral nobles was materially abridged, while the royal prerogative was greatly extended. The prompt and impartial administration of justice restored tranquillity and order; and it had been well for the fame of these sovereigns if their salutary severity had been only directed against the disturbers of the public peace. But unfortunately they were equally severe against all who ventured to differ from the established faith. Against apostates, all converts who, after baptism, reverted to Judaism or the faith of Islam, their hatred was implacable. Their intemperate zeal led them to establish, or rather to re-organize, an ecclesiastical tribunal, which became proverbial throughout the civilized world for its enormous cruelties and injustice. This was the court of inquisition.

We now approach what is not only an important event in the reign of Ferdinand and Isabella, but an era in the history of Europe, namely, the conquest of Granada, the last possession of the Mahommedans in Spain. A sovereign so zealous for the Catholic faith as Ferdinand proved himself to be, was not likely to allow such enemies of Christianity to remain long in the Peninsula, if by force of arms he could expel them; and accordingly he early turned his attention to the subject. Every thing conspired to favour his design; the Moorish kingdom was distracted and disunited by a civil war between father and son; and Ferdinand having obtained the bull of Sixtus IV. authorizing a crusade, put himself at the head of his troops, and entered Granada. He continued the war with rapid success; Isabella attended him in several expeditions; and they were both in considerable danger at the siege of Malaga, an important city, which was defended with great courage, and taken in 1487. Baza was reduced in 1489, after the loss of 20,000 men. Gaudix and Almeria were delivered up to them by the Moorish king Alzagel, who had first dethroned his brother Alboacen, and afterwards been chased from his capital by his nephew Abdali. That prince engaged in the service of Ferdinand and Isabella, who, after reducing every other place of eminence, undertook the siege of Granada. Abdali made a gallant defence; but all communication with the country being cut off, and all hopes of relief at an end, he capitulated, after a siege of eight months, on condition that he should enjoy the revenue of certain places in the fertile mountains of Alpuxarras; that the inhabitants should retain the undisturbed possession of their houses, goods, and inheritances; the use of their laws, and the free exercise of their religion. Thus ended the empire of the Arabs in Spain, after it had continued about eight hundred years.

Its overthrow was soon followed by the expulsion of the Saracens from Spain. This expulsion, however, was not entirely effected till the 17th century. Vast numbers of the Moors, indeed, oppressed by their conquerors, abandoned a country where they could not reside with comfort and with freedom. From the reign of Ferdinand of Castille, to that of Philip III. of Spain, more than 3,000,000 of these people quitted Spain, and carried with them, not only a great part of their acquired wealth, but that industry and love of labour which are the foundation of national prosperity.

The conquest of Granada was followed by the expulsion of the Jews, under circumstances of great injustice and atrocity. This unhappy people had engrossed the greater part of the wealth and commerce of Spain, yet not being allowed to take away the value of their property in the precious metals, they were compelled to barter it for the produce or manufactures of the Peninsula, and this could not be effected except at a great sacrifice. One alternative was left them, to embrace Christianity. The inquisition exhausted first its art and then its fury to accomplish this object, but with comparatively little success. Many, indeed, to save their property, always dear to an Israelite, outwardly at least embraced the faith of the cross; but by far the greater number, in profound despair, and stripped of much of their wealth, took leave of the land of their birth. About the same time that this decree was promulgated, their Catholic majesties concluded an alliance with the emperor Maximilian, and a treaty of marriage for their daughter Juana with his son Philip, archduke of Austria, and sovereign of the Netherlands. To this period also belongs the contract concluded with Columbus for the discovery of new countries; an event which more powerfully than any other attracts the notice of posterity to this splendid reign, and which materially tended to raise the Spanish monarchy above any other in Europe. To Isabella must be ascribed the glory of the enterprise, for she it was who borrowed the sum of money necessary for the armament, and bade the great navigator depart. This great queen died in 1504, leaving her daughter Juana, and after that princess her own grandson (the celebrated Charles V.), heirs to the monarchy, but appointing her husband Ferdinand regent of the kingdom till the majority of Charles. The latter years of Ferdinand's life were embittered by family dissensions, which broke out even before Isabella had breathed her last. Juana was undoubtedly queen, for the Salic law, which excludes females, never existed in Spain. This was well known, and is important, as bearing on events which happened in more recent times. Philip therefore prepared to enforce his right, while Ferdinand, fond of power, and backed by the will of his late wife, showed a determination to maintain his position in the kingdom. But just as the affairs of Spain were assuming a serious aspect, Philip died, and Ferdinand gradually resumed his authority over the whole country. Insurrection quailed before him, the laws resumed their empire, and prosperity revisited the people. The remaining events of his reign must be briefly summed up. He solicited and obtained the hand of Germaine, niece to Charles of France, in the hope of leaving a male heir to the throne; but his anticipations were not realized. In several expeditions to Africa, important conquests were made in that country, Algiers, Tunis, and other places submitting to become vassals to the king of Spain. In 1511 he went to Italy to assist the pope against the schismatics under the protection of the king of France and the emperor. But into the interminable affairs of Italy, the critical wars carried on by Ferdinand in that country in defence of his Sicilian and Neapolitan possessions, we cannot enter. This war, however, led to one memorable result, and one not very glorious to Ferdinand. Desirous of carrying hostilities into France, he demanded from Jean d'Albret, king of Navarre, permission to march his troops through that country. The Navarrese refused, but at the same time promised to remain neutral. He broke his engagement, however, and entered into an alliance, offensive and defensive, with France. Determined to accomplish his end by force, and to punish the duplicity of the Navarrese, Ferdinand invaded Navarre, and in a short time obtained possession of the whole kingdom, annexing it to that over which he formerly ruled, and successfully defending it against the invasion of the French. This was the last great event of Ferdinand's life, and, however fortunate for the country, it was by no means honourable to the king. After a lingering illness, his death took place on the 23d of January 1516. In his last will he declared his daughter Juana heiress to all his dominions in Spain and Italy, and after her his grandson Charles. Cardinal Ximenes Cisneros was at the same time appointed sole regent of Castille till the arrival of his grandson. Ferdinand is justly regarded as the founder of the Spanish monarchy; and although his character has some dark stains upon it, intolerant bigotry being not the least conspicuous, he was certainly the greatest prince of his age, and one of the ablest and best that ever swayed the sceptre of Spain. We shall now glance at the civil and political condition of Spain under the Moors and under the Christians respectively, from the period of the Mahommedan conquest till the death of Ferdinand.

Mal ame- dan ain.

Mahommedan Spain originally comprehended nearly nine tenths of the Peninsula. Murcia, which the Arabs call Tadmir, though governed by the Christian Theodomir and his successor Athanagild, was as much dependent on the Saracens as Andalusia or New Castille. The districts over which the barbarian sway never extended were the mountains of the Asturias, Biscay, Navarre, and an angle of Aragon. Thus not only by far the greatest, but infinitely the most valuable, part of the Peninsula was comprised in the Mahommedan kingdom. Under the viceroys of the caliphs, and the immediate successors of the first Abderahman, that is, during the first three centuries, it was the admiration and terror of Europe. The revenues which the kings of Cordova derived from their ample possessions were doubtless immense, and this enabled them to maintain not only a large army of native troops, but great bodies of foreign auxiliaries. These mercenary soldiers are supposed by some of the most distinguished Arabian historians to have been the principal cause of the downfall of that splendid monarchy. The spirit of nationality was not destroyed; it was fostered by transplantation from the original soil; the Egyptians in Beja and Lisbon; the Persians in Huete; the Assyrians in Granada; the Berbers and Slavones in most of the great cities, especially about the court; the inhabitants of Damascus, Emessa, and of Old Palestine, in Cordova, Seville, Niebla, Medina Sidonia, and Algeziras; became so many rival factions, all eager in the pursuit of power, and all mutually hostile. Their frequent quarrels occasioned great disasters in the state, and allowed the ambitious no less than the desperate a long-continued impunity. In this distracted state of the kingdom, rebel chiefs contrived to retain and even to extend their governments; while the Christians, ever ready to take advantage of circumstances, drove the Saracens from city to city, and from province to province, till they finally expelled them from the country. After Cordova fell from its proud eminence, the Mahommedan power declined with great rapidity. The rulers of Toledo, Badajos, Beja, Seville, Ecija, Malaga, Granada, Almeria, Lorca, Murcia, Denia, Valencia, Lerida, Saragossa, and Huesca, all openly aspired to independent sovereignty. Many of these petty states were annihilated by the king of Seville; but his own, with those which still remained, were swept from the Peninsula by Yussef, the first emperor of the Almoravides. This African dynasty was again subverted by the still more ferocious Almohades. In the decline of the latter, the local governors again endeavoured to establish independent kingdoms. The Moorish domination thus became circumscribed within the mountainous region bounded by the sea, and by a line drawn from Malaga through Archidona, Loxa, Guardia, the Sierra de Cazorla, to the environs of Lorca. This small state was still farther limited by the succeeding sovereigns of Castile, from Alfonso el Sabio downwards, till, as we have seen, it was finally subjugated by Ferdinand the Catholic.

In all the states of Spain, whether Mahommedan or Christian, the government was absolute, but not despotic. If the Christian, as a protection against arbitrary power, could appeal to the legal code of the country which he inhabited, the Mahommedan could also invoke the provisions of the Koran, for the laws of the followers of the prophet are founded in their religion. Several of the Mahommedan potentates were the munificent patrons of literature and literary men, the names of some of whom are mentioned with respect at the present day. At the close of the eleventh century, Mahommedan Spain could boast of seventy public libraries, and of colleges, or seminaries of learning, in all the principal cities. Thus learning was much encouraged; and among these numerous collections of books were many hundred volumes by native writers. So great, in fact, was the literary reputation of the Spanish Arabs, that when the caliph of Egypt desired his library to be arranged and indexes to be made, he confided the task to two individuals of that nation. These men of learning comprised historians, poets, grammarians, orators, rhetoricians, mathematicians, astronomers, philosophers natural and moral, physicians, lawyers, and divines. It was in the physical and experimental sciences that the people most excelled, and that too at a time when many of the sciences were wholly neglected or totally unknown in the rest of Europe. Their knowledge of botany was far famed; that of chemistry was still more so. Indeed they are to be regarded, if not the founders, at least the regenerators, of that science in Europe. Their skill in medicine was great; in the mathematics they particularly distinguished themselves; the improvements which they made in algebra are well known. Optics and astronomy were much cultivated by them; nor were the useful arts less attended to, more especially agriculture, including horticulture and planting. The mechanical arts and manufactures were also carried to considerable perfection by the Spanish Arabs. Commerce was deemed no less worthy of encouragement than domestic industry. The fine arts however were less cultivated; but still all the great cities of Mahommedan Spain, Cordova, Granada, Toledo, Valencia, Ubeda, Coimbra, were deeply indebted to the Moorish inhabitants; a fact sufficiently proved by the remains of their past magnificence, which still exist.

From the foundation of the Christian states, the extent of territory comprised by each was usually variable, dependent alike on their conquests over the common enemy and among themselves. The relative extent of each at different periods may be briefly noticed. 1. When Pelayo established his little court at Cangus, the *Asturian* kingdom could only have occupied the mountainous district immediately surrounding that humble capital. By Alfonso I. this territory was extended into Galicia on the west, probably to Aragon on the east, and to the confines of Toledo on the south. Alfonso III. still further amplified the Asturian kingdom, by extending its frontiers to the Sierra de Cuenza, in the territory of Toledo, to the Duero, in Estremadura and Portugal; in one instance even as far as the Guadiana. The capital regularly continued to shift towards the centre of Spain as new territory was acquired. Thus the Asturian kingdom went on increasing till, on the incorporation of Castille with it, and the subsequent conquest of Andalusia by San Fernando, the capital of the monarchy was fixed at Seville. From the reign of San Fernando may be dated the true era of Spanish greatness. Murcia was conquered by his son Alfonso; and by his successors the Moorish kingdom of Granada was first circumscribed and finally subjugated. 2. *Navarre* (that is, Spanish Navarre), from its origin to its conquest by Ferdinand V. underwent little change in its dimensions; and its capital was always Pamplona. See the article NAVARRE. 3. The *Lordship of Barcelona*, which for some time continued dependent on the Carlovingian princes, comprehended anciently, not only Catalonia, but likewise Languedoc. The Spanish frontier, however, was subsequently held as a separate government, to which other lordships were subordinate. The dependence on France was of short duration, and appears nearly to have ceased towards the close of the ninth century, when Wifredo II., count of Barcelona, entirely cleared Catalonia from the infidels. That ruler decrees in the sovereign style, and is recognised even by the French as the founder of an hereditary state; which continued as independent a sovereignty as any in the Peninsula, till its union with Aragon, about the middle of the twelfth century. 4. *Aragon* was at first but a small mountainous region at the foot of the Pyrenees, the capital of which was Jaen, or San Juan de la Peña. The conquest of Sobrarve, Ribagorza, and Pallas, by Ramiro I.; of the Mahommedan fortresses from the Pyrenees to the Ebro by Sancho I.; of Huesca by Pedro; of Tudela, Saragossa, Calatayud, Daroca, Mequinencia, &c. by Alfonso I., amplified this little lordship into a considerable kingdom, the capital of which in 1119 was transferred to Saragossa. When Lerida and Fraga were reduced by the prince of Aragon, the Balearic Isles and Valencia by Don Jayme el Conquistador, Aragon became, next to Castille, the most extensive and powerful of the peninsular kingdoms.

The government of all the Christian states was absolute, and in the whole of them latterly it was hereditary. The powers of the sovereign varied at different times; latterly they became very great. He could concede or revoke, interpret or abrogate laws, declare war or make peace, appoint judges, levy and exact contributions, and the like. But still all was to be done *according to the ancient form*, that is, according to established custom. Other restraints were placed upon his power, and it is pretty certain that the Spanish kings were not commonly tyrannical. The true tyrants were the feudal lords, who were at perfect liberty to exercise almost royal authority within their respective jurisdictions. Of their violence and rapacity there are innumerable complaints in the national chronicles, and in the acts of the Cortes. It is worthy of remark, that the queens presided with their husbands in the Cortes, the councils, and the tribunals of justice, and that as judges, not merely as spectators. The only great feudatories of the crown, exercising a local jurisdiction, were the condes, who held different ranks and enjoyed different degrees of power. But, from the thirteenth century, the governors of provinces were termed *adelantados* (now captains-general), while those of cities, towns, and fortresses, were known as *alcaldes*. As conquest gave the Christians additional territory, admirals and constables were appointed, with power over the affairs of sea and land respectively. Of the dignities, whatever their names might be, most were doubtless of a mixed nature, partly civil and partly military. But there were functionaries who exercised an exclusively military authority. Among the officers of administration, those of the law must have occupied a prominent place. The judgment in civil or criminal cases properly depended on the counts or viscounts, who sometimes decided themselves, sometimes in concert with men learned in the law, called counsellors, and at other times they left the duty to the ordinary judges. These counsellors or judges were expressly educated for the office, and otherwise well adapted for such a situation. The forms of proceeding, which were simple and brief, were conducted in public, and the sentence was also openly delivered. From the decision of all the ordinary judges, lay an appeal to the royal tribunal, which also took cognizance of certain offences and cases. Spain can boast of an ample body of laws promulgated during the middle ages.

As the circumstances of the country altered, and the state of society advanced, it became necessary to extend or limit the existing laws, and to enact new ones. To encourage the cultivation of waste lands, the Christian kings promised to the lower orders, that if they reclaimed unoccupied wastes, formed themselves into small communities, building villages and towns, and defended their possessions against the common enemy, they should enjoy certain social privileges in addition to the profits of their industry. Of these privileges the most highly prized were those which rescued the people from the jurisdiction of their feudal tyrants, which empowered them to elect their own magistrates, to form municipal juntas, and to dispose of certain revenues arising from forests and other possessions. It may well be believed that so brilliant a reward attracted many settlers, who were thus at once raised from the rank of serfs to that of citizens. Such was the origin of many *fueros*, or provincial laws, which varied in their spirit according to the liberality of the monarch and the relative importance of the colonies. These fueros were devised with jealous care to preserve the inhabitants from feudal domination. No baron or noble could settle in a community, unless he abandoned his birthright, enrolled himself among the citizens, and owned obedience to the local fuero. So many temptations did these new communities present, in the shape of municipal posts, that many nobles were known to renounce their rank, and class themselves among the plebeians, for the purpose of obtaining them. The defects of such a system were not long in being felt, and a remedy was provided by the introduction of the "Siete Partidas," so called from the seven parts into which it is divided. It is by far the most comprehensive code of Spain, being taken from the code of Justinian, the Visigothic, the Fuero Viejo, the local fueros, as well as from the canon law.

Cortes.

Passing over the much-disputed question regarding the origin of popular representation in Spain, we find that there were present, at the Cortes held at Leon in the year 1188, "the deputies of towns, chosen by lot," that is, representatives of the people, the third estate. On these municipal towns many important privileges were conferred by successive sovereigns, the direct tendency of which was to abridge the powers of the feudal lords. But even at the brightest period of popular representation, which was the fourteenth century, the representation was never definite. Many of the great towns neglected to send any deputies at all, and those which did return them appear to have observed little proportion in the numbers. Two was the number which ought to have been returned by each, but some towns sent eight, while others of larger size sent only one or two. Indeed it seems highly probable that the privilege of sending deputies was a favour granted by the sovereign to such towns as it was his pleasure to honour. It is preposterous, therefore, to look upon the third estate as consisting of independent representatives of the nation: the members were little better than nominees of royalty, and their numbers could be increased or diminished just as it suited the purposes of government. Much as the popular representation of Castille is extolled by national writers, it seems to have been better adapted for securing and extending the power of the crown, than for protecting the rights of the people. Under Ferdinand and Isabella the last lingering traces of popular liberty were destroyed; but the power of the other orders of the state suffered at the same time a corresponding diminution, as we have already noticed. Such is a brief outline of the government and laws of Castille and Leon, the most important of the peninsular kingdoms, and almost the only ones in which the reader will take much interest, or, indeed, regarding which authentic documents remain. It may be mentioned, however, with regard to the kingdom of Aragon, that, with the exception of the lowest order, the serfs of the soil, the Aragonese possessed a greater share of individual liberty than any other people in the Peninsula. The citizens and nobles frequently coalesced for the purpose of obtaining fueros or privileges from the crown, and when thus united they were generally too powerful to be resisted. Hence numerous concessions were made by successive sovereigns, and an amount of popular freedom obtained by the people which frequently threatened the existence of the monarchy itself. Catalonia and Valencia were always distinct from Aragon, both in government and laws. Each had its Cortes, consisting of three estates, prelates, nobles, and deputies, all no less tenacious of their privileges than those of Aragon.

Lite ure, scien and gion.

Several historians of note, whose works have come down to us, flourished in the various Christian kingdoms of Spain during the period of Mahommedan domination. Poetry sprung up about the middle of the twelfth century, and some very interesting specimens of these ancient compositions still remain, particularly the *Poema del Cid*. The old Spanish ballads are well known, and celebrated throughout Europe. The scientific state of Spain, as compared with the Mahommedan, exhibits a lamentable contrast; nor does it appear that in any of the useful arts of life the Spanish Christians were equal to the Moors. The most distinguished place in Spanish science during this period has been assigned to Alfonso X. surnamed el Sabio; but even he was greatly indebted to the Arabians for the perfection which he attained. The theologians of Spain, during the middle ages, were more numerous than all her other writers put together, and the writings of many of these shining lights of the church are to be met with in the libraries of Spain. With regard to religion it is only necessary to state, that the Catholic faith prevailed in full force, and was characterized by the darkest bigotry and the fiercest intolerance, as the doings of the inquisition amply testify.

Char I.

Charles I. (V. of Germany) became king of Spain on the death of Ferdinand, but a regency had been nominated to govern the kingdom until he should attain his twentieth year. If the events and transactions in which this monarch was concerned were to be woven into the history of Spain, it would in fact be the history of almost all Europe during the period of his reign. But our business is with events purely peninsular; or if others of a more general character are occasionally noticed, it will be because they are too closely connected with the former to be separated without violence. His foreign wars, negociations, and other transactions, arose from his position as emperor of Germany, not from his being king of Spain; and an account of them will be found under the heads France, Italy, and England, to which articles the reader is referred.

The Cardinal Ximenes Cisneros, to whom the regency had been left by the deceased king, was bitterly opposed in his administration, principally by the nobles of Castille, who, envious of his dignity, displeased with his firmness and vigour, and hoping for impunity under a young monarch, soon showed a disposition to refuse him obedience. Popular discontent reached a great height; and as his best measures were misrepresented to the king, Charles perceived the necessity of making his appearance in Spain, where he arrived in 1517. Nobles and prelates hastened to meet their sovereign, and among the rest the calumniated Ximenes. But that sovereign he was not destined to see; he suddenly sickened and died, not without suspicions of poison. Charles brought with him a multitude of Flemings from the Netherlands, who soon monopolized the principal situations in church and state, and in all their dealings evinced an unquenchable thirst for gold. The favour extended to these foreigners so incensed the people, that Charles found extreme difficulty in obtaining the homage of the Spaniards. Although they swore allegiance to him, it was on certain stipulated conditions, sufficiently advantageous to themselves. In 1519 occurred an event destined to exercise great influence over his future life, over his hereditary states, in fact over all Europe. This was his election to the imperial throne of Germany, left vacant by the death of his paternal grandfather Maximilian. The Spaniards were pleased that this dignity was conferred on their sovereign; but as the old grievances continued to gall them, they were not so dazzled as to be insensible to their own interests. The leading men of many of the principal cities publicly remonstrated with Charles, and it was only by granting certain concessions that he could keep them from open rebellion. His presence having become absolutely necessary in Germany, he quitted Spain, but proceeded first to England to concert with Henry VIII. the means of humbling the power of the French king, Francis I. This monarch had been a candidate for the imperial diadem; but, disappointed in his ambition, and in hatred of his successful rival, he leagued himself even with the enemy of the Christian faith. He also laid claim to Italy, the Netherlands, and Navarre; so that war was unavoidable, and hostilities immediately commenced; for an account of which see the articles already referred to.

The turbulence of the times was not likely to be assuaged by the absence of the king from his all but revolted territories in the Peninsula. Opposition had now degenerated into rebellion; and what before might have been dignified with the name of patriotism, could only be characterized as crafty schemes of personal ambition. Unfortunately for the interests of order, the regency of Castille, where disaffection had assumed the most serious aspect, was held by a man, estimable and virtuous, indeed, but little fitted for such stormy times. The appointment of this individual, Cardinal Adrian, who subsequently wore the triple crown, had at the first given great offence to the nobles and deputies at court; but the king, though solicited, would not change him for another. The persons upon whom the fury of the mob fell were chiefly the governors and deputies of the cities and provinces. Many were massacred; open insurrection spread from city to city; and no species of crime was left uncommitted. In this critical position of the royal cause, it was fortunate that Aragon, Catalonia, and most of Andalusia, stood aloof from the confederation. Had they joined it, the evils might have been long protracted, and the whole Peninsula plunged in misery and ruin. But the revolted cities followed one another in making their submission to government; and those which did not voluntarily submit were reduced by the royal troops, now augmented to a considerable body. An attempt of the French king to seize Navarre was happily frustrated, so that in 1522 the whole country was restored to tranquillity.

In July of that year, the emperor, whose presence had been often requested by the royalists, arrived in Spain. It was expected that summary justice would be inflicted on those who had taken a prominent part in the recent disturbances; but on this occasion Charles showed a degree of clemency almost unexampled in history, very few being condemned to suffer. During the remainder of this prince's reign, the domestic tranquillity of Spain was undisturbed, except by an insurrection of the Moors, which was soon suppressed. Of two expeditions of the emperor to the African coast, to humble, if not to extirpate, the Mahommedan pirates, one was successful, the other disastrous. He compelled the Grand Turk, who penetrated into the centre of Europe, to retreat; and took his great rival, Francis I. of France, prisoner at Pavia. Such were some of his achievements in his foreign wars, by which the fame of the Spanish arms was extended throughout Europe. The mines of the west also had begun to pour their inexhaustible wealth into the country, so that the military and political power of Spain now attained its zenith, and became a source of uneasiness to other nations. In 1525 Charles married the Princess Isabella, sister of Joam III. king of Portugal. The issue of this union was, besides two daughters, the infant Philip, destined to be no less famous than his father. Charles made an ineffectual effort to procure for him the imperial crown of Germany; but in 1554 succeeded in obtaining the hand of the princess Mary of England. That the nuptial ceremony might be performed with greater splendour, he invested his son with the regal title, by abdicating in his favour his Italian possessions, the kingdoms of Naples and Sicily, and the duchy of Milan. This was but a prelude to a still more extraordinary sacrifice. It appears that from the very prime of life the emperor had meditated a retreat from the world; and that on the death of his mother Juana, in 1555, he was determined on fulfilling his long-cherished project. Many reasons have been assigned for this memorable act, but the principal cause is to be traced to his superstitious temperament; something is also to be allowed for the bad success of his arms during the latter years of his reign. Having concluded a truce with Henry, the successor of Francis, and recalled Philip from England, he assembled at Brussels the states of the Netherlands. There, amidst the most imposing solemnity ever witnessed since the days of the Roman Cæsars, he resigned the sovereignty of the Low Countries into the hands of his son. With the same august ceremony he resigned the crown of Spain, and the dominions thereto belonging; and from the monastic retreat to which he retired, he sent his resignation of the imperial diadem. The place which he had chosen for his residence was the monastery of St Justus, one of the most secluded and delightful situations in Estremadura. Here, employed in religious observances, passed the latter years of the life of the most powerful sovereign Europe had seen since the days of Charlemagne and the empire of the west. His character has been variously described by natives and foreigners; the former can see little in it to condemn, the latter nothing to admire. His policy was always close, sometimes crooked, and in not a few instances dishonourable. He was no friend either to civil or religious liberty, and may safely be pronounced a bigot. Under him the condition of Spain was more splendid, perhaps also more prosperous, than in any prior or subsequent reign. Notwithstanding his many wars, the people do not appear to have been overburdened in supporting them, for the New World poured its treasures at his feet. A new impulse was given to national industry by the markets opened for Spanish productions in the transatlantic colonies. But the brightest landscape has its masses of shade. The nobles held a power over the people which was often exercised with violence. Favouritism to foreigners was practised to an unprincipled extent, and the sale of offices became a branch of traffic. Another baneful evil was the multiplication of religious orders. Lastly, the exemption from taxation of the nobles and clergy, which threw the whole weight of public contribution on the third estate, increased the disaffection of that body, and was one of the chief causes of the subsequent decline of the kingdom. For an account of the private life and character of Charles, see the article CHARLES V.

The reign of Philip II. commenced in 1556, and extended to the year 1598. Much of it was occupied in foreign wars, to which we can only briefly advert. For an account of Philip's long, bloody, and inglorious struggle with his revolted subjects of the Low Countries, see the article HOLLAND. The circumstances which led to the invasion of Portugal, and the annexation of that kingdom to the Spanish crown, will be found fully detailed under the head Portugal. An attempt was made by the pope, in conjunction with France, to wrest from Philip his Italian dominions, but without success. The duke of Alva, the viceroy of Naples, put his troops in motion, seized several fortresses of the papal states, and the holy city began to tremble for its security. Philip himself invaded France, and inflicted a severe blow on Henry under the walls of St Quentin. The French army, under the duke of Guise, was recalled from Italy; and the pope, left at the mercy of the duke of Alva, was compelled to purchase his safety by withdrawing from the French alliance. In 1559 peace was made with France; and Philip having become a widower, further ratified the treaty by marrying Elizabeth, sister of the French king. But the Turks continued to harass Naples, although they durst not make a stand before the Spanish forces. In 1565, Philip assisted the Maltese with 10,000 Spaniards in the famous siege which they underwent from sultan Solyman. Five years afterwards, the war between the Venetian republic and the Porte again brought the Spaniards into collision with the latter power, and they had no small share in achieving the glorious victory of Lepanto. The Mahommedans, however, still continued to make descents on the Italian coast, and to harass the African possessions of Philip; but, on the whole, the war with the misbelievers was honourable to the Spanish arms.

We now approach an event of peculiar and lasting interest to every Briton, the projected invasion of England by the famous Spanish Armada. Elizabeth had certainly done much to provoke the resentment of Philip. She had succoured the insurgents of the Netherlands, fomented the disturbances in Portugal, assisted France, and her naval captains had ravaged the dominions of Spain in both hemispheres. Philip's patience being exhausted, he prepared a mighty armament for the invasion of England. A complete account of this famous attempt to plant a foreign standard on our shores, and its disastrous termination, will be found in the article ENGLAND. A second expedition for the invasion of Ireland shared the fate of the former; and this effectually cured Philip of all ambition to attempt the subjugation of the most hated of his enemies.

The revolt of the Moriscos occupies a remarkable place in the native annals of the sixteenth century. These Christianized Moors still remained Mahommedans at heart, making amends for compulsory apostasy by celebrating in secret the rites of their religion. It was the jealous policy of Spain to destroy, if possible, every vestige of their nationality. To effect this end the government had recourse to severe and unjust measures, which produced open revolt and civil war in Granada. Dreadful atrocities were committed by the Moriscos, and fierce was the retaliation of the Christians. The war raged with various success for some time, but how the struggle must terminate could never for a moment be doubtful. The Moriscos fled to the mountains, the ancient asylum of liberty; and in the deep caverns with which they abound they deemed themselves secure. But thither they were hunted by the Christians, and, like wild beasts, smoked to death by fires kindled at the mouths of these subterranean retreats. All who were in arms were cut off in this manner, or by the sword. The total expulsion of the Moriscos, however, did not take place till a subsequent period. To some affairs of a private or more trivial nature it is unnecessary to advert, although some of them deeply implicate the character of Philip. This prince died in September 1598, in the palace of the Escurial, of which he was the founder, and which is the noblest monument of his reign. By the last of his four wives, Anne of Austria, Philip left a son, who succeeded by the title of Philip III.; his other male children preceded him to the tomb. Don Carlos, one of these, is generally believed to have been murdered by the command of his bloody and unrelenting father. The character of Philip was gloomy, stern, and cruel; he was suspicious, dark, and vindictive, the irreconcilable foe of civil and religious liberty, for which there can only be brought forward as a palliation his zeal for what he called religion. But Philip was eminently prudent, attentive to public affairs, and what he conceived to be the best interests of his country. It has been supposed that the sceptre of Philip was swayed over 100,000,000 of human beings, including the population of all the foreign possessions of Spain. At this time the state of the inhabitants of the Peninsula was one of comparative comfort. Agriculture, manufactures, and commerce, flourished to an extent even greater than in the best period of the emperor's reign. Yet all his vast resources, especially in the New World, were unhappily wasted by Philip; and his own policy destroyed the very foundations on which they rested, and hastened the decay, or rather ruin, of the kingdom. The measures which exercised so fatal an influence over the destinies of Spain may be briefly enumerated. 1. His persecution of the Flemings and Dutch, which led to a revolt that cost him 150,000,000 of ducats; 2. his war with England, no less expensive and disastrous; 3. the treasures sent to support the abominable Catholic league, and wars in other quarters; 4. the subjugation of the Moriscos, and the proceedings of the inquisition, by which the most productive and useful classes of his subjects were ruined or expatriated. From these and from other minor causes, notwithstanding the enormous revenues and resources of the kingdom, Philip died insolvent.

Phili II.

The greatness of Spain having passed away with Philip II., from this period it declined with fearful rapidity. For a long period there is little to be recorded beyond the reign of worthless favourites, the profligacy of courts, and the feeble efforts of a government struck with mortal paralysis. Our retrospect of these reigns will therefore be characterized by a brevity corresponding with their importance. The most signal event of Philip III.'s reign was the total expulsion of the Moriscos from all parts of Spain where they had sought a home during the struggle recorded in the last reign. The loss to agriculture and commerce, for they were by far the most ingenious and industrious portion of the community, and the blow which would be inflicted on the national prosperity by the withdrawal of so much wealth as they possessed, were never taken into account by the duke of Lerma, the prime ministers, nor any of his inquisitorial councillors. Orders were issued for their immediate expulsion in September 1609, and no fewer than 600,000 individuals were forcibly dragged from their homes, and landed on the African shore, there to be treated even worse, by the most cruel and perfidious of the human family. The foreign transactions of this reign are unimportant. Philip III. died in March 1621, leaving his kingdom to a son who bore his name, and also inherited his imbecility.

Philip IV.

Philip IV. ascended the Spanish throne in his seventeenth year. Profligate extravagance and dissipation soon began to characterize the proceedings of the court, and murmurs and complaints to agitate the people, who were exhausted of their wealth in supporting pantomime and mummery at home, and iniquitous wars abroad. The reins of government were surrendered into the hands of the Conde de Olivares, a worthless favourite. An attempt to enforce an obnoxious measure drove the Catalans to revolt. They sought and obtained the aid of France, and this occasioned a feeble and unimportant war, which languished till 1660, when peace was concluded, but not till Spain had surrendered part of her territory to France. Contemporary with the origin of the Catalan insurrection was that of Portugal, by which the Portuguese freed themselves from the Spanish yoke. See PORTUGAL. During his long reign, Philip was frequently at war with England, Holland, and France, and every power committed fearful ravages on his territories. England took Jamaica during this disastrous and disgraceful period of Spanish history. In Naples, a terrible shock was sustained in 1646, by the insurrection of Massaniello. See the article NAPLES. But the most calamitous of Philip's transactions was the war in the Low Countries, which terminated in his recognising the independence of the seven United Provinces. Philip died in 1665. His character needs no description. Since the days of Roderick the Goth, a more disastrous reign than his had not darkened the annals of Spain.

Charles II.

Charles II. son of Philip IV. succeeded to the throne when only four years of age. As the affairs of the kingdom were then situated, they were not likely to improve under a child; and it was a further misfortune, that throughout his long reign the king remained little better than a child. He was feeble in body, and next to imbecile in mind; in proof of which it may be mentioned, that he believed himself bewitched, and submitted to the exorcisms of his confessor with devout solemnity. Louis of France, who espoused Maria Teresa, sister of Charles II. by a prior marriage, in right of his wife preferred a monstrous claim to the Low Countries, and poured his legions over the frontier to make it good. The union of Sweden, Holland, and England, to oppose the ambition of the Frenchman, saved the whole Netherlands from subjugation; but by the peace of Aix-la-Chapelle Louis retained the most valuable of the conquests which he had made. In this reign the complete independence of Portugal was recognised. In 1672, France invaded Holland, now the ally of Spain, conquered Franche-Comté, which belonged to Spain, made some destructive inroads into Catalonia, and reduced some fortresses in the Low Countries. By the alliance against France, in which England, Germany, and Spain joined, Louis's career of ambition was effectually checked. But subsequently he reduced Valenciennes, Cambray, St Omers, and other places; Ypres and Ghent were assailed with equal success; and a place on the Catalan frontier also yielded to his arms. Most of these places, however, were restored at the peace of Nimeguen in 1678, one of the conditions of which was, that Charles should receive the hand of Maria Louise, niece of the French king. On the death of this princess in 1689, the French again poured the storm of war over the frontier of Catalonia. Destitute of money and of troops, Spain trembled to her most distant extremities. But circumstances of a delicate nature, into which we shall not enter, induced Louis to restore all his conquests at the peace of Ryswick in 1697. The health of Charles, always infirm, now rapidly declined, and he expired on the 1st of November 1700. He was the last of the Austrian dynasty; and glorious as the condition of Spain was under its early sovereigns, those who succeeded them had brought the kingdom to the verge of ruin. From the accession of the third Philip it had declined, from causes already specified.

History.

The condition to which it was now reduced was pitiable. The army and navy were in a state of utter disorganization; the walls of towns and fortresses were in ruins; the public revenues had dwindled to little more than a nobleman's income; and trade, manufactures, and commerce, had all but ceased to exist. Another such reign as that of Charles II. would have dissolved the bonds of society.

Philip V.

Charles II. was succeeded by Philip V. duke of Anjou, grandson to Louis XIV. of France. He was the eldest son of Maria Teresa, eldest daughter of Philip IV., consequently the most legitimate sovereign; for Charles left no issue, and before his death he had subscribed an instrument, declaring Philip his successor. The foreign events of this reign demand our first attention. The transactions of the war which was soon declared against France and Spain, by England, Holland, and the empire, assisted by Savoy, Portugal, and Prussia, have been already related under the article Britain. The chief objects of the alliance were to obtain satisfaction for the Austrian claims on Spain, the emperor Leopold being not only descended from Fernando, brother of Charles V., but whose mother was the daughter of Philip III.; to rescue the Netherlands from France; to prevent the union of the French and Spanish crowns; and to exclude subjects of the former from the Spanish possessions in the West Indies. The treaty of Utrecht, which terminated the differences between the principal contending powers, was signed in 1713; and in 1715 a permanent peace was concluded between Spain and Portugal. By the celebrated treaty of 1713, Spain was stripped of half her European possessions. Philip was indeed acknowledged king of Spain and the Indies; but Sicily was ceded to the duke of Savoy; Milan, Naples, Sardinia, and the Netherlands, to the emperor; and Gibraltar and Minorca to the English. The Catalans, who had revolted and joined the allies, were likewise guaranteed a general amnesty, but without any stipulations for the preservation of their ancient fueros or privileges, which they had justly forfeited. Philip also renounced, both for himself and his successors, all claims to the French crown. In return for this renunciation, he forced rather than persuaded his council to introduce a measure to which subsequent events in the history of Spain gave great importance. This was to alter the order of succession, and establish a sort of Salic law, by which the most distant male of the family would be called to the inheritance in preference to the nearest female. The innovation was regarded with discontent. By the ancient law, which, in default of direct male issue, called females to the throne, the monarchy had been formed. By it Catalonia had been united with Aragon, and the latter with Castille; and by it Philip himself had inherited the crown.

Philip made an unsuccessful attempt to recover Sicily, Sardinia, and Naples; for he had now rendered both his navy and his army formidable alike by discipline and numbers. His fleet, however, was totally destroyed off the coast of Sicily, by our Admiral Byng, in the year 1718.

By a new treaty in 1720, Sardinia was given to the duke of Savoy, and Sicily to the emperor; and by the treaty of Seville, concluded in 1729, the duchies of Tuscany, Parma, and Placentia, were ceded to Spain. In 1731, the Spanish king invaded Naples, took possession of that kingdom, and conferred it on his son Don Carlos, in consequence of which war was declared between Spain and the empire in 1733. At the end of that year the palace of Madrid was consumed by fire, and all the archives relating to the Indies perished in the flames. In 1739, hostilities were renewed between Spain and Britain; but the only successes obtained by the latter power were the capture of Porto Bello by Admiral Vernon, and that of the Manilla galeon by Commodore Anson. Philip's long and turbulent reign was now drawing to a close. In July 1746, he was hurried to the grave by an attack of apoplexy. One memorable event of his reign remains to be noticed. In imitation of the emperor, he resigned the cares of royalty into the hands of his son in 1724; but finding seclusion irksome, he resumed them again in a very short time. Whatever might be the weaknesses of this prince, he had a sincere desire for the good of Spain, and retrieved it from hopeless ruin by several judicious measures which he introduced, so that the country attained a degree of positive prosperity unknown since the days of the second Philip.

Fero nd VI.

Ferdinand VI. a mild, prudent, and beneficent prince, reformed abuses in the administration of justice and management of the finances. He revived commerce, established manufactures, and promoted the prosperity of his kingdom.

Cha III.

Charles III. succeeded Ferdinand in 1759. The famous family compact was concluded at Versailles in 1761, among the four kings of the house of Bourbon. The English, alarmed by the naval preparations of Spain, declared war in 1762, and took Havannah in the island of Cuba, and Manilla in the East Indies. Notwithstanding this success, peace was hastily concluded at Fontainebleau, in November, by which the Havannah was restored. In 1767 the Jesuits were expelled from Spain. An unsuccessful expedition was concerted against Algiers in 1775, the particulars of which it is unnecessary to detail. In the war between Great Britain and her American colonies, Spain, by the intrigues of the French court, was instigated to take up arms in support of the latter. At the conclusion of that calamitous war, Great Britain, in a treaty with Spain, ceded to this power East and West Florida, and the island of Minorca. Charles died in 1788, and was succeeded by his second son Charles Anthony, prince of Asturias, the eldest having been declared incapable of inheriting the crown.

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Charles IV. had not long been seated on the throne before the portentous revolution in France involved Europe in a general scene of political and military contest. The king of Spain joined the general confederacy against the new republic, and in consequence was numbered among the objects of its resentment, by a declaration of war in 1793. The military operations of Spain, however, were extremely languid; and after two campaigns, in which she might be said to carry on rather a defensive than an offensive war against the republican armies, she was compelled to conclude a treaty of peace, which was signed at Basel on the 22d July 1795. By this treaty the French republic restored to the king of Spain all the conquests which she had made from him since the commencement of hostilities, and received in exchange all right and property in the Spanish part of St Domingo.

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This treaty was soon followed by a rupture with Great Britain. On 5th October 1796, the court of Spain having published a manifesto against this country, the court of London made a spirited reply; and about the same time was published a treaty of offensive and defensive alliance, which had been concluded about two months before, between the king of Spain and the French republic. In the war which followed between Spain and Great Britain, his Catholic majesty could boast of but little honour or success; and the French republic gained little from its new ally but the contributions of money which it from time to time compelled him to advance. On the 14th of February 1797, a Spanish fleet of twenty-seven sail of the line was defeated by Sir John Jervis off Cape St Vincent, and four of the Spanish line-of-battle ships were left in the hands of the victors. From this time till the temporary cessation of hostilities by the peace of Amiens in 1802, there is nothing remarkable in the transactions of Spain.

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On the renewal of the war in 1803, Spain was again compelled, by the overbearing power of France, to take an active part against Great Britain, and fitted out a formidable fleet, which was united to a considerable naval force belonging to the French. The Spanish declaration of war against Britain is dated at Madrid on the 12th of December 1804; and on the 21st of October 1805, the combined fleets of France and Spain were annihilated by Lord Nelson off Cape Trafalgar. After this terrible blow to the naval power of Spain, nothing of importance took place till 1808, when the liberties of Spain were subverted by the machinations of Napoleon. The designs of the French emperor, long suspected, became sufficiently apparent in 1808. Unfortunately the dissensions of the royal family of Spain were so favourable to his plans, that they may be said to have hurried on their execution. The dark and tortuous policy by which he effected his purpose, and the course which events took in Spain, will be found detailed in the article FRANCE, so that only a brief notice of the leading facts will be given in this place. At this time (1807) the management of state affairs was in the hands of Don Manuel Godoy, the favourite of Charles IV. and his queen, and better known by the name of the Prince of Peace. He had been raised from the humblest station to be the richest and most powerful subject in the kingdom, and to fill its highest posts. Ferdinand, the prince of Asturias, had refused to marry the sister-in-law of this fortunate minion, and to secure himself from his vengeance he wrote to Napoleon asking for protection. At the same time he exposed the administration of Godoy, in a letter to his father, and requested to be allowed some participation in the government. This so enraged the queen that she ordered his immediate arrest; but, on asking pardon of the king, Ferdinand was restored to liberty, not however before Charles had taken the fatal step of appealing to Napoleon regarding his son's supposed treasonable conduct. The emperor of France was thus constituted umpire between father and son. French troops poured into Spain, which was thrown into a ferment by the rumour that the royal family were preparing to fly to America. Popular indignation was kindled against the hated favourite, who narrowly escaped with his life. At length Charles abdicated in favour of his son, but two days afterwards privately protested against his own act, and sent a copy of this strange paper to Napoleon, who afterwards made it a pretext for his ulterior designs.

Ferdi nd VII.

The prince of Asturias, now elevated to the throne under the title of Ferdinand VII. made his triumphal entry into Madrid. Shortly afterwards he was induced to undertake a journey to Bayonne to meet Napoleon, and consult about the affairs of the kingdom. This memorable interview took place, and the eyes of Ferdinand were now thoroughly opened to the designs of the French emperor, by finding himself a captive in his hands, and his right to be considered king of Spain rudely denied. The rest of the royal family eagerly rushed into the snare set for them by the master of toils at Bayonne. Here father and son surrendered the crown of Spain into the hands of Napoleon, by whom it was transferred to the head of his brother Joseph. But such a momentous event as a change of dynasties, effected under circumstances of such atrocious perfidy, could not take place without rousing every loyal and every indignant feeling in the bosoms of the Spanish people. No sooner was the fact of the renunciation known, than the northern provinces burst into open insurrection. Asturias and Galicia set the example; and it was soon followed by almost every part of Spain not immediately occupied or overawed by the armies of France. One of the first steps taken by the leaders of the insurrection was to assemble the juntas or general assemblies of the provinces. When these were organized, they issued proclamations, calling on the Spaniards to rise in defence of their sovereign, and in the assertion of their own independence. Besides these proclamations from the provincial juntas, addresses were published in almost every province by the leaders of the popular cause; in particular, the province of Aragon was addressed by Palafox, a name celebrated in the annals of the Spanish revolution, in a bold and spirited manifesto. The junta of Seville, which assembled on the 27th of May, formed itself into a supreme junta of government, caused Ferdinand to be proclaimed king of Spain, took possession of the military stores, and issued an order for all males from sixteen to forty-five, who had no children, to enroll themselves in the national armies. On the 4th of July the alliance of Great Britain with the Spanish nation was proclaimed, and a struggle began which terminated in the complete expulsion of the French from the Peninsula. The events of this celebrated war will be found recorded in the article BRITAIN.

The loss of the royal family, by which they were deprived of a directing power, a legitimate head to give the constitutional stamp to their proceedings, plunged the Spaniards in great difficulties. Unity of opinion was wanting to the junta, and vacillation and weakness marked its proceedings. It was unfortunate, that while one spirit animated the mass of the people against the French, many of the nobles and other influential individuals had given in their adhesion to the French dynasty. The successes of the latter were attributed, probably not without some reason, to treachery; and more than one Spanish general fell a victim to public indignation, whether justly or unjustly cannot now be known. But whatever victories the French gained, they only remained masters of the places which they occupied. A vast system of guerilla warfare had been organized and vigorously prosecuted, which served to preserve the energy and confidence of the nation unbroken. The guerillas everywhere surrounded and harassed the French; no line of communication was safe for them. These petty achievements, however, could not compensate for the loss of battles on a large scale, and the capture of fortresses, the strongholds of the kingdom. The supreme junta fell under suspicion, and, unable to sustain the weight of government and the storm of public indignation, it was agreed that the Cortes should be convoked, and a regency appointed. The manner in which this celebrated Cortes was constituted has been a subject of keen disputation; but the circumstances in which the kingdom was placed at the time, rendered it impossible for the members being chosen according to the ancient forms. It has been alleged that this assembly was of a much more popular and democratic nature than the regular Cortes, which is undoubtedly the fact. It ought to be recollected, however, that the nobles were a suspected body, and therefore the burgesses and others might consider it dangerous to admit their voice in a matter which involved the liberties of the kingdom. But, we repeat, the situation in which Spain stood at this eventful moment made it a matter of necessity for those who directed the affairs of the nation, to act as they did. Had not the progress of the French armies dispersed the central junta, and concentrated the fugitive patriots at Cadiz, it is more than probable that the Cortes would have been assembled according to the ancient forms, and that the privileged classes, supported by the majority of the nation, would have defeated any attempt to alter the old constitution. But Cadiz offered to that party which has been since known by the name of liberal, the most favourable opportunity of striking a deadly blow at the very root of the monarchical power under which they had so long groaned in hopeless yet silent restlessness. Cadiz was not only in itself a place much more democratic than any other in Spain, but during the usurpation of the French it had become the asylum of all who professed liberal principles. As they generally belonged to that numerous class of the Spanish gentry who look up to the patronage of government for the means of subsistence, the court drew them together from the provinces. On the prospect of the political changes which the captivity of Ferdinand opened to the country, these men attached themselves to the central junta, and finally followed its members in their flight from

Seville to Cadiz. Hither, too, flocked all the stragglers of the philosophical party; and on the dissolution of that dull, dilatory knot of ill-assorted men, who, under the veil of dignified gravity, had for a time concealed their unfitness to direct the nation, the Spanish speculatists found themselves in the midst of a population highly disposed to listen to their doctrines, to approve their views, and constitute them the organs of the new laws which were to remodel the kingdom.

New constitution.

The majority of the first Cortes being composed of liberals, the project of a constitution was immediately set on foot, and a committee of the ablest members appointed to draw up the fundamental code of the monarchy. Such a task, at all times arduous, was, in the present circumstances of the country, beset with peculiar difficulties. Encouraged by the absence of the king, placed beyond any check from the privileged classes, and the weight of the landed property of the country, it is not surprising that the framers of the constitution allowed their zeal to carry them too far, especially when it is considered that the Spanish people were almost entirely unaccustomed to the exercise of civil rights. The government was wholly remodelled, so that from being the most absolute monarchy in Europe, it became the most strictly limited of all limited monarchies. As this constitution, with the exception of a few alterations, is nearly the same as that which is now in force, our introducing it in this place will serve to give greater clearness to the subsequent narrative of events. It was drawn up by 184 members of Cortes, on the 18th March 1812. On the 20th of the same month the regency, which consisted of Cardinal Bourbon and two other apparently incapable individuals, took the oath to maintain it. This constitution was acknowledged by the allies of Spain, namely, Great Britain, Sweden, Denmark, Prussia, Russia, and other states.

By one of the first articles in the code, the sovereignty is declared to reside essentially in the nation, which, being free and independent, neither is nor can be the patrimony of any person or family. All Spaniards, without distinction, are subject to taxation. "The religion of the Spanish nation is, and shall be for ever, the Catholic, Apostolic, and Roman, which is the only true religion." "The nation," it is added, "protects it by wise and just laws, and forbids the exercise of any other whatever." The government of the Spanish nation is stated to be "a limited hereditary monarchy." The power of making laws is vested "in the Cortes, jointly with the king." In describing the class of Spaniards who enjoy the privileges of citizenship, persons "reputed of African origin, either by the father or the mother's side," are excluded. A similar exclusion is given to Spaniards who obtain naturalization in another country, or who, without leave, absent themselves five years from Spain. The only basis for the number of representatives in the Cortes is *population*, to be taken from the census of 1797, till one more correct can be made. For every seventy thousand souls there is to be one deputy in the Cortes. The returns of the members are made by three successive elections. Every parish appoints electors for the district to which it belongs. These repair to the chief town of the district to choose another set of electors, who, lastly, meeting in the capital of the province, make the final appointment to the Cortes. The Cortes are triennial. No member can be elected for two successive representations. No debate can be carried on in the presence of the king; his ministers may attend and speak, but are not allowed to vote. There is a permanent deputation, or committee of the Cortes, composed of seven members, appointed by the whole body, before a prorogation or dissolution, whose duty is to watch over the executive, and report any infringement of the constitution to the next Cortes. It also belongs to them to convoke an extraordinary meeting of the Cortes in the cases prescribed by the constitution.[1]

The powers of the Cortes are chiefly these: 1*st*, To move and pass the laws, and to interpret and alter them when necessary; 2*d*, to administer the constitutional oaths to the king, the prince of Asturias, &c.; 3*d*, to determine any doubt or fact relative to the succession; 4*th*, to elect a regency, and define its power; 5*th*, to make the public recognition of the prince of Asturias; 6*th*, to appoint guardians to the king while a minor; 7*th*, to approve or reject treaties previous to ratification; 8*th*, to allow or refuse the admission of foreign troops into the kingdom; 9*th*, to decree the creation or suppression of offices in the tribunals established by the constitution, as well as of places of public trust; 10*th*, to fix, every year, by the king's proposal, the land and sea forces; 11*th*, to regulate the military code in all its branches; 12*th*, to fix the expenses of the government; 13*th*, to impose taxes, contract loans, and direct every thing relating to the revenue; 14*th*, to establish a plan of public instruction, and direct the education of the prince of Asturias; 15*th*, to protect the *political* liberty of the press; 16*th*, to enforce the responsibility of the secretaries of state, and other persons in office.

Laws may be proposed, in writing, by any one of the deputies. Two days after the motion, the bill is to be read a second time. It is then determined whether the subject is to be debated, or to be referred to a committee. Four days after the bill has been voted worthy of discussion, it is read a third time, and a day is appointed for the debate. A majority of votes decides the fate of the bill; the members present on these occasions must exceed half of their total number by one.[2]

The powers of the king are, 1. To suspend the passing of a law, by withholding his sanction. He can exercise this power against any decree of the Cortes for two consecutive sessions; but is compelled to give his assent if the same law is passed by three Cortes successively. 2. The executive power resides exclusively in the king, and extends to whatever relates to the preservation of public order in the interior, and to the external security of the state, according to the constitution and the laws. The privileges and duties of the executive are thus detailed in the constitution. The king may issue decrees, regulations, and instructions, for the more effectually enforcing of the laws; it is his duty to watch over the administration of justice; he declares war and makes peace, under the control of the Cortes; he appoints judges to all the civil and criminal courts, on the presentation of the council of state; all civil and military employments are of the king's appointment; he presents to all bishoprics, ecclesiastical dignities, and benefices which may be in the gift of the crown, all by the advice of the council of state; the king is the fountain of honour; the army and the navy are at his command, and he has the appointment of generals and admirals; he has the right of coinage, and the privilege of impressing his bust on the metallic currency of the realm; the king can propose new laws, or amendments to those in existence. It belongs also to him to circulate or withhold the pope's rescripts and bulls. He can choose and dismiss his own ministers.

The following checks are imposed on the king's authority by the constitution.

1. The king cannot prevent the meeting of the Cortes at the periods fixed by the constitution, neither can he dis-

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[1] The Cortes were separated into two bodies in 1836, and the election was made direct, not indirect.

[2] Some alteration in the powers of the sovereign was made in 1836, when this constitution was adopted. It was then decided, that the crown should have an absolute veto in the enactment of laws, and should likewise have the power of convoking, proroguing, and dissolving the Cortes; but in the latter case to be under the obligation of assembling others within a given time.

solve them or disturb their sittings; his advisers and abettors in such attempts are guilty of treason. 2. If the king should quit the kingdom without the consent of the Cortes, he is understood to have abdicated the crown. 3. The king cannot alienate any part of the Spanish territory. 4. He cannot abdicate the crown in favour of his successor without the consent of the Cortes. 5. He cannot enter into any political alliance, or make commercial treaties, without the consent of the Cortes. 6. He cannot grant privileges or monopolies. 7. The king cannot disturb any individual in the enjoyment of his property, nor deprive him of his personal liberty. If the interest of the state should require the arrest of any individual by virtue of a royal order, the prisoner must be delivered over to a competent tribunal within eight and forty hours. 8. The king cannot marry without the consent of the Cortes; he is supposed to abdicate the crown by taking a wife against their will.

The council of state is composed of forty individuals, viz. two bishops, two priests, and four grandees; the other thirty-two must not belong to any of these classes. The members of the council of state shall be chosen by the king, out of a triple list presented to him by the Cortes. The councillors of state cannot be removed without a trial before the supreme court of justice. Their salary is fixed by the Cortes. The functions of this council of state are to advise the king on all important matters of government, and especially upon giving or refusing his sanction to the laws, declaring war, or making treaties. The king, besides, cannot bestow any ecclesiastical benefice, or appoint any judge, but at the proposal of the council of state, who, upon every vacancy, are to confine his choice to one out of three individuals, whose names they are to lay before his majesty.

The laws for the security of personal liberty are these: 1. No Spaniard can be imprisoned without a summary process, in which he is credibly charged with the infraction of some law that subjects the offender to corporal punishment; 2. the arrest cannot take place without the warrant of a competent judge; 3. prisoners are not to be examined upon oath; 4. the gaoler shall keep a register of the prisoners, expressing the warrant, and the alleged cause of his confinement.

The rapid series of misfortunes which had shaken the imperial throne of France to its foundations opened the way for the return of the captive Ferdinand to Madrid. The constitutionalists looked forward to his appearance in the country with no favourable eye, and the arrival of despatches from him to the regency threw them into great consternation. Ferdinand announced that he had concluded a treaty with Napoleon. This assumption of absolute power on the part of the king, without the knowledge of the Cortes, was aiming a direct blow at their authority, and violating the constitution recently established; and they accordingly rejected the treaty. They likewise suspended the king from the exercise of all power till he should take the oath which the new constitution prescribed. He entered the Spanish territory on the 24th of March 1814, and took up his residence at Valencia. On his way he had not been slow to discover that the lower orders were in general indifferent to the constitution. The fact is, the new political principles had scarcely struck root among the people; and with a very considerable party, consisting of grandees, dignitaries of the church, and others, the king was still absolute, and these flocked around their master. In the Cortes itself there was a strong body opposed to the new order of things. A petition, signed by sixty-nine members, was presented to the king, in which the Cortes was described as a mere tool in the hands of a republican party, without freedom of debate, and acting under the control of a mob regularly hired to take possession of the galleries. Nothing, therefore, could be more favourable to Ferdinand's resuming absolute power. Accordingly, on the 4th of May 1814, a decree was solemnly promulgated, in which the Cortes were declared illegal, and all their laws consequently rescinded. Some of the leading members were arrested, as a prelude to what was shortly to happen. Under their usual leaders, the priests, the lower orders broke out into fierce demonstrations of joy when the news of these events reached the chief towns, and the king proceeded in a sort of triumph to Madrid. Further arrests of the deputies of the late Cortes took place; property was sequestrated and papers were seized; judges were appointed to try obnoxious members; but justice proving too tardy for the king's eager spirit of revenge, he himself pronounced sentence on the prisoners in a wholesale manner, in open defiance of all law and justice. A few were capitally punished, and a great many more were consigned to dungeons. The inquisition was restored, and was urged to exert its powers against all persons suspected of liberal opinions. Monks became once more the sole directors of the king's conscience, and the reign of absolutism and bigotry was completely restored.

But these arbitrary acts roused the dormant spirit of the Spanish people, and a revulsion of feeling was the consequence. In vain did the court party silence the press or bribe it into their service; facts which could not be concealed from the people daily pleaded the cause of liberty. Bribery and venality were soon observed to prevail around the throne; the treasury was completely drained, and the army remained unpaid; while, to add to the difficulties and dangers of Ferdinand's position, armed bands of guerillas, now become organized banditti, swarmed over the country, setting the helpless magistrates at defiance, and committing all sorts of atrocities. Free-masonry was abolished, and effectually kept in check; but a far more dangerous society, the members of which assumed the name of *Comuneros*, was secretly formed, and, in spite of the inquisition and its emissaries, held meetings in most of the principal towns, and kept up an active correspondence among their lodges. The constitution was publicly burned; but this served only to spread disaffection, and to give it an importance in the eyes of the people which it did not formerly possess. Cadiz having been fixed on as the head-quarters of the liberals, a regular plan for the overthrow of the government was there formed, and its secret influence was extended throughout the provinces. Our limits do not permit us to mention the numerous conspiracies which were discovered, and quenched in blood. They were sufficient to alarm any monarch but one wholly abandoned to the guidance of weak, wicked, or fanatical counsellors. Those who ventured to remonstrate with the king were banished or thrown into prison. The promise which he had made of granting a constitution founded on liberal principles remained unfulfilled, and for six years (1814-1820) Ferdinand reigned with absolute power. During that time there had been no less than twenty-five changes in the ministry, mostly sudden, and attended with severities. They were produced by the influence of the *camarilla*, or individuals in the personal service of the king. Every attempt to save the state was frustrated by such counsellors; and the overthrow of the government, now apparently inevitable, became accelerated by the loss of the American colonies.[1]

The army was the instrument of its fall. Amongst the officers several conspiracies had been organized for the restoration of the new constitution, at the head of which were

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[1] It is unnecessary to do more in this place than merely allude to the revolution in the Spanish colonies of South America, which broke out in 1808, and finally terminated in the achievement of complete independence. Under the heads MEXICO, PERU, PLATA, &c., the revolutions in the various provinces will be found described.

Porlier, Mina, Lacy, and Vidal. Mina had succeeded in making his escape, but the others were taken and executed, their friends at the same time being put to the torture or thrown into prison. But these severities had no effect in repressing the discontent of the army; for the cause which immediately produced it was not removed,—the arrears due to the troops still remained unpaid. The money which might have been employed for this purpose was foolishly lavished in fitting out an expedition to destroy the liberties of the revolted South Americans: by a singular destiny it became the instrument of the overthrow of despotism at home, and the restoration of Spanish freedom. The troops which were to embark in the autumn of 1819, were indisposed to the American service; and the officers, favourable to the constitution of the Cortes, took advantage of this state of feeling to effect their own purposes. Whole regiments had determined not to embark; and the commander himself, O'Donnel, count del Abisbal, was in the secret. But he basely betrayed the cause, and had the principal conspirators arrested in front of the troops. For this devotion to despotism he was rewarded by the court party by being removed from the command of the expedition. Such ungrateful conduct towards a man who had forfeited his honour to save them, could not fail to bring the *Serviles*, as they were designated, into general contempt. A favourable opportunity soon occurred for the liberals carrying into execution the same plan which had failed through the perfidy of O'Donnel. The yellow fever having made its appearance at Cadiz, the safety of the troops which were there assembled demanded that they should be removed to some distance, thus leaving the members of the secret societies and other patriots at liberty to prosecute their schemes without fear of violent interruption. The embarkation of the troops had been fixed for January 1820; but on the first of that month, Riego, who had been placed at the head of the insurrection, gained over several battalions, and proclaimed the constitution of 1812. He arrested Calderon, the successor of O'Donnel; and finally joining Quiroga, a liberated patriot, and at the time in command of some troops, the combined force, amounting to 5000 men, marched on La Caracea, which was occupied. They had previously taken possession of La Isla. But still the country showed no disposition to second this bold movement of the army. In vain Riego led a flying column through the provinces, proclaiming the constitution, and expecting support from the inhabitants; few or none joined him. But several fortunate circumstances which occurred at this time materially contributed to the success of the insurrection. Mina, who had been obliged to fly to France, entered the Spanish territory of Navarre on the 25th of February, and a numerous band immediately surrounded his standard. Risings simultaneously took place in different quarters in favour of the constitution, which was publicly proclaimed in Galicia, Saragossa, Valencia, Murcia, Granada, and many other places. General Freyer, who had been appointed to the command of the troops in Seville, was himself obliged to publish the constitution in that city.

These insurrections could not fail to appal the weak, ignorant, and unpopular party which surrounded the throne. Ferdinand himself saw no general of sufficient ability or loyalty to be trusted with the command of a large army, which could soon have been concentrated, for there still existed fidelity among a sufficient number of the troops. It was however an expiring feeling, which could only have been re-animated by a great leader, but which, in the present destitution of the country, a mere breath might extinguish. And it was extinguished. Ferdinand was abandoned by his troops. Even O'Donnel, who had acted the part of traitor to the liberal cause, became one of its principal supporters. At Ocana he proclaimed the constitution; an event which produced a great sensation in Madrid. The royal palace was surrounded by a crowd, who called on Ferdinand to accept the constitution, and he now found that no alternative was left to his choice. The humbled monarch appeared at the balcony, holding a copy of the constitution in his hand, as a pledge of his readiness to swear to its observance. This occurred early in March 1820. To give efficacy and legality to the restoration of the constitution, it was necessary that the Cortes should be convoked, and the oath of the king to uphold the new order of things taken in their presence. The Cortes assembled on the 9th of July, and all the formalities were regularly observed. Meanwhile the constitutional system had been put into complete operation. During its proclamation at Cadiz, a bloody and disgraceful transaction took place; some of the royal troops present wantonly fired on the unarmed multitude, and about 500 were killed or wounded. The inquisition was abolished, as inconsistent with it, the state-prisoners were liberated, and new ministers were appointed. In place of the Council of Castille, and that of the Indies, a supreme judicial tribunal, with appropriate subordinate courts, was established; national guards were organized in the provinces, and the municipal authorities were made to conform to the constitution.

The meeting of the Cortes of 9th July, and their subsequent proceedings, mark the establishment of a new order of things, destined however to be of short duration. This assembly acted with extreme moderation, the measures of retaliation being infinitely less severe than those which followed the king's triumph over the constitution. The members strove to temper the violence of the liberals, and endeavoured to restore the *afrancesados* (those who took the oath to support the French dynasty) to their rights, to counteract the machinations of the serviles, and to heal the wounds of the country. But some of their proceedings were characterized by less judgment and humanity. The suppression of many of the convents and of the *majorates*, the banishment of the nonjuring clergy, and some other of their measures, excited discontents. Various parts of the country became disgraced by popular excesses, while on the frontiers of Portugal the royalist party formed a junta for restoring the privileges of the crown and the church. Conspiracy and openly avowed disaffection to the new order of things spread so widely, that when the second session of the Cortes opened in April 1821, the country was declared to be in a state of danger. The command of the army having been intrusted to Morillo, quiet was in some measure restored; but still it was found necessary to summon an extraordinary meeting of the Cortes in September. Spanish affairs in America had now assumed their gloomiest aspect; and the government wished to compromise the matter by acknowledging America as a kingdom independent of Spain, but united with her under a common sovereign, Ferdinand VII. Such an absurd proposal was rejected with scorn. The absolutists, although beaten everywhere by the troops of the government, could not be entirely suppressed; and even the adherents of the constitution began to complain of the weaknesses and mistakes of the ministry. The Cortes requested the king to appoint abler men; and to this he reluctantly yielded in 1822. Notwithstanding the errors of the Cortes, considering that the king was with them, and that his brother Carlos, although approving of the conduct of the absolutists, had not ventured to join them, it is probable that the struggles, after continuing for a few years, might have ended in a compromise, had not the whole power of France been thrown into the scale of the serviles.

The events which immediately preceded Ferdinand's restoration to absolute power, and the complete annulment of all the acts of the Cortes, were so various and complicated, that, if fully detailed, they would of themselves more than occupy all the space within the limits to which this outline of Spanish history must be confined. Into particulars, therefore, we shall not enter; only the most important transactions can be noticed. Disaffection to the government in the southern provinces, where a strong body of French troops was stationed as a sanitary cordon during the prevalence of pestilence in Spain, terminated in open revolt. The national guards were called out to suppress it, and they were everywhere victorious; but the pecuniary resources were chiefly in the hands of the supporters of despotism. In Madrid an occurrence took place in July 1822, which threatened the most disastrous consequences. This was a daring attempt of the friends of absolute government to overthrow the constitution. They were supported by the royal guards, while the national guards were ranged on the popular side. A conflict took place, in which nearly the whole of the royal guards were cut off. But insurrection, although thus suppressed in the capital, still prevailed to an alarming extent in Biscay, Navarre, and Catalonia, where armed bands, under the name of apostolical troops, *feotas*, or soldiers of the faith, committed revolting cruelties. Near the French frontier, and probably under French influence, the absolutists appointed a regency, which issued orders in the name of the "imprisoned" king, as they thought fit to call Ferdinand, although he had recently, under no compulsion, but in the most voluntary manner, again declared his adherence to the constitution. The avowed object of this regency was the restoration of every thing to the state in which it had been prior to the 7th of March 1820. But this band of outrageous serviles, unsupported by the nation, was compelled to fly to France in November 1822. The foreign relations of Spain now fell into a state of dreadful disorder; and the principle of armed intervention pronounced by Austria, Russia, and Prussia, in relation to this unhappy kingdom, was threatened to be acted upon by France. The restoration of Ferdinand to the full enjoyment of sovereign authority was demanded by the four powers named, while England advised the Cortes to yield, and offered her mediation. But the Spanish government repelled with indignation this attempt of foreign powers to interfere in its affairs. The consequences were the recall of the foreign ambassadors by their respective courts, and the march of 100,000 French soldiers across the Bidassoa. The duke of Angouléme, by whom this army was commanded, established a junta, consisting of Eguia, Calderon, and Erro, who formed a provisional government, declaring the king the sole depositary of sovereign power, and that no change in the government should be recognised but such as the king should make of his own free choice. All the decrees of the Cortes were declared void; in short, the object of French interference was simply to restore the reign of absolute power. Unfortunately the Cortes had no ally. The relations of Portugal to Great Britain did not allow her to conclude a defensive treaty with Spain. Britain remained neutral; but the exportation of arms and ammunition to Spain was allowed, and, in parliament, Canning called the attempt of the French unjust, and wished the arms of the Cortes success; an expression of sympathy which led the Spaniards for a time to hope that Britain would take a part in the war. Ferdinand, for greater safety, had removed to Seville, and on the 23d of April 1823 he formally declared war against France; but he in vain called on the nation to support the constitution. The great mass of the people were completely under the influence of the most bigoted priesthood in the world, who of course were absolutists, and hailed the arrival of the French; the adherents of the constitution were confined to the educated class, the army, and the inhabitants of cities. The Spanish army might be equal in strength to that of the French, but a considerable part of it was disposed in garrisons and fortresses, scattered over a large surface of country. The military operations of the French, during their advance upon Madrid, were the siege and capture of several strong towns, and a few partial engagements, in one of which, at least, that of Logroño, they were defeated. The southern provinces, where the absolutists had always a preponderancy, were occupied by the invaders with hardly any resistance; but in Lower Catalonia, where Mina commanded, they were kept in check for a considerable time. The main body of the French army under Angouléme hastened to the capital, which was occupied on the 24th of May. One of the first steps taken was to appoint a regency, which put every thing on the same footing as before March 7, 1820. But the regency had no pecuniary resources, and no power, if they had the will, to prevent the furious ebullitions of party hatred. The Cortes had in vain tried to excite a general guerilla war; it was but too plain that the mass of the people, at once miserably ignorant and furiously bigoted, without any just notions of what rational liberty was, or in what the new constitution consisted, were content to surrender themselves entirely to the guidance of the priesthood, and consequently everywhere opposed the constitutionalists. Their hatred was still further increased by the seizure of all the property of persons of the opposite party, by a large forced loan, and by the coining of the superfluous church plate, to which measures the want of money compelled the Cortes to have recourse. The war had now spread from the south to the north over the whole breadth of the land, and was actively prosecuted in Andalusia and Estremadura. An attempt at mediation on the part of the English ambassador, Sir W. A'Court, failed; and the king having refused to go to Cadiz, the Cortes, acting on that part of the constitution which provides for the moral incapacity of the sovereign, appointed a regency with royal powers. We cannot regard this proceeding in any other light than as a gross indignity offered to the king, and most impolitic at the time. However, Ferdinand accompanied the Cortes to Cadiz, and the regency ceased to exist. On the other hand, the members of the Cortes who had declared the king morally incapable, were denounced as traitors by the regency of Madrid, which now became recognised by foreign powers, Austria, Prussia, and France, as the only legitimate government of Spain.

Meanwhile the war was briskly carried on, but nothing would induce the people to join the constitutionalists, who accordingly were gradually driven from stronghold to stronghold, although in some places they made a gallant resistance. Defection among the officers of the army materially contributed to the downfall of their cause. Morillo and Sarsfield were among the deserters. The regency of Madrid conducted themselves in a cruel and outrageous manner towards the friends of the constitution, notwithstanding the strenuous efforts of the French generalissimo to restrain their fury. The duke of Angouléme took possession of the city of Cadiz on the 4th October 1823. Previously to this, the Cortes had reinvested Ferdinand with absolute power, and requested him to remove to the French head-quarters, where he was received with becoming pomp. The first measure of the king was to declare all the acts of the constitutional government from March 7, 1820, to October 1, 1823, null and void, on the ground that during that period he was acting under compulsion. The war terminated in November; and on the 22d of that month the duke of Angouléme took his leave of the army of the Pyrenees. Among the crowds of fugitives were Mina and the count of Abisbal; and among the victims capitally punished was Riego, who suffered at Madrid on the 6th of November.

The party which now succeeded to power, although weak from want of means, was powerful enough to exercise a persecuting and vindictive policy towards the former partisans of the constitution. The French wished to secure mildness and moderation, but the bad faith of the Spanish government frustrated these objects. To restrain the violence of party fury, which so widely prevailed, a treaty was concluded with France, by which that power agreed to maintain a large military force in the country, until the Spanish army could be organized. This was certainly a wise measure in the circumstances; for Spain, if left to itself, would probably have fallen into irretrievable confusion. It was divided by two parties, who mortally hated each other; and the bonds of society, already shaken loose by years of war and unrestrained licentiousness, required little more to dissolve them altogether. The reports from the provinces were appalling; the treasury was empty; home and foreign credit were alike destroyed; and trade and commerce were paralyzed. The personal moderation of the king led to the formation of a plot by the absolutists, to compel him to abdicate, and to raise his brother Carlos to the throne. This was the origin of the Carlists, who make so conspicuous a figure in the sequel. An attempt to restore the inquisition was happily frustrated. In May 1824, a decree of amnesty appeared; but it was a mere mockery, for it contained so many exemptions, that those who were to enjoy its benefits seemed rather to form the exception than the rule. The year 1825 was disturbed by several insurrections of the Carlists, which were attended with numerous executions. The independence of the American colonies was recognised by foreign powers, but Spain herself did not acknowledge it till the year 1836. The general interruption of commerce and industry, with the flight of many persons of property, occasioned much distress. The disturbances continued for some years, attended with the same marks of feebleness on the part of the government, and a continuance of general distress. It was a period of terror for the liberals, who were plundered and imprisoned on the slightest pretexts. The army, purged of all officers suspected of liberalism, was recruited by a motley throng of adventurers, friars, smugglers, mechanics, publicans, and muleteers, who had been officers in the guerilla bands of Catalonia and Navarre. The ranks being replenished in this manner, the French troops were enabled to evacuate Spain in 1828. Some insurrections, which had broken out during the preceding year, were suppressed without much trouble; and in spite of the arbitrary rule of the Carlists, their tortuous policy, and their open violence, the country began to show some symptoms of improvement.

In May 1829, Ferdinand lost his queen, and on the 9th of November following, her place was supplied by a Neapolitan princess, Christina Maria. Unblessed with issue by his three former marriages, the hope and the desire of having a child of his own to inherit his honours and preserve the throne to his dynasty, probably hastened the nuptials of Ferdinand. The French revolution of 1830 caused much less sensation in Spain than might have been expected. The fact is, the liberal party had been so devoured or dispersed by the sword, the scaffold, exile, and the dungeon, that in the country itself it was not powerful; but a rash and ill-judged attempt in the constitutional cause was made from without. General Mina assembled a body of refugees and others, and invaded the Basque provinces; but they were speedily repelled, and sought refuge in France. Meanwhile, some events of momentous importance had taken place in the royal family. The Infant Don Carlos was presumptive heir of the throne; the succession to the Spanish crown had been subjected to the Salic law by Philip V., so that, as matters stood at present, no daughter of the reigning king could interrupt its descent to his brother. The queen of Ferdinand was about to make him a father, and in order to secure the crown to his own child, should the issue prove a female, he resolved on revoking the Salic law, which excludes females. It is important to observe, that, in 1789, Charles IV. issued a pragmatic sanction, having the force of law, and establishing the regular succession to the crown of Spain in females as well as males. The Cortes of 1812 likewise solemnly revoked the law of Philip V., and re-established the old law of the Partidas. But as Ferdinand had annulled the acts of that assembly, and as the decree of Charles IV. might be cavilled at by the fierce and intolerant party who wished that Carlos should succeed to the throne, the king obtained the records of the Cortes of 1789 regarding the succession, and on the margin opposite the decree of Charles IV., with his own hand, wrote a decree to the same effect. The minister, Calomarde (a Carlist at heart), remonstrated with the king against its publication; but Ferdinand was firm, and ordered the resolution to be carried into effect. In compliance with this demand, the whole was forwarded to the council; and in the gazette of the 6th of April 1830, the edict was published to the world. It was likewise regularly proclaimed in the streets of Madrid with the usual formalities. Ferdinand's foresight was justified. The infant with which the queen presented him was a daughter, born on the 10th of October, and christened Isabella Maria Luisa.

But the Carlists did not wait for the expected birth of the heir to the throne to show how terribly the publication of the decree had staggered them. They rushed into hasty plots against the government, which were detected before they were ripe for execution; and in various ways showed their chagrin and irritation. In order to render the succession still more secure, Ferdinand called a meeting of the Cortes, before which the edict of Philip V. was again repealed, and his daughter, the Infante Isabel, recognised as princess of the Asturias. An insurrection broke out in Cadiz in 1831, at the head of which was General Torrijas. It was soon quelled, and the leader, with fifty-three companions, fled to Malaga, where they were taken prisoners, and all shot in cold blood. The other events of this year are unimportant, with the exception of a sudden illness of the king, which so excited the hopes of the Carlists, that they strenuously urged their master to take advantage of the circumstance, and at once seize the crown. This remarkable fact shows with what spirit they were animated. It was not a love of justice, but ambition, and a spirit of vindictive hostility to the constitutionalists, who now began to be tolerated, that instigated them to attempt the exaltation of Carlos to the throne, and that at all hazards, even before he possessed the semblance of a claim to it; for while Ferdinand lived, by what right could he grasp at his sceptre? Yet his partisans extol his magnanimity in refusing it at this time.

In the course of the year 1832, Ferdinand had an alarming relapse of his disease, during the paroxysms of which a transaction took place of the utmost importance in itself, and which has been very differently represented by different parties. It was the signing of a decree by which he restored the Salic law to full operation, and the further confirming the disinheriting of his daughter, by annulling his testament in her favour. It is certain that the ministers strenuously urged him to adopt this measure; and that they were under Carlist influence, is no less certain. Every thing was accomplished to their wishes; the document was signed and properly secured, and the king appeared to have fallen into the sleep of death. His dissolution indeed was announced; but, contrary to all human expectation, the disease took a favourable turn; all symptoms of immediate danger disappeared, and consciousness and understanding were restored to Ferdinand. The use which he made of the lucid interval thus vouchsafed to him, was to dismiss his ministers, to appoint the queen regent during his illness, and to undo what he had lately done regarding the succession, thus restoring to his daughter her right to the throne. The decree to this effect was issued on the last day of the year. The former ordinance, he declared, had been extorted from him, not only when he was in the agonies of expected death, but under false misrepresentations that all Spain demanded it, and that the inviolability of the monarchy required it; whereas it had only been desired by an ambitious and unscrupulous faction, and was opposed to the fundamental laws of the kingdom. A more liberal ministry was formed, and some liberal measures were adopted; high expectations were raised that milder times were at hand, and the funds in Madrid rose ten per cent. Early in 1833, Ferdinand was able to resume the reins of government. On the 20th of June he assembled the Cortes to swear allegiance to his daughter, and do homage to her as their future sovereign. This solemnity was performed with great pomp in the church of the royal monastery of St Jerome. Don Carlos refused to take the oath; but previously to this he had taken up his residence in Portugal, where his nephew was playing the same desperate game which he himself was about to undertake. Ferdinand survived the ceremony of the *jura* only a few months. He expired on the 29th of September 1833, leaving a will, in which he appointed his daughter Isabella heir to the crown, and her mother regent during her minority.

No sooner was Isabella II. proclaimed queen, than Don Carlos announced his claim to the throne, and the flames of civil war burst out in the northern provinces, where his partisans, assembled in great numbers, stood ready armed for the contest. Of the bloody and protracted struggle for the throne which ensued, we can afford room for few details; indeed, an account of the numerous battles, skirmishes, sieges, and other warlike operations, would prove a very uninteresting and monotonous portion of the modern history of Spain. Isabella was acknowledged without opposition throughout all the provinces of Spain, and by the leading powers of Europe. The question of the Spanish succession, apart altogether from the bloody war to which it gave rise, has been keenly agitated in this and many other countries. It may be briefly stated as follows. Carlos's right rests upon the Salic law, which had never the force of law in Spain. The Salic law was not the ancient rule of succession; it was first introduced by the Bourbon Philip V., the great-grandfather of Don Carlos. Females could always succeed in Castille, Leon, and Portugal. It was by marriage with the heiress of Navarre that a king of France obtained a claim to that kingdom; and although females were excluded in Aragon, yet it was through a princess that its inheritance passed to the counts of Catalonia. It was by the right of female succession that the house of Austria reigned in Spain; it was by the same right that the Bourbons themselves occupied the throne. It formed a part of the Partidas, or system of constitutional law, which Philip swore to observe on his succession to the throne. The Salic law, on which Carlos grounds his claim, could only be established in two ways; by the old forms of the constitution, or by the despotic will of the sovereign. If the advocates of Don Carlos take their stand on the former ground, the answer is, that the forms as well as the substance of the constitution were violated when Philip V. established his law of succession; and that, conscious of its invalidity, he did not register it in the form usual with similar acts; while again, if we pass over the Cortes of 1789 as secret and irregular, we have the Cortes of Cadiz in 1812, which abolished the decree of Philip, and restored the ancient law of the Partidas. But Ferdinand having annulled the proceedings of this body, its re-establishment of the right of female succession must fall to the ground with its other decrees. There is however Ferdinand's own decree, constituting his daughter his successor, which was just as regularly sanctioned by the Cortes as Philip's law of succession. If, on the other hand, the sovereign is to be regarded as despotic in Spain, the question is at an end; for even Carlos must acknowledge that Ferdinand had a right to regulate the succession according to his own royal pleasure. This view seemed to have been taken by the king's confessor, and his minister Calomarde, when, during his dangerous illness at La Granja in 1832, they induced him to sign a new will, settling the crown on Don Carlos. Ferdinand's recovery disconcerted their plan; but their effort plainly shows that the partisans of Don Carlos at that time felt that the Salic law was a very weak support to their favourite's claims. The transaction by which Ferdinand (supposed to be on his death-bed) transferred the crown to his brother, is admitted by the Carlists to have been a perfectly legal proceeding. Can the subsequent transaction, by which, under exactly similar circumstances, the king appointed his daughter his successor, be considered otherwise than as an equally legal proceeding? If the constitution be referred to, the question is decided against Don Carlos; the will of the sovereign is against his claim; and, what is of yet more consequence, as the event has shown, the will of the majority of the nation is against him.

It was in the northern provinces, in Navarre, Guipuscoa, Biscay, and Alava, that the strength of Don Carlos lay. Here he was immediately proclaimed in several towns by the title of Charles V., and bands of Carlist guerillas assembled to maintain his right to the throne. He himself still hovered a fugitive on the frontiers of Portugal, his movements being closely watched by a royal force under General Rodil. Another strong division of the queen's army, under General Sarsfield, marched against the disaffected provinces. The Carlists retired before him; Bilboa and other towns were occupied and garrisoned; the constitutional party was restored in several places where it had lost ground; and the insurrection seemed at first to have been happily put down without much loss. But early in 1834 the affairs of the Carlists assumed altogether a new aspect. Hitherto their operations were carried on in an unconnected manner; this system was now exchanged for one of steady unity of design. Indeed so numerous were the adherents of Don Carlos in the north, that there was only required a firm hand to seize the reins, control local jealousies, and direct aright the energies of the provinces. Such a man was Thomas Zumalacarreguy, who now assumed the chief command of the Carlists. He was admirably skilled in the desultory warfare of these provinces, and well acquainted with the country and with the character of the inhabitants. By his activity and enterprise he repeatedly inflicted severe blows upon the forces of the queen, or the Christinos, as they were generally called. His method of fighting was to surprise the enemy in an unprotected position, and cut off as many of them as he could before they recovered from their panic. His troops would then suddenly separate and fly, but only to unite again at a predetermined point some miles in the rear. By this mode of warfare he caused great loss to the Christinos, while his own small band suffered little. The Christino army under General Rodil, who had now obtained the chief command, might amount to 20,000 men, and was thus sufficiently strong at least to have confined Zumalacarreguy to the mountains; but it was greatly reduced by several thousand troops having been distributed among a number of petty fortresses, most of which, one after the other, fell a prey to the Carlist chieftain. It was further weakened by being divided into different corps and scattered over the country. Rodil found it necessary to resign the command, which now devolved upon Mina, from whom much was expected. Nor did he disappoint the hopes which were formed of him. Just before his appointment, Generals O'Doyle and Asina had severally been defeated with great loss by Zumalacarreguy, which occasioned much alarm at Madrid, and loud outcries against the ministry. But the old warrior, though broken by sickness and infirmities, restored confidence by making head against the hitherto victorious Carlists, and bringing victory to the standards of the queen.

In the mean while, Don Carlos, after paying a short visit to England, made his appearance in Spain; and his presence among his partisans greatly strengthened his cause in the northern provinces. France and Britain had acknowledged Queen Isabella II. These two powers, along with Portugal, entered into a treaty with Spain, the conditions of which quadruple alliance were, that France should watch the frontiers, so that the insurgents might receive no aid from that country; that Britain should supply such arms and munitions of war as the Spanish government should stand in need of, whilst at the same time she should guard the northern ports of Spain, so as to prevent the insurgents from receiving any assistance in men, money, or ammunition, and also assist the queen with a naval force; and that Portugal should co-operate by every means in her power: but that country was at the time in too embarrassed a situation to render any efficient assistance. As soon as the arrival of Don Carlos in Navarre was known, the four powers who had been parties to the treaty renewed its stipulations, in respect that its object had not yet been attained. This imparted confidence and vigour to the cabinet of Madrid, of which it stood greatly in need. A variety of measures occupied the attention of government during the year 1834, not the least important of which was the plan of a new charter or constitution. It is quite unnecessary to enter into any details of what the Cortes proposed should be done, as every thing was overturned and put upon a new footing by a revolution which occurred two years afterwards. The financial state of Spain, particularly the large debt which the government owed to foreign nations, formed a subject of protracted discussion. Doubts were raised as to whether a part of it was legitimately owing; but the debates in the Cortes terminated in the whole being recognised as justly due. This contributed to restore the credit of Spain in foreign money-markets, where it had been greatly shaken, and enabled the government to contract for a new loan. Another measure of importance which engaged the attention of the Cortes, was the passing of a bill of exclusion from the throne against Carlos and his descendants. During the year the ministry had undergone a complete change, chiefly through the instrumentality of a popular leader of the name of Llauder. Zea was superseded in the office of prime minister by Martinez de la Rosa, supposed to be a person of more liberal predilections.

The military operations of 1835 were prosecuted with great vigour on the part of the Carlists. Several important towns and fortresses fell into their hands, and siege was laid to Bilboa, the capital of Biscay. After sustaining a furious bombardment for several days, the place was relieved, principally through the instrumentality of some British gunners under Lord John Hay, commander of a ship of war then on the coast of Biscay. It was during the attack on Bilboa that Zumalacarreguy received the wound of which he died on the 23d of June. The death of this chief threw a gloom on the affairs of Don Carlos: it was the severest loss which his cause had sustained, and he never properly repaired it. Among the Christinos this event diffused a joy and hope which they made no efforts to conceal. Worn out by long service, by age, and by disease, the veteran Mina resigned the command, which ultimately devolved upon General Cordova, under whom was the celebrated Espartero. The Spanish government having been permitted to levy a body of mercenaries in Great Britain, several thousand recruits were raised in this country, and were led to the theatre of war in Spain under the command of General Evans. The British legion soon took an active part in the war, and distinguished itself upon various occasions. The Carlist army, although it abandoned the siege of Bilboa, still continued in the neighbourhood, prepared to take advantage of circumstances. An opportunity soon occurred for attacking the Christinos at the village of Arrigoriaga, which they made an attempt to pass. The royalists were driven back with considerable loss, and this check for the time interrupted the movements of Cordova's army. On the other hand, the Christinos laid claim to more than one victory gained over their enemies; but these doubtful and unproductive skirmishes, which in the flush and enthusiasm of triumph were magnified into decisive battles, are too insignificant to require a detail in this place. At the close of 1835, matters stood much as they did at the commencement of the year. But the war was now carried on with more humanity than formerly. A strong remonstrance on the part of the British government, against the barbarous practice of putting prisoners to death, had the desired effect, at least for a time, of staying the effusion of blood in this inhuman manner.

Those parts of Spain exempt from the horrors of war, were for the most part subjected to the scourge of political anarchy. The new government of the queen-regent had been founded on an abandonment of the old system of unmitigated despotism. Her daughter's throne was to be identified with more liberal institutions, and was thus to be protected by all political reformers, all who were inimical to absolutism. But the extent to which the old system was to be abandoned, and the form in which a popular government was to be established, were questions regarding which every possible diversity of opinion prevailed. The unquiet elements thus at work showed themselves first in a military revolt, and then in the revolt of several provinces, in which the democratic party sought to usurp the powers of government. For a time they set the lawful authorities at defiance, for the government of Madrid was helpless. Even here disaffection had spread to a most alarming extent, the urban militia having openly revolted. In vain were royal decrees issued, and strong measures put in force to repress the disturbances; an open war between the government and numerous sections of the liberals seemed on the eve of breaking out. Fortunately this was averted by a change of the ministry, which was loudly demanded by the factious opposition. The life and soul of the new ministry was Mendizabel, a man of great vigour, and very popular among the people, on account of his liberal principles. He condemned the repressive measures which had been acted upon, adopted a more lenient system of dealing with the malcontents, and proposed various alterations in the constitution, the mere mention of which sufficed to restore the country to comparative tranquillity. But all the deliberations of the ministry and the Cortes were rendered abortive by the military revolution which broke out at Malaga on the 25th of July 1836. The object of the ultra liberals had uniformly been the restoration of the constitution of 1812. Without this no change of ministers could satisfy them, and no vigilance on the part of government could prevent them from covertly prosecuting their designs. It was with the national guard that the revolt originated. In Malaga the governor was assassinated, and a junta was appointed to proclaim the constitution. Intelligence of these events spread throughout the country with the greatest rapidity. Cadiz and Saragossa took up the signal nearly at the same moment; and they were instantly followed by Seville, Cordova, Granada, and Valencia. At length the capital itself joined the insurgent cities; and on the 13th of August the queen, now deserted and helpless, was compelled to issue a decree, promising the restoration of the constitution of 1812. But all men who were reasonable and honest in their politics felt and admitted that some alterations in that code were quite indispensable. The Cortes accordingly appointed a committee to consider and propose such alterations as were necessary and advisable; and this they accomplished in a highly satisfactory manner. The changes recommended and finally adopted by the Cortes were, 1st, that the part of the constitution which contained mere regulations and forms, and regarded organic bodies and laws, should be entirely suppressed: 2dly, that instead of the Cortes continuing to form, as they did under the constitution of 1812, only one body, they should now consist of two bodies, differing from each other in the personal qualification of their members, &c. but neither to be hereditary nor privileged: 3dly, that the crown should have an absolute veto in the enactment of laws, and should likewise have the power of convoking, proroguing, and dissolving the Cortes; but in the latter case to be under the obligation of assembling others within a given time: 4thly, that the election of members of the Cortes should be direct, and not indirect, as established by the constitution of 1812.

While Spain was thus undergoing the most momentous political changes, the very existence of the queen's government was threatened by the Carlists, who were making alarming progress in the very centre of the kingdom. During the early part of the year the Christinos attacked the position of the Carlists at Arlavan, but with so little success that they were compelled to make a retrograde movement. However, early in May, the British legion, under General Evans, gallantly carried the Carlist lines before St Sebastian; but unfortunately this victory, like many others gained, was productive of no important result, chiefly through the sloth and inactivity of the Spanish generals. The circumstance which created the great alarm to which allusion has been made, was the march of a large body of Carlists under Gomez through the very heart of Spain. This chief penetrated from province to province, to the centre of Andalusia, laying the country under heavy contribution, and carrying off loads of booty from every place which he visited. The audacity of this enterprise seems for a time to have paralyzed the royalists. Consternation spread over Spain from Madrid to Gibraltar. Gomez attacked and carried several towns, and some bodies of troops who attempted to arrest his progress were totally destroyed. No less than three distinguished Spanish generals, each with a large army, were despatched to cut him off; but all their efforts to entrap him and his daring band proved fruitless. He was repeatedly surrounded, and apparently on the eve of being taken, but always succeeded in effecting his escape. At length, however, he was hemmed in to the sea-coast at San Roque, and his destruction seemed inevitable; but, by a daring and masterly movement, he broke through the line which encompassed him, and secured his retreat to the strongholds of the north.

Towards the close of 1836, the town of Bilboa was again invested by the Carlists, to whom it was an object of great importance, as being a city of sufficient consideration to give dignity to the court of Carlos, and an appearance of permanence to his establishment. It was, besides, the capital of Biscay, and inseparably connected, in the eyes of the Basques, with their *fueros* and local parliament. The siege was carried on with an ardour corresponding with the importance attached to the place. The defence was equally spirited and heroic. During the sixty days which the investment lasted, the fortitude of the besieged was put to the severest test, not only by the long-continued fire of the Carlists, by their repeated attacks, and by their mining operations, but by want of proper food and by sickness. At length General Espartero succeeded in compelling the Carlists to retire with the loss of all their guns and *matériel* for the siege, and Bilboa was relieved. The intelligence was received at Madrid with unbounded enthusiasm, and honours and rewards were heaped upon the defenders, and those who had so opportunely relieved them. The Christinos, however, as usual, neglected to follow up the success, allowing the Carlists to remain unmolested in the neighbourhood. Near St Sebastian they mustered very strong during the early part of 1837, and here they were attacked by the Anglo-Christinos under General Evans, and driven back with some loss; but receiving a great accession of strength, the Carlists in their turn compelled the royalists to retreat with at least equal loss. The affair of Hernani would have been much more disastrous, but for the steady bravery of a small body of British marines, who checked the advance of the Carlists, and retired to St Sebastian in good order. In a subsequent attack on Irun and Fuentarabia, General Evans was completely successful; but it seems perfectly clear that this officer was never cordially supported by the Spanish commanders. The defeat before Hernani would never have taken place had Espartero and Sarsfield supported him according to the concerted plan. The time for which the British legion volunteered its services expired in the month of May, and shortly afterwards it disbanded, nearly the whole returning to England in the most destitute condition. Meanwhile Don Carlos had followed the example of Gomez, by marching an army through the central parts of the kingdom. Our limits will not permit us to follow him in this daring but useless expedition. One body of Carlists advanced within a few leagues of Madrid, and all was consternation in the capital. But the Christino generals concentrating their forces, compelled the main body of the Carlist army to retire from the provinces into which it had made so fierce an irruption. Disunion also began to show itself in the camp of Don Carlos, so that, disappointed and disheartened, he retreated to his old fastness beyond the Ebro, accompanied however by a large convoy of booty. Besides these military operations, prosecuted on a large scale, there was a system of desultory warfare maintained all over the country, more destructive in its effects upon the inhabitants than the regular operations of an army. Brigandage, never viewed with much horror in Spain, had now become as common as a lawful trade. Remorseless cruelty characterized the proceedings of all parties; and civil life, except in the large towns, seemed for the time suspended.

The civil and parliamentary history of Spain for 1837 presents little that is of any importance. The new constitution formed a fruitful theme of discussion in the Cortes. After undergoing the alterations already mentioned, and some others of less moment, it was solemnly ratified by the queen-regent in the Cortes, and proclaimed to the nation. It is worthy of being noticed, that an attempt to introduce toleration in religious matters, by an amendment to the article which establishes the Catholic faith, met with the strongest opposition. This striking fact shows how deeply rooted the old Spanish bigotry remains in the national mind. During the year, bills were passed for the suppression of religious houses, and the abolition of the payment of tithes, the maintenance of the clergy being left to the government. Several judicious ecclesiastical reforms were projected; and among other important measures passed by the Cortes, was the abolition of the local parliaments in the Basque provinces. Ministerial changes repeatedly took place during the year, but into these we shall not enter.

The military operations of the Carlists in 1838 were less successful and less enterprising than they had been during the two previous years. Cabrera, indeed, a general who had frequently signalized his talents for war, had firmly established himself in Aragon and Valencia, and the bands of partisans allowed no respite to the distracted provinces; but we have to record none of those daring and brilliant flying expeditions which more than once traversed Spain in all directions with such celerity and success as to command the attention of Europe. Something of this kind was indeed attempted by Basilio Garcia, and by Tallada, but both these generals were signally defeated. The cause of Don Carlos was now visibly declining: the best and bravest of the chiefs who had served him had successively incurred his displeasure, and were either in disgrace, exile, or confinement; above all, the country was beginning to be favourably disposed to the queen. Her troops however were very unsuccessful in the field. General Orad was defeated at Morella, and General Alaix also suffered a repulse. But the principal battle fought between the Carlists and Christinos was that of Maella, where General Cabrera completely routed the queen's troops under Pardinas, but sullied his victory by butchering nearly two hundred prisoners in cold blood. The war throughout had been disgraced by similar atrocities, notwithstanding the efforts of Britain to put a stop to them. Both parties appear to have been equally guilty of this inhuman practice. The operations of Espartero were feeble and uncertain. He did little but march a large army from place to place, without striking a decisive blow. As usual, almost every part of Spain continued to be ravaged by guerilla bands, who swarmed over the provinces with no other objects in view but plunder and bloodshed. During the year, the Cortes had twice met; their deliberations chiefly referred to the state of the finances and the negociation of a loan, which was not effected. The ministry, always feeble, had now become more feeble than ever, notwithstanding that changes were continually taking place. The queen-regent found it impossible to form a strong government in the present political state of the country. Its helplessness was such that the generals commanding in the different provinces found it necessary to act independently of its arrangements, and to appropriate the revenues of each province to the payment of the military expenses incurred in it, instead of allowing the monies to pass into the treasury. Thus General Van Halen, who had organized a fine army of 40,000 men, called the army of the centre, after declaring the kingdoms of Aragon, Valencia, and Murcia, in a state of siege for the rest of the war, and that in future the civil were to consider themselves in subordination to the military authorities, proclaimed, that the entire revenues of those provinces should be paid into the military chest, and exclusively appropriated to the expenses of the war. This was probably the very wisest measure that could have been adopted for bringing the war to a speedy termination. Want of pay had repeatedly paralyzed the operations of the Christino armies; it had dispersed the British legion; and at this very moment it was exciting discontent, if not revolt, in the camp of Don Carlos. To place the pay of the queen's troops upon a sure footing, was therefore the first step to secure ultimate triumph in the field.

During 1839, the cause of Don Carlos rapidly declined, notwithstanding the desperate efforts made by Generals Cabrera and Maroto to maintain it. Espartero, the commander-in-chief of the queen's troops, after some hard fighting, cut off the Carlists completely from the plains of Alava, while Diego Leon likewise expelled them from the rich country between the mountains and the Ebro. Many towns and fortresses of importance, one after another, submitted to the triumphant Christinos, so that almost the only parts of Biscay which now owned the authority of Carlos were rugged mountainous tracts of country, whither no regular army could follow the fugitives. An armistice was at length concluded between Maroto and Espartero, which was followed by twenty-one Carlist battalions laying down their arms. Don Carlos himself, reduced to the last extremity, fled for refuge into France, where he formally renounced his pretensions to the throne of Spain, under certain conditions alike reasonable and necessary. The question relative to the fueros of the Basques and Navarre, which, it will be recollected, had been abolished, caused much uneasiness. It seemed perfectly evident that these important provinces would not be satisfied, or completely surrender themselves to the queen's authority, unless their local privileges were restored. After some debating in the Cortes this measure was agreed to, government stipulating that it would so modify the fueros as to reconcile the interests of these provinces with those of the nation, and with the constitution of the monarchy. The only Carlist chief who gave any uneasiness to the government was Cabrera, who, little affected by the pacification of the northern provinces, still maintained his footing in Valencia, determined to support the cause of Carlos while an army remained to back him. Towards the close of the year, however, sickness paralyzed his exertions; nor is it supposed that he will be able to effect much when the season again arrives for an army taking the field. It is to be hoped that this protracted, bloody, and disgraceful war is now virtually at an end. It has left Spain overwhelmed with a debt which at present she has no prospect of being able to pay for many years to come. National property, chiefly that of the church, was sold to the amount of L.10,000,000, to meet the exigencies of the time, but even this large sum fell far short of what was required. The resources of the country are no doubt great, but a long period of peace, and a wise administration of public affairs, will be necessary before these are developed to their full extent. Spain has scarcely been free from internal war since this century commenced. The injury thus inflicted on agriculture, commerce, trade, and manufactures, is not to be estimated, while its effect on the morals of the people has been most pernicious, transforming the peaceful husbandman into a robber, and the aspiring student into a leader of banditti. That Spain has struggled through this sanguinary period of her history without being involved in total ruin, proves that the natural resources of the country are immense, and only require proper management to raise her above her former rank in the scale of nations.

STATISTICS.

The position and boundaries of Spain have already been described. Its extent north and south is from Tarifa Point, in the Straits, in 36° north latitude, to Cape Ortegal in Galicia, 43° 46′, making 7° 46′ of latitude, or about 540 English miles. From east to west the extreme points are Cape Creus, in Catalonia, 3° 17′ of east longitude, and Cape La Roca, 9° 17′ of west longitude, the distance in this direction being 560 miles. The Peninsula thus forms almost a square, allowance being made for the irregularity of its outline; and the entire extent of Portugal being excluded, it is reckoned to contain about 176,000 square miles English.

Spain may be considered as composed of a series of mountain terraces, which, projecting successively their rugged edges towards the south, present a flight of gigantic steps from the Pyrenees to the Mediterranean. The chains of mountains which terminate and divide the great plains of the Peninsula are branches of the immense ridge that, from the most elevated part of Tartary, runs across Asia and Europe, penetrates into the south of France by Switzerland, and, entering Spain in the direction of the valleys of Roncal and Bastan, separates Navarre from Guipuscoa, Biscay from Alava, the highlands of Burgos from the plains of Old Castille, and Asturias from the kingdom of Leon; then crosses Galicia, and dips into the ocean at Capes Ortegal and Finisterre.

The Pyrenees are lateral ramifications of this great trunk, which run east and west on the eastern side of Spain, and take a south-west and north-west direction on the confines of Aragon and Navarre. The accumulated mass of these mountains presents, towards the Peninsula, the convex side of a spherical segment, which, like a shield with its boss to the south, rounds its edges near the Atlantic and the Mediterranean, and rears the highest part of its curve on the Spanish territory, between the springs of the rivers Cinca and Ara. This eminence, called *Mont Perdu* by the French, is known, in Aragon, by the appellation of Tres Sorores, alluding to its three peaks, distinctly seen from Saragossa, of which the highest rises 4114 Spanish yards above the level of the sea. The line of perpetual congelation is there at the height of 2924 yards.

In the minor branches which strike off from the Pyrenees in a south direction, without forming a part of the great secondary chains, which we shall presently describe, there are some mountains too remarkable to be left unnoticed. Such are the Monsein, on the coast of Catalonia, near the town of Arens, and the well-known Monserrat, which rises, on the same coast, to the height of 1479 yards above the sea; such the Sierras of Ribagorza, Barbastro, Huesca, and Jaca, which take their names from the principal cities in their neighbourhood; such, finally, those numerous spurs of the great ridge which run into Navarre, whose various appellations would only tend to confuse the reader.

Of the main ridges which run across the Peninsula, that which rises to the west of the source of the Ebro was called *Idubeda* by the Romans, and formed the limits of the ancient *Celtiberia*. In its course towards the Mediterranean, the natives, according to a general custom, distinguish the various portions or great links of the chain by the appellation of *Sierras*, adding the name of some town or notable height in their vicinity. Such are the Sierra de Oca of Urbion (the *Distertiæ* of the middle ages), of Moncayo (*Mons Caunus*), of Molina, Albarracin, and Cuenza. Part of this chain forms the limits of Aragon and Castille; it then penetrates into Valencia, Murcia, and Granada, and ends in the Capes Oropesa (Tenebrium), Martin, Palos, and Gata. The small town of Alcolea, in the province of Soria, stands on this chain, at the height of 1486 yards above the sea. Its mean elevation, on the road between Molina and Teruel, in Aragon, is 1580 yards.

The first point where this great ridge splits into the minor chains, which lose themselves in the Mediterranean, is to the north of Albarracin, in Aragon. Of these branches the most remarkable is that which, entering the province of Valencia, is again subdivided into the smaller ridges which terminate at Peñiscola and Cape Oropesa. The waters that descend from these heights, to the north, mix finally with the Ebro, while the Turia and the Mijares are swelled by those which flow from the southern declivities. On the branch stretching towards Peñiscola, and in the limits of Aragon, rises the Muela de Ares, a conical mountain, deprived of its apex; whose top is an extensive plain covered with luxuriant pasture, and surrounded by fearful precipices, at the elevation of 1562 Spanish yards above the sea. This is one of the highest spots in the Peninsula. The Tagus, the Xucar, and the Cabriel, take their rise among these mountains, and divide the waters which flow from their sides between the Atlantic and the Mediterranean. Numerous flocks of sheep, both itinerant and stationary, find, in the valleys formed by this chain, the most abundant summer pastures.

From Albarracin, this chain strikes into the territory of Cuenza, in a direction nearly north and south. It then sends off a branch to the east-south-east, on which the Collado de la Plata, or Silver Hill, rises 1598 yards above the sea. It contains a quicksilver mine, which was formerly worked. From the neighbourhood of this town the Sierra de Espadan runs, like an unbroken bulwark, to the sea near Murviedro, in a direction between south-east and north-west. These hills are described as singularly grand and picturesque.

Near the source of the Tagus, the Iberian ridge sends off another branch, which, stretching in almost a southern direction, separates La Mancha from the province of Murcia, to the west of the town of Albacete, and rises into the lofty mountains of Alcaraz and Segura (the ancient *Orospeda*), dividing the waters between the Guadalquivir and the Segura, the two main streams which severally and finally convey them to the ocean and the Mediterranean. One of the two great limbs which terminate the Iberian ridge runs into the sea at Cape Cervera; the other, bending to the south, skirts the kingdom of Granada, and disappears at Cape Gata. To the latter belongs the mountain called Cabezo de Maria, between Carthagena and Cape Gata, one league west of the town of Vera, on the coast of Valencia. It rises 2287 yards above the sea, and has its summit covered with snow during one half of the year.

Smaller branches of this chain project between the Turia and the Cabriel, which loses itself in the Xucar at Cofrentes. A ridge runs between the last-mentioned river and the Alcoy, another stream, which flows into the sea near Gandia. A minor chain separates the Alcoy and the mouth of the Segura. The province of Valencia is, in fact, divided by mountains into most fertile stripes, watered by numerous streams, and enjoying every blessing which nature grants to the most favoured climates.

Great ridge between the Duero and the Tagus.

The great ridge whose summits divide the waters between the Duero and the Tagus grows out of the Iberian chain, not far from the sources of the Xalon and the Tajuña, to the south of the city of Soria, and the site of the ancient Numantia. Where it divides the province of Guadalaxara from that of Soria, it is called Sierra de Paredes, and Altos de Baraona. On one of the hills, north of Siguenza, rises the Henares, which gives its name to the ancient *Complutum*, now Alcala de Henares, the seat of a university. Near the source of the Lozoya, a rivulet which runs into the Xarama, these mountains are called Somosierra, till, more to the west, they bear the name of Guadarrama; an appellation which they preserve throughout the long course in which they skirt the provinces of Segovia, Avila, Guadalaxara, and Madrid. The Puerto de Navacerrada, the highest point on the road from Madrid to the summer palace of San Ildefonso, is 2204 yards above the sea.

The mountains of Guadarrama are a very striking object when seen from the neighbourhood of Madrid, on the road to Old Castille. They principally consist of naked, fractured granite rocks, heaped up together, and adorned only towards their bases with single evergreen oaks, while the upper parts are bleak, dreary, and barren, presenting fantastic prominences, and in many places covered with perpetual snow. This chain, in its course towards Portugal, where it ends in the Rock of Lisbon, rises into some remarkable elevations. We shall notice that of Peñalara, between the sources of the Eresma and the Lozoya, 2834 yards above the sea; the Puerto del Pico, in the province of Salamanca; the Peña de Francia, and Sierra de Gata, on the northern limits of Spanish Estremadura.

The minor branches run nearly north and south from the main ridge, and may be traced from the opposite course of the rivers which flow either into the Duero and the Miño, or into the ocean, on the western coast of Galicia.

Chain of the Tagus and the Guadiana.

Almost parallel to the mountains of Guadarrama, we find the ridge which divides the waters between the Tagus and the Guadiana; but it rises to no great height, and is altogether of minor importance.

Ridge of the Guadiana and Guadalquivir.

The third great branch of the Iberian ridge is the Sierra Morena (*Montes Mariani*), which divides the waters between the Guadiana and the Guadalquivir. It begins in the vicinity of Alcaraz, near the eastern limits of the province of La Mancha, issuing from that spur of the Iberian chain which terminates in Cape Palos, and, trending in a direction north-east and south-west, with La Mancha and Spanish Estremadura to the north, and Jaen, Cordoba, Seville, and Algarve in Portugal, to the south, ends in the ocean at Cape St Vincent. The pass named Puerto del Rey, where the road from Madrid to Andalusia crosses these mountains, is 821 yards above the sea. Near Cordoba, where the bold skirts of the *Montes Mariani* are seen, within a short distance to the north, like a skreen raised to protect the rich and extensive plains watered by the Gaudalquivir, the ridge borrows the name of the neighbouring city. On the southern limits of Estremadura, and to the north of Seville, it is called Sierra de Guadalcanal. The chain now bends to the south-west, forms the northern boundary of the Portuguese province of Algarve, and, through the Sierras of Caldeiraon and Monchique, connects itself with Cape St Vincent.

Ridge of Granada and Ronda

The brink of the last mountain plain towards the south of Spain is skirted by the ridge of Granada and Ronda, which, striking off at the extremity of the Iberian chain, is successively called Sierra de Gador, Sierra Nevada, Bermeja, and de Ronda, till it ends in various points of the coast, but most conspicuously in the Rock of Gibraltar.

Part of Sierra Nevada rises above the highest Pyrenees. The Cumbre de Mulhacen is 4254 yards above the sea, the Picacho de Veleta 4153. The line of perpetual congelation is found in these mountains at the height of 3305 yards.

Rivers.

The five great streams which water the plains lying between the great mountain ridges, are the Miño, the Ebro, the Duero, the Tagus, the Guadiana, and the Guadalquivir.

The Miño.

The Miño, or Minho (*Minius* or *Bænis*), rises in Galicia, in the district of Lugo, from a beautiful spring called Fuente Miña. This river is navigable only to Salvatierra, two leagues above Tuy.

The Ebro.

The Ebro rises, near Reynosa, out of a spring so copious that it turns a corn-mill a few steps from its source. After a course of 110 leagues, it flows into the Mediterranean at Alfaques. From the boundaries of Navarre to the sea, the Ebro makes a progress of 1° 12′ 42″ towards the south. The chief towns on this stream are Logroño and Calahorra, in the province of Rioja; Tudela, in Navarre; Saragossa, in Aragon; and Tortosa, in Catalonia. It is a misfortune for Spain that this great river presents strong obstacles to navigation, both in its course and where it reaches the sea. Of the plans which have been conceived, and partly executed, to obviate these impediments, we shall presently have occasion to speak.

The Duero.

The Duero, or Douro, has its source to the north of the city of Osma, in a deep lake, at the summit of that portion of the neighbouring chain of mountains called Sierras de Urbion. Its course is at first towards the south, passing by Garray and Soria, where it turns to the west, continuing in that direction till it reaches Miranda. From this town to Moncorvo the river falls again into a south direction. It lastly takes a decided course to the ocean, which it reaches near Oporto, having traversed a distance of 150 leagues. This river is navigable up to the tower of Moncorvo, a space of thirty leagues. The navigation, which was formerly obstructed by rapids, has been expedited through the exertions of the Portuguese company of Alto Douro. Some of the smaller streams flowing into the Duero rise at remarkable heights. The Adaja, which descends from the northern slope of the great chain between the Duero and the Tagus, is, at Avila, 1271 yards above the sea; the Eresma, when it flows by the castle of Segovia, is 1107 yards above the same level.

The Tajo, or Tagus.

We have mentioned that elevated part of the chain between the Tagus and the Guadiana which takes the name of Albarracin, and the truncated mountain called Muela de San Juan. An inconsiderable spring, denominated Pie Izquierdo, is the source of the majestic Tagus. In its course through the province of Cuenza it is considerably augmented by the contributions of several streams. Before its waters reach Aranjuez, they surmount the rocky edge of its native mountain, and, dashing upon the plain beneath, sink into a pool of great depth, called Olla de Borlaque. The Tagus, now running placidly through the plains of Zorita and the royal gardens of Aranjuez, at the elevation of 621 yards above the sea, directs its course to Toledo, passes by Talavera, Alcantara, Abrantes, and Santarem, losing itself finally in the sea near Lisbon. The latitudes of several towns on the banks of the Tagus show the gradual inclination of its stream towards the south.

The diana

The sources of the Guadiana are found north of Alcaraz, in La Mancha, at the pools of Ruidera. The course of the river is first to the north-west for eight leagues. It is then absorbed by the soil, and disappears for seven leagues. The first gathering of its waters, after their subterraneous dispersion, takes place near Daymiel. The spot is called Ojos (Eyes) de Guadiana. The stream now proceeds to Ciudad Real, the chief town of the province of La Mancha, to Merida, Badajos, Mertola in Portugal, and, re-entering the Spanish territory, terminates in the ocean at Ayamonte. In its course to this point, the Guadiana passes over a space of more than 100 leagues, but it is not navigable higher than Mertola in Portugal.

The dalqu

The Guadalquivir occupies the centre of the plain which lies between the Sierra Morena and the chain of Granada, where it takes its course to the north-east of Jaen. The chief towns on its banks are Andujar, Cordoba, Seville, and San Lucar (*Templum Luciferi*). At the ferry near Mengibar, on the road from Madrid to Granada, the Guadalquivir is 203 yards above the sea. This river is navigable for large vessels up to Seville; but its bed being constantly raised and obstructed by growing shallows, the navigation is extremely tedious.

If we except the series of small lakes from which the river Guadiana takes its rise, there are in Spain few lakes that merit particular notice. The most remarkable of these is the lake of Abulfera, in the province of Valencia. This lake begins near the village of Cataroija, about a league north of the city of Valencia, and extends nearly four leagues, as far as Cullera. When it is full, it is about four leagues in length, and two in breadth; but it is so shallow that small boats can scarcely float in it. To supply the deficiency of water, an engine is employed, by which the neighbouring waters are drawn into the bed of the lake; and any superabundant water occasioned by heavy rains is carried off into these by means of an artificial opening. This lake contains a great many fish, and numerous aquatic birds make it their haunt.

Soil clim

According to Professor Hausmann, viewing Spain as a whole, a threefold principal difference is to be observed. The northern zone, which extends to the Ebro, differs entirely in its characters from the middle zone; and this again is completely different from the southern zone, which is bounded on the north by the Sierra Morena and a part of the Ostrandes. The northern zone, which includes Galicia, Asturias, the Basques, Navarre, the northern part of Aragon and Catalonia, is a widely extended, mountainous, and hilly country. The snow-fields and glaciers of the Pyrenees on the one side, and on the other the north and north-west winds, have a marked influence in lowering the temperature of the atmosphere, and in increasing the supply of water. The increased humidity is favourable to vegetation, which on the whole very much resembles that of the south of France; and the variety of rocks containing lime, clay, and sand, and also their frequent alternations, operate beneficially on the soil. Everywhere it invites to cultivation, and the inhabitants of this region are active husbandmen. The middle part of Spain, which comprises Old and New Castille, a part of Aragon, Leon, and Estremadura, is not so favourably circumstanced. Generally speaking, it is deficient in either beauty or variety of aspect. The broad and lofty table-lands present a uniform and monotonous surface, destitute of trees, and scorched by the rays of the sun. The corn-fields are wretchedly cultivated, and desert heaths of cistus everywhere meet the eye. Plantations of olive-trees are rare; here, in short, every kind of vegetation dwindles for want of water. In most cases the rivers carry but little water in comparison with the extent of the land and the number of considerable mountain chains. The causes of this great deficiency are principally the extreme dryness of the atmosphere; the inconsiderable cover of snow on the mountains, and its short continuance; the absence of forests and great moors on the heights; and the comparatively inconsiderable breadth of the mountain ranges. The southern and south-western part of Spain, which comprehends Andalusia, Granada, and Murcia, is very different from that just described. On the opposite side of the Sierra Morena the whole land has a more southern aspect, which announces itself not only by the vegetable, but likewise by the animal kingdom. The great difference of climate is produced by the southern situation, the exposure of the acclivity on the south and south-west to the African winds, and the strong reflection of the solar rays from the lofty naked mountain-walls. The mountain ranges are more closely aggregated, the valleys more deeply cut; and there is also a greater difference in the rocks and in their position, so that extensive table-lands cannot be formed. The south of Spain thus possesses not only a much higher temperature, one fit for the orange and the palm, but also a more varied and more favourable soil for cultivation. In East Valencia and Murcia, in the south of Andalusia and the Algarves, in Western Alemtejo and South Estremadura, the rich and varied vegetation rivals that of the fertile plains of Syria. In Andalusia frosts are unknown, and the snow, if it ever falls, melts the moment it touches the soil; so that it is not surprising that, in the cultivated districts, the Spaniards, so famous for their maritime expeditions of yore, should have introduced many vegetables from remote parts of the world, thus giving a perfectly tropical appearance to the country. There is, however, a deficiency of moisture, but it seems only to affect the growth of some of the lower species of plants.

Passing over such productions of the soil as are only interesting to the botanist, we shall enumerate those which come under the cognizance of the husbandman. Spain may be reckoned one of the most fruitful countries of Europe, and it presents a great variety of products. Wheat, secale, barley, maize, and flax, are cultivated in almost all the provinces, but still not in crops sufficient for home consumption. Oats are neglected, barley being given to the cattle instead of that grain. Oil and soda are the principal products of the southern shores of the Mediterranean; the others are sumach, and different esculent plants of an admirable quality. In the same part of the country are fields of saffron, plantations of rice, which stretch out like so many plains, and the cotton shrub thrives as on its native soil. The mulberry trees are very luxuriant, and their leaves afford rich nourishment to the bombyx, which easily accounts for the superior quality of the silk. In the south of Spain there is an immense variety of the most delicious fruits, not only such as are common in temperate climates, but many which naturally belong to the tropical regions. The sugar-cane grows near the cotton plant, and numerous olives furnish the oil which forms so important a branch of commerce. Kali, from which barilla is extracted, is produced in great abundance in Valencia; anise, maize, and different dye-stuffs in Murcia; and the honey of Cuenza is still as celebrated as it was in the time of the Romans. Among the vegetable products we may briefly mention chestnuts and a variety of other nuts, the cork-tree, palm, lemon, banana, date, pomegranate, fig, citron, cheremoya, laurel, bay, cypress, almond, and strawberry tree; potatoe and other culinary vegetables; forests of oak, pine, and other trees, chiefly in Catalonia, the Asturias, Galicia, and the Sierra Morena. Extensive valleys covered with rich pastures are found in Navarre, and numerous herds are fattened on them. In the Asturias considerable forests still exist, chiefly of evergreen oaks, from which naval timber is obtained. But of all the vegetable productions of Spain, the vine is the most important, the lands being almost everywhere favourable to its culture. The excess of the vintage above the quantity consumed in the country forms a considerable branch of the export trade, and it is capable of being greatly extended. The best wines are those of Peralta in Navarre; Ribadavia and Betanzos in Galicia; Mansanares and Val de Penas in La Mancha; Xeres or Sherry, San Lucar, and Rota, in Seville; Cabra, Lucena, and Campine, in Cordova; Malaga in Granada; and lastly, Alicant in Valencia. Sherry wine is produced in great quantities in the plain of Xeres, and a considerable portion is exported to this country. Mr Jacob estimates the quantity of this wine annually produced at 40,000 pipes, of which 15,000 are exported, mostly to England. The finest wine is produced in Malaga, but not in large quantities.

Mr Swainson thus describes the zoology. "The native zoology has been so little investigated, that nothing beyond a meagre list could be furnished of indigenous animals. In the mountains of Asturias the ibex is not uncommon, and the Alpine squirrel (*Sciurus Alpinus*) is only found in the Pyrenees. In the southern parts, bordering on the African shore, a few species of warblers have recently been found, which are as yet unknown to the rest of Europe. The European bee-eater frequents the vicinity of Gibraltar in large flocks during the season of migration. Among the domesticated animals, the horse and sheep deserve particular notice, as having been long celebrated throughout Europe. The best horses are generally about four feet six or eight inches in height; they have all the fire, docility, grace, and action of the beautiful Arabians of Barbary, and there can be no doubt of these noble animals having been introduced by the Moors and crossed with the native breed. Those of Andalusia, Granada, and Estremadura, are the most distinguished. At Zeres are found two perfectly distinct races; the one, which possesses the fine qualities above mentioned, is still preserved in all its purity at Chartreux. The other race is larger, stronger, less elegant, and used for common purposes. But little care has latterly been bestowed in keeping up the more noble breed, so that fine horses are not so common in Spain as formerly. The mule in so mountainous a country is particularly useful, and, with the ass, is principally used for conveying goods into the interior. The breeds of the latter are very fine, and are hardly excelled by those of Egypt. Spain is still celebrated for its Merino race of sheep. The flocks are kept constantly travelling during the greater part of the summer, but are carefully pent up in winter. This race, subdivided into breeds, is extended over the greater part of Spain, but those of Cavage and Negrate are the best. A third breed, the Sowan, appears more hardy, and passes the winter in Estremadura, Andalusia, and New Castille. These three constitute what is called the Transhumante, or travelling race, to distinguish them from the Estautes, or those of a somewhat inferior breed, which do not migrate. The best fleeces are those which appear almost black on their surface, caused by the dust adhering to the peculiar greasy pile; for it is invariably found that such fleeces are of the purest white beneath." There is a very large breed of oxen in the country round Salamanca; but the cattle of Spain have been much neglected, the mountaineers deriving all their milk and butter from goats. Fine cattle, however, are reared in the Asturias; and pigs are very common on the mountains of the same province. The wild boar, the wolf, the bear, and different kinds of deer, are still found in Spain, but these are gradually becoming extinct. The chamois and the lynx still find shelter in the Pyrenees and the mountains of Cuenza. The wild animals of the southern part of Spain are very similar to those of the north of Africa.

Minerals.

Spain has long been celebrated for its richness in minerals, and large veins of various metals are still found in several parts of the country. Gold and silver mines were formerly worked; but they have been given up, although grains of these metals are still found. Lead is found in considerable quantities; the principal veins, as the lead-glance veins of Sinares, are found in granite. The colossal deposit of galena, which yielded 600,000 quintals of lead in 1829, lies in irregular masses in a limestone formation. The principal mines are near Tortoza in Catalonia; at Zoma, Benasques, and Plan in Aragon; in Estremadura, in Murcia, in Old Castille, in Seville; and at the district of Linares, in Jaen. Mercury is also found, and at Almaden there is a rich mine of this valuable mineral, which is wrought in the clay slate. Iron ore occurs in very large quantities, principally in the northern provinces. In the Pays Basque, the lias formation is very rich in iron ore; and at Solomostro, near Bilboa, enormous deposits of carbonated iron are found. Veins of copper, antimony, and sulphur, are occasionally discovered, but not in such quantities as to be worth working. Coal also exists in considerable quantities in many provinces; and this mineral is gaining in importance every year, from other fuel becoming scarce.

Agriculture.

Although Spain possesses all the advantages of climate, and the soil is generally fertile, the agriculture of the country is in a state of deplorable backwardness. A variety of causes has been assigned for this, but the principal cause is what has been appropriately termed the curse of the Mesta. This is a privilege granted to the proprietors of flocks to conduct their sheep into different provinces for the sake of pasturage. In their progress the sheep commit considerable depredations on the crops. The law of entail, which exists in Spain in its worst form, is also supposed to hinder improvement in agriculture; but perhaps the most serious obstacle to improvement is the want of internal communication, and the indolence of the rural population. The farms are generally small, and the farmers of a district live together in villages. There is no rotation of crops, and the wheat, after a slight ploughing, is sown at the commencement of the rains. The operation of thrashing and cleaning the grain is performed in the open air, and the grain is left in the fields or concealed in caves till sold. Implements of husbandry are of the rudest description; fanners are unknown except about the sea-coast, and the spade is still in use in some of the mountainous parts of the country. The most careful cultivation is to be found in the *huertas* of Granada, Murcia, and Valencia, which are well irrigated by the waters of the Xenil, Segura, and Xucar. Rice is produced in Valencia, and a mild red pepper is the chief vegetable cultivated in Murcia. These three provinces are considered as the gardens of Spain, and annually yield three and four crops of vegetables, maize, and a mild red pepper. In spite of this fertility, however, it is calculated that the entire lands of Spain do not yield more than from one and a half to two per cent. to the proprietors. Some improvements have recently been introduced, but even now scarcely a fourth of the surface of the country is applied to any profitable use. A far greater extent of land is devoted to pasturage than is required for the maintenance of the cattle; and only about a twelfth of the superficies is occupied by wood. In Biscay, agriculture has made many improvements; and in spite of the disadvantages of soil, the population of this district is more numerous, and grain cheaper, than in the fertile plains to the south and east of Seville; which, if properly cultivated, might supply all Spain. "The kingdoms of Old Castille and Leon," says a writer in the Foreign Quarterly Review, vol. v. "are justly considered the granaries of Spain. They have their outlets in the north by various ports from Gijon to St Sebastian, the principal being Santander and Bilboa. The provinces of Burgos and Palencia are the nearest points from which these ports get any considerable supply; the distance being from 130 to 140 English miles from each. The elevated and rich *campos* which extend from Logroño to Burgos, and thence on each side of the Arlanza and Pisuerga, and along the Cauvion, and numerous other streams which water the provinces of Palencia, Valladolid, and Zamora, yield immense quantities of wheat; and further to the west, and on the south side of the Douro, the provinces of Toro and Salamanca may be considered as forming a portion of the richest wheat country in Spain, or perhaps in the world. The crop is often so abundant for a series of years, that the produce of the fields at a distance from the villages is sometimes allowed to rot on the ground, the expense of conveying it home being considered beyond its value. It was calculated that the accumulated surplus of four or five successive years, in the *silos* and granaries of these plains, amounted at the close of the harvest of 1828 to 6,000,000 of fanegas, or 1,200,000 Winchester quarters. The ordinary cost of carriage does not exceed seven or eight shillings for every hundred miles; but the means of transport are so defective and so badly organized, that when any extraordinary demand for exportation takes place, the rates advance accordingly. Thus, in September 1828, the usual price was seven or eight shillings; but in consequence of extensive demands from France and England, it rose two months after to fourteen shillings and sixteen shillings per quarter. The grain of Spain is of the finest quality, that of Andalusia bearing a price ten or fifteen per cent. higher than that of any foreign grain brought to the markets of Cadiz. In spite of her facilities for agriculture, it is remarkable that Spain regularly imports, upon an average, 400,000 quarters of grain. This may arise from the want of proper means of transporting grain from one province to another, and not from any deficiency in the produce of the country." Several of the provinces, such as Galicia, Asturias, part of Leon, Santander, Biscay, and the kingdom of Navarre, barely produce sufficient for the consumption of their inhabitants. Catalonia does little more than maintain the half of its inhabitants; Valencia exports rice, but both it and Murcia import wheat; Cuenza, Guadalaxara, Segovia, Avila, and Madrid, produce less than their consumption. The provinces of Old Castille, part of Leon, Estremadura, part of Andalusia and Toledo, produce such an abundance that they might supply all the deficiencies of the other parts of Spain, and also export to foreign countries in seasons of plenty. Miñano calculates the gross amount of agricultural produce in 1826 at L.76,965,000, and the net produce at L.28,403,666. The same authority estimates the number of cattle, &c. in the kingdom in 1826 as follows: horned beasts, 2,944,885; horses, 400,495; mules, 223,646; sheep, 18,687,159; goats, 5,187,668; asses, 641,788; swine, 2,728,283; bee-hives, 1,697,593.

Manufa- tures, merce,

The manufactures of Spain are in a very depressed state, although some thriving manufactories exist, principally on the sea-coast. The manufacture of silk was formerly the grand staple of trade, and although now much depreciated, it is calculated to furnish employment for nearly 16,000 persons. Numerous manufactures of various kinds have been established in Catalonia within the last twenty years; those of silk and cotton are the most extensive, and are in a thriving state. The looms of Valencia are calculated to employ at the present day nearly 3000 persons, and produce tissues, gauzes, and ribbands, equal to the French manufactories. The silk manufacture of Talavera de la Reyna and Saragossa are still in high repute. The latter province also produces cloth, which is much in request. Galicia annually imports 20,000 hundredweight of flax, which is conveyed to Santiago, and distributed throughout istics.

the villages of this province to be converted into linen, and sold in the Castilles. In the north, Bilboa and Santander, in the south, Seville and Cadiz, are the great entrepôts for the exportation of wool, which is also spun and manufactured into cloth in Catalonia and Barcelona. These manufactures, however, are by no means sufficient for the inhabitants, and almost every species of manufacture is imported. In Catalonia there are numerous manufactories of coarse cloth, which enjoy a monopoly; coarse cloths of foreign manufacture being almost prohibited by a heavy tax. The finest cloth is manufactured in Valencia, and the trade is in a flourishing state, employing nearly 10,000 hands. Tanning is the most active branch of manufacture in the northern provinces. Potteries are numerous, but the articles produced are generally of an inferior description. There is a royal porcelain manufactory at Madrid, the produce of which is very superior, but it costs the government more than it returns. Hat and paper manufactories have also been established, and have met with considerable success. The manufacture of arms forms a part of the trade of Spain, but the quantity made is by no means great. There are two large factories in Biscay; at Abaceti and Toledo swords are made; at Segovia, fire-arms; and at this latter place, as well as at Seville and Placencia, there are good founderies. Seville carries on a considerable trade in leather, a species of which, prepared with gall-nuts, is in much request. Ferrol and Vittoria possess considerable tanneries; and the former has an establishment where varnished leather is made. Iron manufactories are very numerous in Biscay, but none of them is conducted on an extensive scale. In almost every village in this province some kind of iron ware is manufactured; horse-shoes, fusils, locks, and bedsteads being the chief articles, which are sent to the interior. Cast iron utensils are prohibited from being imported into Spain; but this regulation does not seem to be attended with any great advantage, for there is only one smelting manufactory at Bilboa. Several other iron manufactories have been established throughout the country, the principal being at Pederoza and Martulla in Andalusia; but it does not appear that they have met with any degree of success. Iron ore is prohibited from being exported, but considerable quantities are nevertheless sent to France. Manufactures are much checked in Spain by the system of monopoly, several of the largest manufactories being in the hands of the government, and consequently ill conducted.

Commerce.

The commerce consists chiefly in the exporting of wines, wool, brandy, fruits, silk raw and manufactured, lead, iron, mercury, barilla, and a few other articles, amounting in all, according to a government return in 1826, to the value of L.1,584,000. Iron, in bars, is exported in considerable quantities from Bilboa, Cumana, and Vittoria, chiefly to Bayonne and Bordeaux. Malaga and Alicant wines are also important branches of commerce; and the coarse wines of Murviedro are extensively exported. The export of dried fruits gives activity to the ports of Alicant, Malaga, Seville, and Valencia; and the latter town is famous for its dyes. The imports of Spain consist of sugar, salt fish, spices, wood, rice, butter, cheese, hides, wool, and cotton, and almost every manufactured article. The transport of salt from Cadiz and Torrevieju, for the fisheries of Galicia, is an important branch of commerce, and, along with the fisheries themselves, employs a great number of hands, producing the best sailors, and giving activity to the towns and villages on the coast, which is seldom seen in the interior. The net produce of commerce and manufactures was estimated by Miñano in 1826 at L.14,660,000. It is difficult to arrive at any correct estimate of the value of the exports and imports of Spain, from the want of official documents; and even when these are obtained, little reliance can be placed on them. The following is from an official document published in 1826.

Value of the Imports and Exports in 1826, distinguishing the Countries.

Statistics.

	Exports.	Imports.
Africa	L.340	L.11,090
Asia	...	214,660
United States	45,925	68,940
England	637,800	957,395
France	450,350	726,170
Germany	26,670	150,510
Holland	56,185	133,525
Prussia	5	2,060
Russia	4,085	135,800
Denmark	11,585	30,070
Sweden	6,210	87,080
Turkey	55	31,255
Switzerland	...	8,930
Sardinia	2	110,895
Italy	83,740	146,300
Portugal	146,160	204,090
Spanish American Colonies	330,373	754,690
Total	1,799,485	3,773,475

Amount of importations from the different states of Europe, the United States, Asia, and Africa	L.3,018,785
Importations from Spanish Colonies	754,690
	L.3,773,475
Amount of exportations to states in Europe, America, Asia, and Africa	L.1,469,112
Exportations to Spanish Colonies	330,373
	L.1,799,485

This table shows a balance of L.1,973,990 against Spain, of the imports over the exports; and the important article of tobacco is entirely omitted; neither is there any account of the imports and exports to and from the free provinces of the north.

Banking is almost unknown in Spain, the principal merchants doing the business of bankers. There are no substitutes for cash in ordinary transactions, bills of exchange being principally used; but these do not pass from hand to hand as cash, except by special arrangement. The difficulty of transmitting specie is the cause of these bills being much used; merchants preferring rather to pay a premium than run the risk of losing the specie altogether. The rate of exchange of course varies with the supply of bills in the market, and also with the character of the houses offering the paper. Most of the bills are at short dates, generally within one month. Some are as short as two days; and these are allowed eight days' grace, unless the word *fixed* is written on them. Interest generally varies from three to four and a half per cent. on discounting bills, but this mode of negociation is not much practised. Interest on mercantile transactions is understood to be fixed at six per cent., and three per cent. on mortgages; but the law is easily evaded, there being no penalty inflicted on those who charge more than the legal interest. There are no bankers with whom money can be lodged; and it is customary for people rather to horde up their money than to run the risk of its being lost in the hands of merchants.

Roads, canals, &c.

In internal communication, Spain lies under great disadvantages, both from the mountainous nature of the country, and the obstructed navigation of the rivers. In the hands of an enterprising people, these difficulties might soon be overcome. The roads and canals are not numerous, and, if we except the principal highways, are but imperfectly kept. The two roads which run from Madrid to Burgos, the one through Valladolid, and the other through Aranda de Douro, are kept in good condition; but the great eastern roads are represented as in a wretched state. The road to France by way of Vittoria and Irun is kept in excellent condition, considering the mountainous nature of the country through which it runs. The road to Corunna and Ferrol, through Galicia, is in many places impassable for carriages or carts. That over the Sierra Morena to Seville is well kept. The roads of Catalonia are said to be in better condition than most in Spain. These roads are kept up partly by tolls, and partly by local taxes; but the amount collected is not sufficient for maintaining proper communications. It appears that L.92,400 were expended in repairing and making roads and building bridges in the year 1826, and L.89,240 for the same purpose in 1827. The ordinary mode of conveying goods is by means of mules, asses, or small carts drawn by oxen. Stage-coaches are becoming more common; but these can only be used on the great roads, the ordinary cross roads being generally too bad for such conveyance. In Biscay and Navarre the roads are under the superintendence of the provincial administration, and are more numerous, better constructed, and more carefully managed, than any others in the country.

The canals are stated to be in a much more deplorable condition than the roads, and although many have been projected by government, none of any importance has been completed. The most important is that which was intended to unite the Mediterranean Sea with the Bay of Biscay; but of this mighty undertaking only two portions exist, the canal of Aragon, running parallel to the Ebro, from Saragossa, and that of Old Castille, along the Pisuerga and Carrion, by Placencia. Neither of these portions, however, approaches the sea, and their benefit is therefore limited. The other canals are, that of Castille, which connects the port of Santander with the Duero; the canal of Segovia, which connects that town with the river of the same name; and the canal of San Carlo, which is constructed to give a port to Fortoza.

The population of Spain presents fluctuations which can only be accounted for by the fact of the internal wars which have so frequently convulsed her, or on the supposition that the returns which have been published are incorrect. It has been gradually increasing for the last two centuries, and latterly at a more rapid progression. It appears that in 1700 the population was estimated at 8,000,000. The following table, extracted from M'Gregor's Statistics of Nations, gives the population in 1803 as exhibited by the official tables, and in 1827 as given by Moreau de Jonnes in his Statistics, which latter, however, must have exceeded the real numbers, as the population was ascertained in 1837 to amount only to 12,168,572.

General Description.	Provinces.	Superficies.		Population.		Inhabitants to Square Mile.	Capitals.	Geographical Position of Chief Towns.		Population 1827.
		English Miles.	French Leagues.	1803. (*a*)	1827. (*b*)			N. Lat. ° '	E. Lon. ° '	
New Castille	Madrid	1,330	110	228,520	297,812	224	Madrid	40 25	3 33	201,000
	Toledo	8,863	734	370,641	485,203	54	Toledo	39 52	4 11	15,600
	Guadalaxara	1,970	163	121,115	157,338	79	Guadalaxara	40 33	3 22	7,000
	Cuenza	11,410	945	294,290	382,577	33	Cuenza	40 6	2 16	7,000
	La Mancha	7,620	631	205,548	257,210	33	Ciudad Real	39 0	4 3	10,000
Old Castille	Burgos	7,752	642	470,588	611,762	78	Burgos	42 25	3 55	12,000
	Soria	4,118	341	198,107	267,537	65	Soria	41 42	2 30	5,000
	Segovia	3,502	290	164,007	221,379	63	Segovia	41 6	4 10	12,000
	Avila	2,600	215	118,061	153,479	59	Avila	40 45	4 45	4,000
Leon	Leon	5,943	493	239,812	311,755	52	Leon	42 45	5 27	5,000
	Palencia	1,751	145	118,064	153,482	87	Palencia	42 6	4 35	10,000
	Toro	1,992	165	97,370	126,581	63	Toro	41 45	5 37	9,000
	Valladolid	3,272	271	187,390	243,607	74	Valladolid	41 45	4 35	32,000
	Zamora	1,606	133	71,401	92,821	57	Zamora	41 35	5 45	7,000
	Salamanca	5,128	471	209,988	272,982	53	Salamanca	41 21	5 40	14,000
Asturias	Asturias	3,725	308	364,238	464,565	124	Oviedo	43 24	5 55	10,000
Galicia	Galicia	16,060	1330	1,142,630	1,585,419	98	Santiago	43 24	8 20	28,000
Estremadura	Estremadura	14,478	1199	428,493	556,780	38	Badajos	38 49	6 47	12,000
Andalusia	Seville	9,080	752	746,221	970,087	106	Seville Cadiz	37 24	5 39	91,000 70,000
	Cordova	4,202	348	252,028	327,256	77	Cordova	37 52	4 46	46,000
	Jaen	3,236	268	206,807	276.905	85	Jaen	37 48	3 51	18,000
	Granada	9,720	805	692,924	1,097,093	112	Granada	37 16	3 46	80,000
	Sierra Morena	1,304	108	6,196	... ...	...	Carolina	38 30	3 5	... ...
Murcia	Murcia	7,957	659	383,226	493,192	61	Murcia	37 59	1 5	35,000
Aragon	Aragon	14,882	1232	657,376	856,219	57	Saragossa	41 38	1 2	55,000
Valencia	Valencia	7,764	643	825,059	1,255,095	161	Valencia	39 29	0 23	66,000
Catalonia	Catalonia	12,111	1007	858,818	1,116,461	92	Barcelona	41 22	2 10	120,000
Navarre	Navarre	2,475	205	221,728	288,244	116	Pampeluna	42 46	1 42	15.000
Biscay	Biscay	1,280	106	111,436	144,875	113	Bilboa	43 14	2 42	15,000
	Guipuscoa	628	52	104,491	135,838	216	St Sebastian	43 10	1 58	9,000
	Alava	1,093	90	67,523	92,807	84	Vittoria	42 55	2 55	7,000
Balearic Isles	Majorca and Cabrora	1,352	112	140,699	... ...	...	Palma	39 30	2 25	30,000
	Minorca	242	20	30,990	242,893	136	Ciudadella	40 5	3 15	
	Iviça and Formen	181	15	15,290	... ...	...	Iviça	38 53	1 29	
	Total	176,627	1555	10,351,075	13,953,959	78				

(*a*) Official census. (*b*) As given by M. Moreau de Jonnes, in his Statistics for 1834. It is generally believed that the census of 1803 is much below the actual number of inhabitants; and according to the returns of 1723 it would appear that in 103 years the population had increased from 7,925,000 to nearly 14,000,000. It also appears, from the observation of most persons, that the actual population of Spain had increased more slowly than that of any other country, particularly before losing her South American empire. M. Moreau de Jonnes estimates the population in 1834 at 14,660,000. According, however, to a return of the number of senators and deputies to the Cortes from all Spain, corresponding to the population of the provinces, which appeared in the royal decree of 3 August 1837, the exact population of the kingdom was 12,168,572.

THE OFFICIAL RETURNS OF THE POPULATION FOR 1826.

Householders having the Qualification of Electors.

Nobility, including men, women, and children	1,440,000
Citizens and farmers, &c	1,560,000

Heads of Families, viz.

Magistrates and advocates	5,883
Notaries	9,683
Attorneys and clerks of law-courts	13,274
Medical men	17,990
Public functionaries and clerks	27,243
Merchants	6,824
Agricultural proprietors	364,514
Heads of families	445,411
Women and children	1,128,275
	1,573,686

Agricultural Population.

Agricultural proprietors	364,514
Farmers	527,423
Labourers	805,235
Proprietors of flocks and herds	25,530
Shepherds	113,628
Heads of families and others	1,836,330
Women and children	6,777,140
Total agricultural population	8,613,470

Merchants and Manufacturers.

Merchants	6,824
Retail dealers	18,851
Manufacturers and labourers	489,493
Heads of families	515,168
Women and children	1,803,088
Total manufacturing population	2,318,256

Other Classes.

Domestics (one in thirty-seven inhabitants)	276,000
Vagabonds (one in seventy)	140,000
Smugglers (one in a hundred)	100,000
Custom-house officers	40,000
Officers of the Inquisition	22,000
Wandering beggars	36,000
Convicts	2,000
All other classes, or one in thirteen inhabitants	700,000

Extent and Population of the Colonies of Spain in 1827.

	Square Miles.	Inhabitants.
Philippine Islands	...	2,525,000
Canary Islands	7,451	210,000
Cuba	46,700	704,487
Porto Rico		284,957
Presidencies of Africa	36	4,000
Total inhabitants	...	3,528,444

The population of Spain, according to the royal decree of August 1837, being 12,168,572, if we add the 3,528,444 of the colonies, the entire population of Spain and its dependencies will be 15,697,016.

The Roman Catholic religion exclusively prevails in Spain, and here in all ages it has assumed its most bigoted and intolerant form. The church establishment includes eight archbishops and seventy-two bishops, 2393 canons, and 1869 prebendaries, together with an immense multitude of other ecclesiastics, under various denominations. In the year 1835 there still remained 1940 cloisters, containing 30,906 monks. Of these the Franciscans alone possessed 651 cloisters, with 11,232 monks and lay-brothers. But by a royal decree of the above year, all the religious houses which did not contain more than twelve monks were abolished. The number of monasteries thus condemned amounted to 900. Their revenues were applied to the extinction of the national debt. The whole income of the church is valued at L.12,500,000 sterling, and the portion of the income which is consumed by the spirituality exceeds the collective income of the state by about L.2,000,000.

Education.

The institutions for public instruction in Spain are the universities of

	Established in	Students in 1827
Valencia, established in	1411	1569
Valladolid	1346	1247
Saragossa	1474	1175
Santiago	1532	1054
Seville	1504	807
Granada	1531	812
Cervera	1717	573
Huesca	1354	537
Oviedo	1580	420
Salamanca	1404	418
Alcala	1490	364
Onate		270
Toledo		257
Palma		177
Orihuela		124

There are two artillery schools, and a hundred and sixty-three colleges and seminaries of a higher order, containing 3810 pupils. The common schools throughout the country have been estimated at about 20,000.

There are numerous public libraries in the more important towns, some of them of considerable extent. One at Madrid contains about 130,000 volumes, numerous manuscripts, and a rich collection of medals. The prohibition, however, of many standard works greatly limits their value.

Finances.

According to the budget of 11th February 1837, the expenditure amounted to..................1,929,300,795 reals.
The income to..............................800,000,000 ditto.

With regard to the national debt of Spain it is impossible to obtain any thing like a correct estimate. For the last eight or nine years it has continued to accumulate with fearful rapidity, and loan after loan has been negociated. It seems almost impossible that so large an amount as from two millions to two millions and a half sterling, can be annually collected to pay the interest of the national debt in a country already grievously oppressed with taxes, and where trade is in some measure stagnant. The balance of her trade, ever since the loss of her colonies, has been in the ratio of two to one against Spain, while the whole value of her exportable produce, even in the most prosperous periods, has not exceeded three millions and a half; and this is now supposed to be greatly reduced, since the exports to England, which is the greatest consumer of her fruits, wine, and wool, have barely averaged for the last four or five years one million sterling. In 1833, the public debts amounted to L.165,000,000, and as the expenditure exceeded the income, and various loans have since been negociated, it has now materially increased. Taxation in Spain is very heavy, and is levied with little regard to the wellbeing or comfort of the population. It is grossly unequal and arbitrary, no one ever being able to tell what he may be required to pay; and the greatest abuses exist in its collection. Scarcely one half of the tax laid on the inhabitants ever reaches the government, the rest being absorbed by the various officers employed. No fewer than 16,000 persons are employed in collecting the custom-duties; and being ill paid, they are open to bribery, and even levy contributions for their own pockets. The same duties are not imposed in the different towns, one merchant being called upon sometimes to pay L.40 of a tax, while another in a different place may have only to pay L.20. The *alcabala* is a tax which is levied upon every article of use, and presses with great severity upon the poor. It was formerly an impost on the transfer of commodities from one hand to another, but is now paid by gate-duties. In towns which are not walled or have no gates, this tax is levied by a calculation of the amount paid by another town of the same size. Tithes are, next to the alcabala, the most oppressive of the taxes; but the clergy do not receive perhaps one half of the amount collected. There is also a tax of six per cent. on the produce of all rented lands; and on the accession of the heir to an entailed estate, the first half year's rental falls to the government. A tax of L.100,000 is levied yearly upon the merchants: the finance minister fixes the amount which each intendancy has to pay, and the intendant the proportion which each town must pay; and another magistrate assesses the individuals. The revenue from tobacco and salt is considerable, they being monopolies in the hands of government. The amount of salt which each town ought to consume is fixed; and landowners and farmers pay in proportion to the number of their dependents, and the cattle and sheep which they possess. The clergy pay an annual subsidy, in addition to some other contributions.

The state of crime shows Spain to be in a very imperfect state of civilization. The administration of justice is extremely slow and uncertain, and indeed all the legislation upon criminal affairs is as bad as possible. The crimes most complained of are those of assassination and robbery; and although these do not prevail now to the extent they once did, the returns show that murder is still a very common crime. The returns for the year 1827 give the number of murders as 1223, and attempts at murder as 1773; and this report is very inaccurate, as no returns were sent from either Aragon or Valencia. A person robbed or assaulted is bound over to prosecute; and should he fail to prove the guilt of the criminal, he has to pay all expenses of the suit. Witnesses are liable to imprisonment in case of the prisoner being acquitted; and this preposterous law has a strong and obvious tendency to interrupt the course of justice.

The poor in Spain are numerous, and begging is considered as no disgrace in many of the provinces. Even students have been known to go on begging excursions during the vacation, labour being in their estimation a greater disgrace than asking alms. There are numerous hospitals in the large towns, chiefly under the management of the clergy. The funds for maintaining them are principally derived from legacies of lands and rents, partly bequeathed by private individuals, and partly by bishops. In the northern provinces the hospitals are supported chiefly by public subscriptions and collections in the churches, the legacies being unimportant. The convents and monasteries support many paupers; the Franciscan, Dominican, and Capuchin orders, although beggars themselves, keeping open table for a certain number of poor. A contribution of L.30,000 is annually made from the public funds, being a portion of the revenue collected by the vicar-general of the *cruzado*. Notwithstanding these institutions, however, the number of beggars is still very great. Only in some of the towns is begging prohibited, and in these the vagrants are employed much in the same way as in our own workhouses.

The character of the Spaniard is grave, adventurous, romantic, honourable, and generous. He is not inclined to adopt foreign manners, and is possessed of great national pride. He is naturally brave, provided his heart be in the cause which he espouses; but he is easily excited to tumultuary violence, and is very unwilling to submit to the restraints of discipline. In prosperity he is apt to give way to supineness and false confidence; but in adversity which might overwhelm others, he will often display great courage and surprising resources. He is very slow in his operations, and often ruins enterprises by temporizing. In all the provinces except those of the north, the inhabitants are extremely indolent, and possess a most invincible hatred of labour. They are fond of amusements, dancing and cards being the favourite recreations. Theatrical exhibitions are not very popular, being generally insipid. They are still attached to the bull-fight, but this cruel amusement is not now so common as formerly. It will however prevail as long as the country remains in its present state of ignorance. Dancing has acquired a national character; and to this day the Spaniard has many an allegorical dance, borrowed from the Moors. The pleasures of society are chiefly sought at evening parties, where only slight refreshments are presented; and indeed, both in eating and drinking, the Spaniards are remarkably temperate. Music also forms one of their principal amusements, the instrument most generally used being the guitar. Castanets are also extremely common, and are employed with great dexterity and address in the national dances. The music of the country is not remarkable, being almost altogether light melodies, with a slight accompaniment from the guitar. Spanish architecture, from its being a mixture of the Moorish and Gothic styles, has somewhat affected the architecture of other countries. The innumerable churches scattered over the country are generally in the Gothic taste, but more light, from its conjunction with the Moorish. Many of them are fine edifices; but the most remarkable architectural monument of Spain is the palace of the Escurial, which is built entirely in the Roman or Vitruvian style. Spain has produced few great painters, which is somewhat remarkable, considering the poetical character of the people. Murillo, Velasquez, and Lope de Vargas have acquired a fame which will endure wherever painting is appreciated. There is at Madrid an academy for painting, sculpture, and architecture, and the royal palace and Escurial have galleries; but it does not appear that these arts are much cultivated in the present day.

The literature of Spain, in the days of her greatness, was almost on a level with that of any other country in Europe; but it has now sunk to a very low condition. The ballad is what the early Spanish writers most excelled in; and this is characterized by romantic fervour, frequently of an oriental character. The language is peculiarly fitted to express the dignified and the pathetic, but its solemn dignity frequently seduces the writer into bombast. No language has such a store of ballads as the Spanish; but they are, particularly the early ones, little more than mere relations of chivalrous deeds. The wars with the Moors form the subject of an endless number of these ballads, which the chivalrous nature of the people of Spain during the middle ages brought to a state of excellence unequalled in any country in Europe. The song was the natural growth of the warlike period of Spain, and served to commemorate warlike exploits; but they were of a very simple character until the period of the conquest of Naples, when they assumed a more lyrical form. The national drama has always been peculiar, consisting chiefly of religious comedies founded on the lives of saints. There are however some noble comedies of an historical nature. The perfection of the intrigue is what the Spanish writers chiefly value; but their plots are con-

Spallanzani.

structed without any regard to the unities. The drama acquired its greatest celebrity from Lope de Vega and Calderon. In romance, Spain has accomplished much. The perfection of Spanish prose is to be found in the works of the inimitable Cervantes. After his time, and when the Bourbons ascended the throne, the literature declined with the state, and may be said to have remained ever since in a similar state of inactivity. Spain possesses at the present day few writers known beyond their own country. Jovellanos on political economy, Campany in philology, Llorente in history, Moralez in mathematics, have done much to rouse a spirit of reflection; and Juan Valdez is called the Anacreon of Spain.

The army of Spain, once the most formidable and best organized in Europe, is now comparatively in a low state. It is, however, represented as the best organized part of her establishment, the pay being regular, and the officers experienced. In the present unsettled state of the country it is impossible to form any estimate of its actual numbers. Besides the regular army, there is a large body of militia called royalist volunteers, who have frequently proved of great service as light troops. The navy now exists only in name: in 1823 there was but one ship of the line, which, being sent out to South America, surrendered to the Peruvian government. (R. R. R.)

SPALATRO, a city of the ancient province of Dalmatia, and the capital of a circle of the same name, which extends over 2060 square miles, and contains 84,980 inhabitants. This city is situated on a peninsula, and is powerfully fortified both by nature and art. It incloses the space where formerly stood the extensive palace of Diocletian, the Roman emperor. It is now the seat of an archbishop, has a cathedral and several other churches, a seminary, and six religious houses, all for Catholics. It has narrow and crooked streets, 1500 large and antique houses, and 7400 inhabitants. It has considerable trade in salted meat, oil, wine, and fruit. The harbour is secure, and protected by two strong bastions. Lat. 43. 34. 30. Long. 15. 49. 25.

SPALDING, a town in the district of Holland, and county of Lincoln, ninety-seven miles from London. It stands near the mouth of the river Welland, which is navigable to the town. Of the adjacent district, the soil is rich, but marshy. Besides corn, chiefly oats, it produces much flax and hemp. Spalding has a fine old church, a spacious market-place, much frequented every Saturday. The famous Dr. Bentley was for a short time master of Spalding school. The inhabitants of the town were in 1811, 4330; in 1821, 5207; and in 1831, 6497.

SPALLANZANI, LAZZARO, a celebrated naturalist, was born at Scandiano, in the duchy of Modena, on the 12th of January 1729. He began his studies in his native country, and at the age of fifteen, went to Reggio de Modena, where he was instructed in rhetoric and philosophy by the Jesuits, who contended with the Dominicans in order to secure his attachment. His thirst for knowledge determined him to go to Bologna, where his relative Laura Bassi, a woman highly celebrated for her genius, eloquence, and skill in natural philosophy and mathematics, was one of the most distinguished professors of Italy. Under this enlightened guide, he was taught to prefer the study of nature to that of her commentators, judging of the real value of the commentary by its resemblance to the original. He availed himself of the wisdom of that lady's counsels, the happy effects of which he very soon experienced. Spallanzani's taste for philosophy was not exclusive, for he carefully studied his own language, became a proficient in the Latin tongue, and attached himself above every other to the Greek and French. By the advice of a father whom he ardently loved, he applied himself to jurisprudence; but being urged by Antonio Vallisnieri to renounce his vocation, by procuring the consent of his father, he gave himself up to the study of mathematics with more zeal than ever, at the same time devoting himself to the study of languages, both living and dead.

It was not long before he was known all over Italy, and, what is seldom the case, his own country first made that estimate of his talents which they justly merited. In the year 1745, he was chosen professor of logic, metaphysics, and Greek, in the university of Reggio, where he taught during ten years, devoting every moment of his leisure to the study and contemplation of the works of nature. The attention of Haller and Bonnet was fixed by his observations on the animalculæ of infusions, the latter assisting him in his laudable career, and ever after distinguishing him as one of the learned interpreters of nature. He was invited to the university of Modena in 1760; and some years after he declined to accept of the advantageous offers made to him by the academy of Petersburg, as well as similar ones from Coimbra, Parma, and Cesena. He preferred his native spot, and therefore continued at Modena till the year 1768, and saw raised up by his care a generation of men constituting at that time the glory of Italy, among whom we find Venturi, Belloni, Lucchesini, and Angelo Mazzo.

In 1765, while he resided at Modena, he published his "Saggio di Osservazioni Microscopiche concernenti il Sistema di Needham e di Buffon;" in which he establishes, by a number of the most ingenious and solid experiments, the *animality of microscopic animalculæ.* This work was sent by the author to Bonnet, who drew from it a prediction respecting the future celebrity of Spallanzani, which he lived to see accomplished. This circumstance gave birth to the most intimate friendship, which lasted to the close of life, and constituted their chief happiness. During the same year he published a truly original work, entitled "De Lapidibus ab Aqua resilientibus;" in which he proves, by the most satisfactory experiments, and in opposition to the common received opinion, that what are called *ducks and drakes*, are not produced by the elasticity of the water, but by the effect naturally resulting from the change of direction experienced by the stone in its movement, after it has struck the water, and has been carried over the hollow of the cup formed by the concussion.

When the university of Padua was re-established upon a larger scale, the Count de Firmian was directed by the empress Maria Theresa, to invite Spallanzani to be professor of Natural History, although the chair was solicited by many celebrated characters. His reputation justified this preference, and immense crowds of students thronged to his lectures. He possessed much ingenuity, and his knowledge was of vast extent: his method was simple, but rigorous in its nature, and what he knew he connected with principles firmly established.

In the year 1776 he published, in two volumes quarto, his work entitled "Opuscoli di Fisica Animale e Vegetabile," containing the explanation of part of the microscopic observations which were previously given to the world. It must be admitted, that the art of accurate observation is one of the most difficult, and it cannot be denied, that it is at the same time the most necessary, and requires a rare combination of talents. These were possessed by Spallanzani in a remarkable degree, as is fully evinced by the researches which his admirable writings have recorded. The polite manner in which he conducted his dispute with Needham respecting the phenomena of generation, secured for him a high degree of applause. On this occasion, he treated of the influence of cold upon animals, and proved that the torpidity of some during winter, does not depend on the impression which the blood may receive from it, since a frog deprived of blood becomes torpid when reduced to the same cold state, by being immersed in ice, and swims as formerly when restored to a proper degree of warmth.

Spallanzani travelled through Switzerland and the Grisons in the year 1779, after which he went to Geneva, spending a month with his friends, by whom his conversation was not less admired than his masterly writings. In the year 1780 he published, in two volumes quarto, his "Dissertazioni di Fisica Animale e Vegetabile," in which he unfolded the secrets of the interpretation of two very intricate phenomena, concerning the economy of animals and vegetables. To this study he was led, from some experiments made by him upon *digestion;* and he repeated the experiments of Reaumur on gallinaceous birds, remarking that the trituration which in this case is favourable to digestion, could not be a very powerful means. He perceived that the gizzard of those birds, by which the stones of fruit are pulverized, did not digest the powder thus formed; it being necessary that it should undergo a new operation in the stomach, previous to its becoming chyle for the production of the blood and other humours. This subject may be regarded as one of the most difficult in physiology, because the observer is always under the necessity of finding his way in the midst of darkness: the animal must be managed with care, that the derangement of the operations may be avoided; and when the experiments are completed with great labour, it is requisite that the consequences be well distinguished. In this work, Spallanzani analyses facts with scrupulosity, in order to ascertain their causes with certainty; comparing nature with his experiments, in order to form a correct judgment respecting them; laying hold of every thing essential to them in his observations, and measuring their solidity by the increase or diminution of supposed causes. John Hunter appears to have been greatly hurt by this work; and in the year 1785, he was induced to publish "Some Observations upon Digestion," in which he throws out some bitter sarcasms against the Italian naturalist. Spallanzani took ample revenge by publishing this work in the Italian language, and addressing to Caldani in 1788, "Una Lettera Apologetica in Risposta alle Osservazioni del Signor Giovanni Hunter." Here he exposed with great moderation, but at the same time with logic which nothing could resist, the mistakes and errors of the British physiologist.

The generation of animals and plants is discussed in the second volume of his Dissertazioni; where, by experiments as satisfactory as surprising, he proves the pre-existence of germs to fecundation, shewing also the existence of tadpoles in the females of five different species of frogs, in salamanders, and toads, before their fecundation. He likewise recounts the success of some artificial fecundations upon the tadpoles of those five species, and even upon a quadruped.

In the year 1781, he took the advantage of the academical vacation, for the purpose of making a journey, in order to add to the cabinet of Pavia. In the month of July he set out for Marseilles, where he began a new history of the sea, which presented him with many new and curious facts on numerous genera of the natives of the ocean. He went also to Finale, Genoa, Massa, and Carrara, to make observations on the quarries of marble, held by statuaries in such estimation. He then returned to Spezzia, and brought from thence to Pavia a vast number of fishes, which he deposited in the cabinet of that city, wholly collected by himself. With the same view and success he visited the coasts of Istria in 1782, and the Apennine mountains the subsequent year, taking notice of the dreadful hurricanes, and the astonishing vapours by which that year became so noted in meteorology. The emperor Joseph, on examining this cabinet, presented Spallanzani with a gold medal. In 1785, he was offered the chair of natural history by the university of Padua, vacant by the death of Antonio Vallisnieri; but in order to prevent his acceptance of it, his salary was doubled by the archduke, and he went to Constantinople with Zuliani, who had been appointed ambassador from the Venetian republic. He set out on the 21st of August, and on the 11th of October reached the Turkish metropolis, where he remained during eleven months. His attention was fixed by the physical and moral phenomena of this country, which were new even to Spallanzani. He wandered along the borders of the two seas, and ascended the mountains in the vicinity; he paid a visit to the island of Chalki, discovering to the Turks a copper mine, the existence of which they had never once conjectured. In the island of Principi, not far from Constantinople, he discovered an iron mine, of which the Turks were equally ignorant.

A voyage by sea was undoubtedly the safest, but the dangers to which he would be exposed by land were regarded as nothing when contrasted with the idea of being beneficial to science and to man. Having reached Bucharest, Mauroceni, the friend of science, received Spallanzani with marks of distinction, presented him with many rarities which the country produced, and supplied him with horses for travelling, with an escort of thirty troopers, to the confines of his own dominions. The philosopher passed by Hermanstadt in Transylvania, and on the 7th of December 1786, reached Vienna, where he remained during five days, and had two long conferences with the emperor. He was much esteemed by the nobility of that city, and respectfully visited by many literary characters. When he arrived at Pavia, the students advanced from the city-gates to meet him, and testified their joy at his return by repeated acclamations. He was almost instantly drawn to the auditory, and compelled to ascend the chair from which he had been accustomed to deliver his fascinating lectures; but in the midst of these demonstrations of joy and shouts of applause, he requested them to indulge him with that repose in his own house which was now so absolutely necessary. His students this year exceeded 500.

The reputation of Spallanzani was sufficiently brilliant to excite envy and detraction. His discoveries were too original and solid to be successfully disputed; but some of those who could not rival his successful ingenuity, began to call in question his integrity in the management of the museum at Pavia. A judicial investigation completely established the purity of his character; and it must be mentioned to his honour, that he had the fortitude to forget this event. His enemies in general confessed their mistake, renounced their unprovoked animosity, and still hoped to regain a friendship of which they had proved themselves so unworthy.

In 1792 he published at Pavia, in 6 vols. 8vo, his "Viaggi alle due Sicilie, ed al alcune parti dell' Appennino." Here we meet with what may be denominated a new volcanology. We are instructed how to measure the intensity of volcanic fires, and almost to touch the particular gas which tears those torrents of stone in fusion from the bowels of the earth, and raises them to the top of Mount Etna. This delightful work is closed by some important inquiries into the nature of swallows, the mildness of their dispositions, the rapidity of their flight; discussing the celebrated problem respecting their remaining torpid during the winter season; proving that artificial cold, much more intense than what is ever naturally experienced in our climates, does not reduce these birds to the torpid state.

Things apparently impossible were discovered by Spallanzani. In the year 1795 he made one of this description, which he gave to the world in his "Lettere sopra il Sospetto di un nuovo Senso nei Pippistrelli." In that work we are informed that bats, deprived of sight, act with the same precision in every instance as those which have their eyes; that they shun in the same manner the most trivial obstacles, and also know where to fix themselves when their flight is terminated. Several philosophers confirmed these astonishing experiments, from which a suspicion arose, that these animals must have a new sense, as it appeared to Spallanzani that the other known senses could not compensate for the want of sight; but he was afterwards inclined to think, in consequence of Professor Jurin's experiments on the organ of hearing in bats, that in this particular instance the sense of hearing might possibly supply the want of sight.

He published many other works, which we cannot here enumerate.[1] He had nearly finished an account of his voyage to Constantinople, and had collected many valuable materials for a history of the sea, when his life and labours were brought to a termination. He was seized with a retention of urine, on the 30th of February 1799, and next morning was so far deprived of the use of his faculties, that he only enjoyed a sound mind during very short intervals. Tourdes and Scarpa did every thing to save him, which could be produced by the joint exertions of genius, experience, and friendship, but in vain. He died on the twelfth of the same month, after having completed the seventieth year of his age. His works have been translated into a great variety of languages, and he was enrolled as a member of many foreign academies.

SPALMADORI, a small island situated between the continent of Asia Minor and the island of Scio. Long. 26. 7. E. Lat. 38. 36. N.

SPAN, a measure taken from the space between the thumb and the tip of the little finger when both are stretched out. The span is estimated at three handsbreadths, or nine inches.

SPANDAU, a town of Prussia, in the government of Potsdam. It is a strongly fortified place, and is the chief arsenal of the kingdom. It stands on a peninsula, formed by the junction of the river Spree with the Havel. There are manufactures of all descriptions of arms, for the use of the government, and some private establishments for making silk goods, together with several breweries and distilleries. In the fortress is the state-prison; and there are institutions for the punishment of offenders, by keeping them to hard labour. The town contains 540 houses, with 6750 inhabitants. Lat. 53. 33. 7. Long. 13. 36. 40. E.

SPANDRELL, the solid work on each haunch of an arch, to keep it from spreading.

SPANHEIM, Ezekiel, a very learned writer, was born at Geneva on the 7th of December 1629. His father, Frederic Spanheim, a distinguished theologian, was successively professor of divinity at Geneva and Leyden. The son accompanied him to the latter university, and there distinguished himself by his proficiency in solid learning. His early reputation procured him the professorship of eloquence at Geneva. He took possession of this chair in 1651; but he only retained it for a few months, the elector palatine Charles Louis having appointed him tutor to his only son. This task he discharged to the entire satisfaction of the elector, by whom he was also employed in divers negociations at foreign courts. In 1677 he entered into the service of the elector of Brandenburg, who in 1680 sent him as envoy extraordinary to the court of France, and soon after made him a minister of state. After the peace of Ryswyck, he was again sent on an embassy to France, where he continued from the year 1697 to 1702. The elector of Brandenburg having during that interval assumed the title of king of Prussia, conferred on him the title and dignity of a baron. In 1702 he left France, and was sent as ambassador to England, which he had previously visited on more than one occasion. He died in London on the 7th of November 1710, at the age of eighty-one. It is surprising, that in discharging the duties of a public minister with so much exactness, and amidst so many different journeys, he could find sufficient time to write the various books which he published. It may be said of him, that he acquitted himself in his negociations like a person who had nothing else in his thoughts; and that he wrote like a man who had spent his whole time in his study. His works display a very profound and variegated erudition. The most elaborate of them is entitled, "Dissertationes de Præstantia et Usu Numismatum antiquorum," first printed at Rome in quarto in the year 1664. The best edition, extending to two volumes folio, was printed at London in 1706–17. Another valuable work is his "Orbis Romanus," of which the best edition is that of London, 1704, 4to. He translated the Cæsars of Julian into French, and illustrated them with annotations. He likewise contributed notes on Aristophanes, Callimachus, and some other Greek writers, of whom he did not himself publish editions.

SPAR, in *Mineralogy*, a name given chiefly to some of the crystallized combinations of lime, as the carbonate and the fluate; the former being called simply lime spar, the latter fluor spar, or Derbyshire spar, from the name of the place where it is found in greatest abundance.

The history of Sparta mostly fabulous till the time of Lycurgus.

SPARTA, or Lacedæmon, the capital of the country of Laconia in Greece, an ancient and most renowned state, the inhabitants of which have been in all ages celebrated for the singularity of their laws and character. The history of Sparta for many ages is entirely fabulous; and the authentic accounts commence only with the celebrated lawgiver Lycurgus, who flourished about 870 B. C.

After his death, the first important transaction which we find mentioned in the Spartan history is the Messenian war, which commenced in the year 752 B. C., and ended in the total reduction of the Messenian territory. During this period, according to some authors, a great change took place in the government of Sparta. This was the creation of the ephori, which is ascribed to one of the kings named Theopompus. Perceiving that there was a necessity for leaving magistrates to execute the laws, when the kings were obliged to be in the field, he appointed the magistrates above mentioned, who afterwards made so great a figure in the state. One great privilege of the ephori was, that they did not, like all other magistrates, rise up at the presence of the kings: another was, that if the kings offended against the laws, the ephori took cognizance of the offence, and inflicted a suitable punishment. From the first election of the ephori the year was denominated, as at Athens from the first election of the archons.

Leonidas undertakes to defend the straits of Thermopylæ against the Persians.

The conquest of Messenia gave Sparta the superiority over the rest of the states, excepting only that of Athens, which for a long time continued to be a very troublesome rival; but the contests between these two rival states have been so fully related under the article Attica, that nothing more is requisite to be added in this place. In the time of the Persian war, Leonidas as the Spartan king, distinguished himself in such a manner, as to become the admiration not only of that but of every succeeding age. It being resolved in a general council to defend the straits of Thermopylæ against the Persians, 7000 foot were put under the command of Leonidas; of whom, however, only 200 were Spartans. Leonidas did not think it practicable to defend the pass against such multitudes as the Persian king commanded; and therefore privately told his friends, that his design was to devote himself to death for his country. Xerxes advancing near the straits, was strangely surprised to find that the Greeks were resolved to dispute his passage; for he had always flattered himself, that on his approach they would betake themselves to flight, and not attempt to oppose his innumerable forces. Still however entertaining some hopes of their flight, he waited four days without undertaking any thing, on purpose to give them time to retreat. During this interval, he used his utmost endeavours to gain and corrupt Leonidas, promising to make him master of Greece if he would espouse his interest. His offers being rejected with contempt and indignation, the king ordered him by a herald to deliver up his arms. Leonidas, in a style and with a spirit truly laconical, answered, "Come thyself, and take them." Xerxes, transported with rage at this reply, commanded the Medes and Cissians to march against them, seize them all alive, and bring them to him in fetters. The Medes, not able to stand the shock of the Greeks, soon betook themselves to flight. In their room, Hydarnes was ordered to advance with that body which was called *Immortal*, and consisted of 10,000 chosen men; but when these assailed the Greeks, they succeeded no better than the Medes and Cissians, being obliged to retire with great slaughter. The next day the Persians, reflecting on the small number of their enemies, and supposing so many of them to be wounded that they could not possibly maintain a second fight, resolved to make another attempt; but, with all their efforts, they could not make the Greeks give way; on the contrary, they were themselves put to a shameful flight. The valour of the Greeks exerted itself in a manner so extraordinary, that Xerxes is said to have three times leaped from his throne, apprehending the entire destruction of his army.

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[1] Biographie Universelle, tom. xliii. p. 246, where a catalogue of Spallanzani's works may be found.

The Persians repulsed with great slaughter.

They are shown a way over the hill to surround the Greeks.

Having lost all hopes of forcing his way through troops that were determined to conquer or die, he was extremely perplexed and doubtful what measures he should adopt in this posture of affairs, when one Epialtes, in expectation of a great reward, came to him, and discovered a secret passage to the top of the hill which overlooked and commanded the Spartan forces. The king immediately ordered Hydarnes thither with his select body of 10,000 Persians; who, marching all night, arrived at break of day, and possessed themselves of that advantageous post. The Phocæans, who defended this pass, being overpowered by the enemy's numbers, retired with precipitation to the very top of the mountain, prepared to die gallantly. But Hydarnes, neglecting to pursue them, marched down the mountain with all possible expedition, in order to attack in the rear those who defended the straits. Leonidas being now apprised that it was impossible to withstand the enemy, obliged the rest of his allies to retire; but he himself remained with the Thespians, Thebans, and 300 Lacedæmonians, all resolved to die with their leader; who, being told by the oracle, that either Sparta should be destroyed or the king lose his life, determined, without the least hesitation, to sacrifice himself for his country. The Thebans indeed remained against their inclination, being detained by Leonidas as hostages; for they were suspected to favour the Persians. The Thespians, with their leader Demophilus, could not be prevailed upon to abandon Leonidas and the Spartans. The augur Megistias, who had foretold the event of this enterprise, being pressed by Leonidas to retire, sent home his only son; but he remained himself, and died by Leonidas. Those who were left did not indulge any hope of conquering or escaping, but looked upon Thermopylæ as their grave; and when Leonidas, exhorting them to take some nourishment, said, that they should all sup together with Pluto, they with one accord raised a shout of joy, as if they had been invited to the banquet.

Leonidas killed with all his men.

Xerxes, after pouring out a libation at the rising of the sun, began to move with the whole body of his army, as he had been advised by Epialtes. Upon their approach, Leonidas advanced to the broadest part of the passage, and fell upon the enemy with such undaunted courage and resolution, that the Persian officers were obliged to stand behind the divisions which they commanded, in order to prevent the flight of their men. Great numbers of the enemy falling into the sea, were drowned; others were trampled under foot by their companions, and very many killed by the Greeks; who, knowing they could not avoid death upon the arrival of those who were advancing to fall upon their rear, made prodigious efforts of valour. In this action fell the brave Leonidas; which Abrocomes and Hyperanthes, two of the brothers of Xerxes, observing, advanced with great resolution to seize his body, and carry it in triumph to Xerxes. But the Lacedæmonians, more eager to defend it than their own lives, repulsed the enemy four times, killed both the royal brothers, with many other commanders of distinction, and rescued the body of their beloved general out of the enemy's hands. But in the mean time, the army that was led by the treacherous Epialtes, advancing to attack their rear, they retired to the narrowest part of the passage, and all drawing together, except the Thebans, posted themselves on a rising ground. In this place they made head against the Persians, who assaulted them on all sides, till at length, not vanquished, but oppressed and overwhelmed by numbers, they all fell, except one who escaped to Sparta, where he was treated as a coward and traitor to his country; but he afterwards made a glorious reparation in the battle of Platæa, where he distinguished himself in an extraordinary manner. Some time after, a magnificent monument was erected at Thermopylæ, in honour of those brave defenders of Greece, with two inscriptions; the one general, and relating to all those who died on this occasion, importing, that the Greeks of Peloponnesus, to the number only of 4000, made head against the Persian army, consisting of 3,000,000. The other related to the Spartans in particular, and was composed by the poet Simonides, to this purport: "Go, passenger, and acquaint the Spartans that we died here in obedience to their just commands." At those tombs a funeral oration was yearly pronounced in honour of the departed heroes, and public games were celebrated with great solemnity. In these none but the Lacedæmonians and Thespians had any share, to show that they alone were concerned in the glorious defence of Thermopylæ.

A dr ul earth ke in Sp

At the end of the 77th Olympiad, a most dreadful earthquake happened at Sparta, in which, according to Diodorus, 20,000 persons lost their lives; and Plutarch avers, that only five houses were left standing in the whole city. On this occasion the Helotes, or slaves, whom the Spartans had all along treated with the utmost cruelty, attempted to revenge themselves, by taking up arms, and marching directly to the ruins of the city, in hopes of cutting off at once those who had escaped from the earthquake. But their attempt was defeated by the prudence of the Spartan king Archidamus; for observing that the citizens were more desirous of preserving their effects than taking care of their own lives, he caused an alarm to be sounded, as if he had known that an enemy was at hand. On this the citizens armed themselves in haste with such weapons as they could come at; and having marched a little way from the city, met the Helotes, whom they soon compelled to retire. The latter however knowing that they had now no mercy to expect from those who had already treated them with such cruelty, resolved to defend themselves to the last. Having therefore seized a sea-port town in Messenia, they from thence made such incursions into the Spartan territories, that they compelled those imperious masters to ask assistance from the Athenians. This was immediately granted; but when the Spartans saw that the skill of the Athenians in besieging towns was much greater than their own, they became jealous, and dismissed their allies, declaring that they had now no further occasion for their services. On this the Athenians left them in disgust; and as the Helotes and Messenians did not choose to come to an engagement with a Spartan army in the

War
the
tes.

field, but took shelter in their fortified places, the war was protracted for upwards of ten years. The Helotes were at last reduced to their former misery; and the Messenians were obliged to leave Peloponnesus, on pain of being likewise made slaves. These poor people were then received by the Athenians, who granted them Naupactus for their residence, and afterwards brought them back to a part of their own country, from whence in the course of the Peloponnesian war they had driven the Spartans.

Wi he Ath ans and r- sia

The Peloponnesian war commenced in the year 431 B. C.; but for its details we must refer to the article ATTICA. This war ended most unfortunately for the Athenians; for their city was taken and dismantled. Thus were the Spartains raised to the highest pitch of glory; and in the reign of Agesilaus, they seemed to be on the point of subverting the Persian empire. But here their good fortune and their views of empire were suddenly checked. Agesilaus had carried on the war in Asia with the greatest success; and as he would hearken to no terms of accommodation, a Persian governor named Tithraustes, having first attempted in vain to bribe the king, dispatched Timocrates the Rhodian with fifty talents into Greece, in order to try whether he could there meet with any persons less incorruptible than the Spartan monarch. This agent found many who inclined to accept his offers; particularly in Thebes, Corinth, and Argos. By distributing the money in a proper manner, he inflamed the inhabitants of these three cities against the Spartans; and the Thebans listened to his terms with the greatest readiness. They saw that their antagonists would not of their own accord break with any of the states of Greece, and did not choose to begin the war themselves, because the chiefs of the Persian faction were unwilling to be accountable for the event. For this reason they persuaded the Locrians to invade a small district which lay in dispute betwixt the Phocians and themselves. The Phocians accordingly invaded Locris; the Locrians applied to the Thebans, and the Phocians to the Spartans. The latter were glad of an opportunity of breaking with the Thebans; but met with a much warmer reception than they expected. Their old general Lysander, who had reduced Athens, was defeated and slain, along with a thousand of his soldiers. On this disaster Agesilaus was recalled, and was obliged to relinquish all hopes of conquering the Persians. His return changed the fortune of the war so much, that all the states began to grow weary of a contest from which nobody derived any advantage except the king of Persia. In a short time a treaty was concluded, known in history by the name of the peace of Antalcidas. The terms of this treaty were highly disadvantageous and dishonourable to the Greeks; for even the Spartans, though successful in Greece, had lost a great battle at sea with the Persian fleet under Conon the Athenian, and this event entirely broke their power in Asia.

A g eral com a- tion ainst Spa

Pea f Ant das.

Hos ies reco en- ced.

By the peace of Antalcidas, the government of Bœotia was taken from the Thebans, which they had for a long time enjoyed; and they were so much provoked, that at first they absolutely refused to accede to the treaty; but as Agesilaus made great preparations to invade them, they at last thought proper to comply. It was not however long before a new war commenced, which threatened the total subversion of the Spartan state. As, by the peace of Antalcidas, the king of Persia had in a manner guaranteed the sovereignty of Greece to Sparta, this republic very soon began to exercise its power to the utmost extent. The Mantineans were the first who felt the weight of their resentment, although they had been their allies and confederates. In order to find a pretext for making war against them, they commanded them to quit their city, and to retire into five old villages, which, they said, had served their forefathers, and where they would live in peace themselves, and give no umbrage to their neighbours. As they refused to obey, an army was sent against them to besiege their city. The siege was continued through the summer with very little success on the part of the Spartans; but having during the winter season dammed up the river on which the city stood, the water rose to such a height, as either to overflow or throw down the houses; and the Mantineans were thus compelled to submit to the terms prescribed to them, and to retire into the villages. The Spartan vengeance next fell on the Phliasians and Olynthians, whom they forced to come into such measures as they thought proper. After this they assailed the Thebans, and, by attempting to seize on the Piræum, drew the Athenians also into the quarrel. But here their career was arrested: the Thebans had been taught the art of war by Chabrias the Athenian; so that even Agesilaus himself took the command of the Spartan army in vain. At sea they were defeated by Timotheus the son of Conon; and by land the battle of Leuctra put an end to the superiority which Sparta had retained over Greece for nearly five hundred years.

The power of Sparta entirely broken.

After this dreadful defeat, the Spartans had occasion to exert all their courage and resolution. The women and nearest relations of those who were killed in battle, instead of spending their time in lamentations, shook each other by the hand, while the relations of those who had escaped from the battle hid themselves among the women; or if they were obliged to go abroad, they appeared in tattered clothes, with their arms folded, and their eyes fixed on the ground. It was a law among the Spartans, that such as fled from battle should be degraded from their honours, should be constrained to appear in garments patched with divers colours, to wear their beards half-shaved, and without resistance to suffer any to beat them who pleased. At present however this law was suspended; and Agesilaus, by his prudent conduct, kept up the spirits of the people, at the same time that by his skill in military affairs he checked the progress of the enemy. Yet, during the lifetime of Epaminondas the Theban general, the progress of the war was greatly to the disadvantage of the Spartans; but he being killed at the battle of Mantinea, all parties soon became desirous of peace. Agesilaus did not long survive; and with him, we may affirm, perished the glory of Sparta. Soon after this all the states of Greece fell under the power of Alexander the Great; and the Spartans, as well as the rest, having become corrupt, and lost their martial spirit, became a prey to domestic tyrants, and to foreign invaders. They however maintained their ground with great resolution against the celebrated Pyrrhus king of Epirus; whom they repulsed for three days successively, though not without assistance from one of the captains of Antigonus. Soon after this, one of the kings of Sparta named Agis, perceiving the universal degeneracy that had taken place, made an attempt to restore the laws and discipline of Lycurgus, by which he supposed the state would be restored to its former glory. But though at first he met with some appearance of success, he was in a short time tried and condemed by the ephori as a traitor to his country. Cleomenes, however, who ascended the throne in 216 B. C. accomplished the reformation which Agis had in vain attempted. He suppressed the ephori; cancelled all debts; divided the lands equally, as they had been in the time of Lycurgus; and put an end to the luxury which prevailed among the citizens. But at last he was overborne by the number of enemies which surrounded him; and being defeated in battle by Antigonus, he fled to Egypt, where he put an end to his own life. With him perished every hope of retrieving the affairs of Sparta: the city for the present fell into the hands of Antigonus; after which a succession of tyrants gained and lost the ascendency, till at last all disturbances were ended by the Romans, who reduced Greece to the condition of a province.

Agis and Cleomenes attempt in vain to restore it.

Institutions of Lycurgus.

It only remains to make some observations on the character, manners, and customs of the Spartans, which, as they were founded on the laws of Lycurgus, may best be learned from a view of those laws.

His laws concerning religion.

The institutions of Lycurgus were divided into twelve tables. The first comprehended such of the Spartan laws as regarded religion. The statues of all the gods and goddesses, even to Venus herself, were represented in armour; in order that the people might conceive a military life the most noble and honourable, and not attribute, as other nations did, sloth and luxury to the gods. As to sacrifices, they consisted of things of very small value; for which Lycurgus himself gave this reason, that want might never hinder them from worshipping the gods. They were forbidden to make long or rash prayers, and were enjoined to ask no more than that they might live honestly and discharge their duty. Graves were permitted to be made within the bounds of the city, contrary to the custom of most of the Greek nations; nay, they buried the dead near the temples, that all degrees of people might be made familiar with death, and not conceive it such a dreadful thing as it was generally esteemed elsewhere. On the same account, the touching dead bodies, or assisting at funerals, made none unclean, but these were held to be as innocent and honourable duties as any other. There was nothing thrown into the grave with the dead body; magnificent sepulchres were forbidden; nor did they even permit an inscription, however plain or modest. Tears, sighs, outcries, were not allowed in public, because they were thought dishonourable in Spartans, whom their lawgiver would have to bear all things with equanimity. Mourning was limited to eleven days; on the twelfth the mourner sacrified to Ceres, and threw aside his weeds. In favour of such as were slain in the wars, however, and of women who devoted themselves to a religious life, there was an exception allowed as to the rules before mentioned; for such had a short and decent inscription on their tombs. When a number of Spartans fell in battle, at a distance from their country, many of them were buried together under one common tomb; but if they fell on the frontiers of their own state, their bodies were carefully removed to Sparta, and interred in their family sepulchres.

Concerning the division of land.

II. Lycurgus divided all the country of Laconia into 30,000 equal shares: the city of Sparta he divided into 9000, as some say; into 6000 according to others; and as a third party will have it, into 4500. The intent of the legislator was, that property should be equally divided among the citizens, so that none might be powerful enough to oppress his fellows, or any be in such necessity, as thus to be exposed to the danger of corruption. With the same view he forbade the buying or selling these possessions. If a stranger acquired a right to any of these shares, he might quietly enjoy it, provided he submitted to the laws of the republic. The city of Sparta was unwalled, Lycurgus trusting it rather to the valour of its citizens than to the art of masons. As to the houses, they were very plain; for their ceilings could only be wrought by the axe, and their gates and doors only by the saw; and their utensils were to be of a similar make, that luxury might have no instruments among them.

Of the citizens, children, &c.

III. The citizens were to be neither more nor less than the number of city lots; and if at any time there happened to be more, they were to be led out in colonies. As to children, their laws were equally harsh and unreasonable; for a father was directed to carry his new-born infant to a certain place, where the gravest men of his tribe looked upon the infant; and if they perceived its limbs straight, and thought it had a wholesome look, they then returned it to its parents to be educated; otherwise it was thrown into a deep cavern at the foot of the mountain Taygetus. This law seems to have had one very good effect, namely, that of making women very careful, when they were with child, of either eating, drinking, or exercising to excess: it made also excellent nurses; for which they were in mighty request throughout Greece. Strangers were not allowed to reside long in the city, that they might not corrupt the Spartans by teaching them new customs. For the same reason, citizens were also forbidden to travel, unless the good of the state required it. Such as were not bred up in their youth according to the law, were not allowed the liberty of the city, because they held it unreasonable, that one who had not submitted to the laws in his youth should receive the benefit of them when a man. They never preferred any stranger to a public office; but if at any time they had occasion for a person not born a Spartan, they first made him a citizen, and then preferred him.

Of ce and m riage.

IV. Celibacy in men was infamous, and punished in a most extraordinary manner; for the old bachelor was constrained to walk naked, in the depth of winter, through the market-place: while he did this, he was obliged to sing a song in disparagement of himself; and he had none of the honours paid him which otherwise belonged to old age, it being held unreasonable, that the youth should venerate him who was resolved to leave none of his progeny behind him, to revere them when they grew old in their turn. The time of marriage was also fixed; and if a man did not marry when he was of full age, he was liable to an action; as were such also as married above or below their condition. Such as had three children enjoyed great immunities; such as had four were free from all taxes whatsoever. Virgins were married without portions; because neither want should hinder a man, nor riches induce him, to marry contrary to his inclinations. When a marriage was agreed on, the husband committed a kind of rape upon his bride. Husbands went for a long time, secretly and by stealth, to the beds of their wives, that their love might not be quickly and easily extinguished. Husbands were allowed to lend their wives; but the kings were forbidden to exercise this license. Some other laws of the like nature there were, which, as they were evidently against modesty, so they were far from producing the end for which Lycurgus designed them; since, though the men of Sparta were generally remarkable for their virtue, the Spartan women were as generally decried for their boldness and contempt of decency.

Edu of th child

V. It was the care of Lycurgus, that the Lacedæmonians, from their very birth, should be inured to conquer their appetites. For this reason he directed, that nurses should accustom their children to spare meals, and now and then to fasting; that they should carry them, when twelve or thirteen years old, to those who should examine their education, and who should carefully observe whether they were able to remain alone in the dark, and whether they had conquered all other follies and weaknesses incident to children. He directed, that children of all ranks should be brought up in the same way; and that none should be more favoured in food than another, that they might not, even in their infancy, perceive any difference between poverty and riches, but consider each other as equals, and even as brethren, to whom the same portions were assigned, and who, through the course of their lives, were to fare alike. The youths alone were allowed to eat flesh: older men ate their black broth and pulse; the lads slept together in chambers, and, after a manner somewhat resembling that recently in use in Turkey for the Janizaries. Their beds, in the summer, were very hard, being composed of the reeds plucked by the hand from the banks of the Eurotas: in winter their beds were softer, but by no means downy, or fit to induce immoderate sleep. They ate altogether in public; and in case any abstained from coming to the tables, they were fined. It was likewise strictly forbidden for any to eat or drink at home before they came to the common meal; even then each had his proper portion, that every thing might be conducted with gravity and decency. The black broth was the great rarity of the Spartans, which was composed of salt, vinegar, blood, &c. so that in our times, it would be esteemed a very unsavoury soup. If they were moderate in their eating, they were likewise so in their drinking; of which thirst was the sole measure; for never any true Lacedæmonian thought of drinking for pleasure. As for drunkenness, it was both infamous and severely punished; and slaves were compelled to drink to excess, that young men might be disgusted by the beastliness of this vice. When they retired from the public meal, they were not allowed any torches or lights, because it was expected, that men who were perfectly sober should be able to find their way in the dark; and besides, it gave them a facility of marching without light.

VI. As the poor were fed as well as the rich, so the rich could wear nothing better than the poor. They neither changed the fashion nor the materials of their garments, which were made for warmth and strength, not for gallantry and show, and to this custom even their kings conformed; for they were not entitled to mark their dignity by splendid apparel, but were contented that their virtue should distinguish them rather than their clothes. The youths wore a tunic till they were twelve years old; they were afterwards furnished with a cloak, which was to serve them for a year; and their clothing was in general so thin, that a Lacedæmonian vest became proverbial. Boys were accustomed to go without shoes: when they grew up, they were indulged with them, if the manner of life which they led required it; but they were always inured to run without them, as also to climb up and slide down steep places with bare feet. The very shoe they used was of a particular form, plain and strong. Boys were not permitted to wear their hair; but when they arrived at the age of twenty, they suffered their hair and beard to grow. Baths and anointing were not in much use among the Lacedæmonians; the river Eurotas supplied the former, and exercise the latter. In the field, however, their sumptuary laws did not take place so strictly as in the city; for when they went to war, they wore purple habits; they put on crowns when they were about to engage the enemy; they also wore rings, but only of iron. Young women wore their vests or jerkins only to their knees, or, as some think, not quite so low; a custom which both Greek and Roman authors censure as indecent. Gold, precious stones, and other costly ornaments, were permitted only to common women; which permission was the strongest prohibition to women of virtue, or to those who affected to be thought virtuous. Virgins went abroad without veils, with which married women were always covered. In certain public exercises, in which girls were admitted as well as boys, they were both obliged to perform naked. Plutarch apologises for this custom, urging, that there could be no danger from nakedness to the morals of youths whose minds were fortified and habituated to virtue.—One of Lycurgus's principal views in this institution, was to eradicate the very seeds of civil dissension in his republic. Hence proceeded the equal division of estates enjoined by him; hence the contempt of wealth, and the neglect of other distinctions, as particularly birth; distinctions which, in other commonwealths, frequently produce tumults and confusions that shake their very foundation. He considered the people of his whole state as one great family.

VII. Though the Spartans were always free, yet it was with this restriction, that they were subservient to their own laws, which bound them as strictly in the city, as soldiers, in other states, were bound by the rules of war in the camp. In the first place, obedience to their superiors was most rigidly exacted in Sparta. This they regarded as the very basis of government, and without which neither laws nor magistrates could much avail. Here old age conferred an indubitable title to honour: to the old men the youth rose up whenever they came into any public place; they gave way to them when they met them in the streets, and were silent whenever their elders spoke. As all children were looked upon as the children of the state, so all the old men had the authority of parents: they reprehended whatever they saw amiss, not only in their own, but in other people's children; and by this method Lycurgus provided, that as youth are everywhere apt to offend, they might be nowhere without a monitor. The laws proceeded still farther: if an old man was present where a young one committed a fault, and did not reprove him, he was punished equally with the delinquent. Among the youths there was one of their own body, or at most two years older than the rest, who was styled *iren:* he had authority to question all their actions, to look strictly to their behaviour, and to punish them if they did amiss; neither were their punishments light, but, on the contrary, very severe. Thus the youths were rendered hardy, and accustomed to bear stripes and rough usage. Silence was highly commended at Sparta, where modesty was held to be a most becoming virtue in young people; nor was it restricted only to their words and actions, but extended to their very looks and gestures; Lycurgus having particularly directed, that they should look forward, or on the ground, and that they should always keep their hands within their robes. A stupid inconsiderate person, one who would not listen to instruction, but was careless of whatever the world might say of him, the Lacedæmonians treated as a scandal to human nature: with such a one they would not converse, but threw him off as a rotten branch, and worthless member of society.

Learning.

VIII. The plainness of their manners, and their being so much addicted to war, made the Lacedæmonians less fond of the sciences than the rest of the Greeks. That of a soldier was the only reputable profession in Sparta; a mechanic or husbandman was thought a low person. The reason of this was, that they imagined professions which required much labour, some constant posture, being continually in the house, or always near a fire, weakened the body and depressed the mind; whereas a man brought up hardily, was equally fit to attend the service of the republic in time of peace, and to fight its battles in time of war. Such occupations as were necessary to be followed for the benefit of the whole, as agriculture and the like, were left to their slaves the Helotes; but for curious arts, and such as serve only to luxury, they would not so much as suffer them to be introduced in their city; rhetoricians, augurs, and dealers in money were consequently excluded. The Spartans admitted none of the theatrical diversions among them; they would not bear the representation of evil even to produce good; but other kinds of poetry were admitted, provided the magistrates had the perusal of pieces before they were communicated to the public.

Above all things, they affected brevity of speech, and accustomed their children, from their very infancy, never to express themselves in more words than were strictly necessary; whence a concise and sententious oratory is to this day styled *Laconic.* In writing they used the same conciseness. We have a signal instance in a letter of Archidamus to the Eleans, when he understood they had some thoughts of assisting the Arcadians. It ran thus: "Archidamus to the Eleans. It is good to be quiet." And therefore Epaminondas thought he had reason to glory in having forced the Spartans to abandon their monosyllables, and to lengthen their discourses.

The greatest part of their education consisted in giving their youth right ideas of men and things: the iren or master proposed questions, and either commended the answers that were made him, or reproved such as answered weakly. In these questions, all matters, either of a trivial or abstruse nature, were equally avoided; and they were confined to such points as were of the highest importance in civil life; such as, who was the best man in the city? wherein lay the merit of such an action? and, whether this or that hero's fame was well-founded? Harmless raillery was greatly encouraged; and this, joined to their short manner of speaking, rendered Laconic replies universally admired.

Music was much encouraged; but in this, as in other things, they adhered to that which had been in favour with their ancestors. They would not permit their slaves to learn either the tune or the words of their most admired odes; or, which is all one, they would not permit them to sing them if they had learned them. Though the youth of the male sex were much cherished and beloved, as those that were to build up and continue the future glory of the state, yet in Sparta it was a virtuous and modest affection, untinged with that sensuality which was so scandalous at Athens. The good effects of this part of Lycurgus's institutions were seen in the union that reigned among his citizens; and which was so extraordinary, that even in cases of competition, it was hardly known that rivals bore ill-will to each other; but, on the contrary, their love to the same person produced a secondary friendship among themselves, and united them in all things which might be for the benefit of the person beloved.

Some authors have accused this great lawgiver of encouraging theft in his institutions; which, they say, was not held scandalous among the Spartans, if it were so dexterously managed as that the person was not detected in it. But this is certain, and seems to be a strong contradiction of the heinous charge, that when a theft was discovered, it was punished with the utmost severity: a person even suspected of it would endure the heaviest punishments rather than acknowledge it, and be branded with so base a crime.

Exercises.

IX. The exercises instituted by law belong to the ninth table. In these all the Greeks were extremely careful, but the Lacedæmonians in a degree beyond the rest; for if a youth, by his corpulence, or any other means, became unfit for these exercises, he underwent public contempt at least, if not banishment. Hunting was the usual diversion of their children; nay, it was made a part of their education, because it had a tendency to strengthen their limbs, and to render those who practised it supple and fleet. Dogs for hunting were reared with great care. They had a kind of public dances, in which they exceedingly delighted, and which were common alike to virgins and young men: indeed, in all their sports, girls were allowed to divert themselves with the youths; insomuch, that, at darting, throwing the quoit, pitching the bar, and such like robust diversions, the women were as dexterous as the men. For the manifest oddity of this proceeding, Lycurgus assigned no other reason, than that he sought to render women, as well as men, strong and healthy, that the children they brought forth might be so too. Violent exercises, and a laborious kind of life, were only enjoined the youth; for when they were grown up to men's estate, that is, were upwards of thirty years old, they were exempted from all kinds of labour, and enjoyed themselves wholly either in affairs of state, or in war. They had a method of whipping, at a certain time, young men in the temple of Diana, and about her altar; which, however palliated, was certainly unnatural and cruel. It was esteemed a great honour to sustain these flagellations without weeping, groaning, or showing any sense of pain; and so strong was the thirst of glory in these young minds, that they frequently suffered death without shedding a tear, or breathing a sigh. A desire of overcoming all the weaknesses of human nature, and thus rendering his Spartans not only superior to their neighbours, but to their species, runs through many of the institutions of Lycurgus; and by keeping this principle in view, we are enabled to understand many circumstances that must otherwise appear inexplicable.

Money, &c.

X. Gold and silver were, by the constitutions of Lycurgus, rendered of no value in Sparta. Of the danger of riches he was so well apprised, that he rendered the very possession of them penal; but as some standard of value was necessary, he directed an iron coinage, whereby the Spartans were supplied with the useful money, and at the same time had no temptation to covetousness afforded them; for a very small sum was sufficient to load a couple of horses, and a great one must have been kept in a barn or warehouse. The introduction of all foreign money was also prohibited, that corruption might not enter under the name of commerce. The most ancient method of dealing, namely, by barter or exchange of one commodity for another, was preserved by law in Sparta long after it had fallen into disuse everywhere else. Interest was forbidden in the Spartan commonwealth; where they had also a law against alienation of lands, accepting presents from foreigners, even without the limits of their own country, and when their authority and character might well seem to excuse them.

Court justice.

XI. Such of the laws of Sparta as related to courts of justice may be brought under the eleventh table. Thirty years must have passed over the head of him who had a right to concern himself in juridical proceedings. Young men were thought unfit for them; and it was even considered as indecent for a man to have any fondness for lawsuits, or to be busying himself at the tribunals, when he had no affairs there of his own. By these rules Lycurgus thought to exclude litigiousness, and to prevent that multiplicity of suits which seems to be a necessary evil in other states. As young people were not permitted to inquire about the laws of other countries, and as they were hindered from hearing judicial proceedings in their courts, so they were likewise forbidden to ask any questions about, or to endeavour to discover, the reasons of the laws by which themselves were governed. Obedience was their duty; and to that alone they would have them kept. Men of abandoned characters, or who were notoriously of ill fame, lost all right of giving their votes in respect of public affairs, or of speaking in public assemblies; for they could not believe that a man unprincipled in private life could be better affected to his country than to his neighbour.

Milit servic

XII. Before the age of thirty, a Spartan was not capable of serving in the army, as the best authors agree; though some think that the military age is not well ascertained by ancient writers. Their forces were forbidden to march at any time before the full-moon; the reason of which law is very hard to be discovered, if indeed it had any reason at all, or was not rather founded on some superstitious opinion, that this conjuncture was more lucky than any other. They were likewise forbidden to fight often against the same enemy. This was one of the wisest maxims in the political system of Lycurgus; and Agesilaus, by offending against it, destroyed the power of his country, and lost her that authority which for many years she had maintained over the rest of Greece; for, by continually warring against the Thebans, to whom she had an inveterate hatred, he at last beat them into the knowledge of the art of war, and enabled them, under the command of Epaminondas, to maintain for a time the principality of Greece. With maritime affairs they were forbidden to meddle, though the necessity of things compelled them, in process of time, to transgress this institution, and by degrees to transfer to themselves the dominion of the sea as well as of the land; but, after the Peloponnesian war, they again neglected naval affairs, from a persuasion that sailors and strangers corrupted those with whom they conversed. As they never fortified Sparta, they were not ready to undertake sieges: fighting in the field was their proper province, and, while they could there overcome their enemies, they rightly conceived that nothing could hurt them at home. In time of war, they relaxed somewhat of their strict manners of living. The true reason for this was, in all probability, that war might be less burdensome to them; for, as we have more than once observed, a strong desire to render them bold and warlike was the reigning passion of their legislator. They were forbidden to remain long encamped in the same place, as well to hinder their being surprised, as that they might be more troublesome to their enemies, by wasting every corner of their country. They slept all night in their armour; but their outguards were not allowed their shields, that, being unprovided of defence, they might not dare to sleep. In all expeditions they were careful in the performance of religious rites; and after their evening meal was over, the soldiers sung together hymns to their gods. When they were about to engage, the king sacrificed to the Muses, that, by their assistance, they might be enabled to perform deeds worthy of being recorded to the latest times. The army then advanced in order to the sound of flutes, which played the hymn of Castor. The king himself sung the pæan, which was the signal to charge. This was done with all the solemnity imaginable, and the soldiers were sure either to conquer or die, nor indeed had they any other choice; for if they fled they were infamous, and in danger of being slain, even by their own mothers, for disgracing their families. In this consisted all the excellency of the Spartan women, who, if possible, exceeded in bravery the men, never lamenting over husbands or sons, if they died honourably in the field, but deploring the shame brought on their house, if either the one or the other escaped by flight. The throwing away a shield also inferred infamy; and mothers, when they embraced their departing sons, were wont to caution them, that they should either return armed as they were, or be brought back so when they were dead; for, as we have observed, such as were slain in battle were nevertheless buried in their own country. When they put an enemy to flight, they pursued no longer than till victory was certain; because they would seem to fight rather for the honour of conquering, than of putting their enemies to death. According to their excellent rules of war, they were bound not to spoil the dead bodies of their enemies; but in process of time, this, and indeed many other of their most excellent regulations, fell into desuetude. He who overcame by stratagem, offered up an ox to Mars; whereas he who conquered by force, offered up only a cock; the former deed being esteemed more manly than the latter. After forty years' service, a man was exempted from military duty; and consequently, if they commenced their career at thirty, the Spartans were not considered as invalids till they attained the age of seventy.

SPARTIANUS, Ælius, a Latin historian, who flourished in the reign of Diocletian, about the year 290. He is known as the author of the lives of Hadrian and Ælius Verus; and to him are likewise ascribed several other lives contained in the collection of "Historiæ Augustæ Scriptores." See Fabricii *Bibliotheca Latina*, tom. iii. p. 95.

SPECIES, in *Logic*, a relative term, expressing an idea which is comprised under some general one called a *genus*.

Species, in *Algebra*, are the letters, symbols, marks, or characters, which represent the quantities in any operation or equation. This short and advantageous way of notation was chiefly introduced by Vieta, about the year 1590; and by means of it he made many discoveries in algebra.

Species, in *Optics*, the image painted on the retina by the rays of light reflected from the several points of the surface of an object, received by the pupil, and collected in their passage through the crystalline, &c. It has been a matter of dispute among philosophers, whether the species of objects which give the soul an occasion of seeing, be an effusion of the substance of the body; a mere impression which they make on all bodies under certain circumstances; or whether they are not some more subtile body, such as light. The moderns have decided this point by the invention of artificial eyes, in which the species of objects are received on paper, in the same manner as in the natural eye.

SPECIFIC, in *Philosophy*, that which is peculiar to any thing, and distinguishes it from all others.

Specifics, in *Medicine*. By specifics is not meant such as infallibly and in all patients produce salutary effects. Such medicines are not to be expected, because the operations and effects of remedies are not formally inherent in them, but depend upon the mutual action and reaction of the body and medicine upon each other; hence the various effects of the same medicine in the same kinds of disorders in different patients, and in the same patient at different times. By specific medicines we understand such medicines as are found to be more uniform in their effects than others in any particular disorder.

Specific Gravity, is a term much employed in the discussions of modern physics. It expresses the weight of any particular kind of matter, as compared with the weight of the same bulk of some other body of which the weight is supposed to be familiarly known, and is therefore taken for the standard of comparison. The body generally made use of for this purpose is pure water. See Chemistry and Hydrodynamics.

SPECTACLES, in *Dioptrics*, an instrument consisting of two lenses set in silver, horn, &c. to assist the defects of the organ of sight. Old people, and others who have flat eyes, use convex spectacles, which cause the rays of light to converge so as to meet upon the retina; whereas myopes, or short-sighted people, use concave lenses for spectacles, which cause the rays to diverge, and prevent their meeting before they reach the retina. See Optics.

SPECTRA, images presented to the eye after removing them from a bright object, or closing them. When any one has long and attentively looked at a bright object, as at the setting sun, on closing his eyes, or removing them, an image, which resembles in form the object he was attending to, continues some time to be visible. This appearance in the eye we call the ocular spectrum of that object. These ocular spectra are of four kinds: 1st, Such as are owing to a less sensibility of a defined part of the retina, or spectra from defect of sensibility. 2d, Such as are owing to a greater sensibility of a defined part of the retina, or spectra from excess of sensibility. 3d, Such as resemble their object in its colour as well as form; which may be termed direct ocular spectra, 4th, Such as are of a colour contrary to that of their object, which may be termed reverse ocular spectra

SPECTRE, an apparition, or something supposed to be preternaturally visible to human sight, whether the ghosts of dead men or beings superior to man. See Apparitions.

SPECULATIVE, something relating to the theory of some art or science, in contradistinction to practical.

SPECULUM for reflecting telescopes. See Optics and Telescope.

SPEED, John, an English historian, was born at Farington in Cheshire, in the year 1542. He was by trade a tailor, and a freeman of the company of merchant tailors in the city of London. In 1606 he published his "Theatre of Great Britain," which was afterwards reprinted in folio, under the title of "The Theatre of the Empire of Great Britain." In 1614 appeared his "History of Great Britain;" and in 1616 he published in octavo, "The Cloud of Witnesses, or, the Genealogies of Scripture." These genealogies were prefixed to many editions of the English translation of the Bible; and King James gave him a patent for securing the property to him and his heirs. He had twelve sons and six daughters; and died in 1629. He was interred in the church of St. Giles's, Cripplegate, London, where a monument was erected to his memory.

SPELDHURST, a large parish in the hundred of Washlingstone and county of Kent, thirty-three miles distant from London. A great part of the township of Tunbridge

Wells is comprehended in it, to which circumstance it owes its increased inhabitants, who were, in 1801, 1618; in 1811, 1901; in 1821, 2297; and in 1831, 2640.

SPELLING, in *Grammar*, that part of orthography which teaches the true manner of resolving words into their syllables.

All words are either simple or compound, as *use, disuse; done, undone;* and the rules for dividing each must be such as are derived from the analogy of language in general, or from the established custom of speaking; which, for the English language, are reduced to the following rules: 1. A consonant between two vowels must be joined with the latter in spelling, as *na-ture, ve-ri-ly, ge-ne-rous;* except, however, the letter *x*, which is joined to the first, as in *flax-en, ox-en*, &c., and compound words, as in *up-on, un-used*, &c. 2. A double consonant must be divided, as in *let-ter, man-ner*, &c. 3. Those consonants which can begin a word, must not be parted in spelling, as in *de-fraud, re-prove, di-stinct:* this rule, however, is sometimes found to fail; for though *gn* begins a word, as in *gnaw, gnat*, &c., yet it must be divided in spelling, as in *cog-ni-zance, ma-lig-ni-ty*, &c. 4. Those consonants which cannot begin a word must be divided, as *ld* in *sel-dom, lt* in *mul-ti-tude, mp* in *tem-per, rd* in *ar-dent;* but in final syllables there are exceptions, as *tl* in *ti-tle, dl* in *han-dle*, &c. 5. When two vowels come together, and are both of them distinctly sounded, they must be separated in spelling, as in *co-e-val, mu-tu-al*, &c. 6. The grammatical terminations or endings must be separated in spelling, as *ed* in *wing-ed, edst* in *de-li-ver-edst, ing* in *hear-ing, ance* in *de-li-ver-ance*, &c. 7. Compound words must be resolved into their simple and component words, as *up-on, in-to, ne-ver-the-less, not-with-stand-ing*, &c.

SPELMAN, Sir Henry, an eminent antiquary, was descended from an ancient family, and born at Congham, near Lynn in Norfolk, about the year 1561. He was knighted by King James I. who had a particular esteem for him on account of his known capacity for business; and he employed him several times in Ireland in public affairs. When he was about fifty years of age, he went to reside in London; where falling into a study to which his own genius had always inclined him, he collected all such books and MSS. as concerned the subject of antiquities, either foreign or domestic. In 1626, he published the first part of his well-known "Glossarium Archaiologicum," which he never carried beyond the letter L; because, as some have suggested, he had made remarks under "Magna Charta," and "Maximum Consilium," which could not then have appeared without giving offence. Upon his death, all his papers came into the hands of his son Sir John Spelman, a gentleman who had abilities to have completed his father's design, if death had not prevented him. The second part was afterwards published by Sir William Dugdale, but with all the marks of a scanty unfinished performance. The next work which he undertook was an edition of the English Councils; of which he published the first volume in 1639, leaving the second volume, as well of this as of his Glossary, to be published by Dugdale. The second volume appeared in 1664. Spelman wrote several other works relating to ancient laws and customs, and died in 1641. His Treatise concerning Tithes, and his History of Sacrilege, deserve a passing notice. His Posthumous Works were published at Oxford, in folio, in the year 1698, under the inspection of Mr. Gibson, afterwards Bishop of London.

SPENCE, Joseph, an eminent writer, was born in the year 1698, but his family-history remains in obscurity. He was probably educated at Winchester, for he became a fellow of New College, Oxford, where he took the degree of A.M. in 1727. During the same year he published a small volume entitled "An Essay on Pope's Odyssey, in which some particular beauties and blemishes of that work are considered." This essay was greatly admired by his contemporaries, and it procured him the friendship of Pope. Spence was elected professor of poetry in 1728, and held that office ten years, which is as long as the statutes will allow. His account of Stephen Duck was first published in 1731; but it was afterwards much altered, and prefixed to an edition of Duck's Poems.

About this time he travelled into Italy as tutor to the Earl of Lincoln, afterwards Duke of Newcastle. In 1736 he republished Gorboduc, at Mr. Pope's desire, with a preface giving an account of its author, the Earl of Dorset. He quitted his fellowship in 1742, upon being presented by his college to the rectory of Great Harwood in Buckinghamshire. He never resided on his living; but paid it an annual visit, distributing large sums of money among the poor, and providing for many of their children. The same year he was appointed professor of modern history at Oxford. In 1747 he published a large folio volume entitled "Polymetis; or, an Inquiry concerning the Agreement between the Works of the Roman Poets and the Remains of ancient Artists; being an attempt to illustrate them mutually from each other." This work was treated by Gray with a contempt which it did not deserve. He raises objections because the author did not illustrate his subject from Greek writers; that is, because he failed to execute what he never undertook. By the publication of his Polymetis, Spence is said to have cleared L.1500. He was installed prebendary of the seventh stall at Durham on the 24th May 1754. He published the same year, "An Account of the Life, Character, and Poems, of Mr. Blacklock, Student of Philosophy in the University of Edinburgh;" which was afterwards prefixed to Blacklock's Poems. The prose pieces which he printed in the Museum he collected and published, together with some others, in a pamphlet called, "Moralities, by Sir Harry Beaumont." Under the same name, he published, "Crito, or a Dialogue on Beauty," and "A particular Account of the Emperor of China's Gardens near Pekin, in a letter from F. Attiret, a French missionary now employed by that emperor to paint the apartments in those gardens, to his friend at Paris." Both these tracts are printed in Dodsley's Fugitive Pieces, as is also "A Letter from a Swiss Officer to his friend at Rome;" which Mr. Spence first published in the Museum. In 1758, he published "A Parallel, in the Manner of Plutarch, between a most celebrated man of Florence and one scarce ever heard of in England." The Florentine was Magliabecchi, and the other individual was Robert Hill the Hebrew tailor. This tract is also to be found among the Fugitive Pieces. During the same year he made a journey into Scotland, which he described in an affectionate letter to Mr. Shenstone, published in Hull's Collection of Letters, 1778. In 1764 he was very well described by James Ridley, in his admirable Tales of the Genii, under the name of *Phesoi Ecneps* (his name read backwards), dervise of the groves. A letter from Mr. Spence to that ingenious moralist, under the same signature, is preserved in the third volume of "Letters of eminent Persons." In 1768 he published "Remarks and Dissertations on Virgil, with some other classical observations, by the late Mr. Holdsworth." On the 20th of August the same year he was unfortunately drowned in a canal in his garden at Byfleet in Surrey. He was found flat upon his face at the edge of the canal, where the water was so shallow as not even to cover his head. The fatal accident, it was supposed, for he was quite alone, was occasioned by a fit.

More than half a century after his death, appeared his "Anecdotes, Observations, and Characters of Books and Men, collected from the Conversation of Mr. Pope, and others. With notes and a life of the author by S. W. Singer." London, 1820, 8vo. Mr. Malone had likewise prepared an edition of this work, and, after his death, it was published during the same year.

SPENCER, JOHN, a very learned theologian, was born at Bocton-under-Blean, in Kent, in the year 1630. From the grammar school of Canterbury he was removed to Corpus Christi College at Cambridge, where he was entered on the 25th of March 1645. Having taken the degree of A.B. in 1648, and of A.M. in 1652, he was chosen a fellow in 1655. In 1660 he preached a sermon before the university, and during the same year it was published under the title of "The righteous Ruler." He afterwards published a learned and curious work, entitled, "A Discourse concerning Prodigies." To the second edition, corrected and enlarged, he added "A Discourse concerning vulgar Prophecies." Lond. 1665, 8vo. During the same year, he proceeded D.D. In 1667, he was presented by his college to the rectory of Landbeach, and on the 3d of August elected master of the college. About a month after his election, he was preferred by the king to the archdeaconry of Sudbury, in 1672 to a prebend of Ely, and in 1677 to the deanery of that church. In 1669 he had published a Latin dissertation concerning Urim and Thummim. But his most elaborate work is *De Legibus Hebræorum Ritualibus, et earum Rationibus, libri tres.* Cantab. 1685, 2 tom. fol. An edition, with the author's additions and improvements, was published at Cambridge in 1727; and several editions, one by Pfaff, were printed on the continent. "It is," as Mr. Orme has remarked, "a very learned, but a very dangerous work; the great object of which is to show, that the Hebrew ritual was almost entirely borrowed from the Egyptians, and accommodated to the taste and prejudices which the Jews had acquired among that people. The same hypothesis had been stated by Maimonides, a philosophizing Jew, in his More Nevochim, and was greedily laid hold of by Sir John Marsham, in his Canon Chronicus Ægyptiacus. A masterly refutation of the work of Spencer was furnished by Witsius, in his Ægyptiaca; and Shuckford, in his Connections, supplies also many arguments on the same side. Warburton partly espoused the system of Spencer, and replied to Witsius, for which he is very properly censured by Dr. Magee, in his work on the Atonement. Socinians and infidels have made very liberal use of the work and arguments of Spencer."[1]

Dr. Spencer died on the 27th of May 1695, in the sixty-third year of his age. He was a great benefactor to his college, to which he bequeathed an estate that had cost him L.3600. He married Hannah, the daughter of Isaac Pullen of Hertford, and had a son and a daughter, who both died before their father.

SPENCER CAPE, a pointed rocky cape, the east point of entrance into Spencer's Gulf on the south shore of New Holland. Long. 136. 56. E. Lat. 35. 18. S.

SPENCER'S GULF, a large gulf on the south coast of New Holland, which extends 185 miles into the interior of the country, in a north-east direction. The entrance between Cape Catastrophe on the west, and Cape Spencer on the east, is forty-eight miles wide. Captain Flinders traced it to within eight miles of its termination.

SPENSER, EDMUND, one of the greatest of English poets, was born in East Smithfield, about the year 1533. There is no record in which the admirers of his genius may trace the incidents of his early years; but there is reason to suppose that they were clouded by poverty and dependence. On the 20th of May 1519, he entered Pembroke Hall, Cambridge, in the humble character of a sizer; a circumstance which is alone sufficient to rescue those luckless scholars from abject despondency, and to render them respectable in the eyes of their more fortunate companions. Some poems, in a collection of fugitive pieces entitled "The Theatre for Worldlings," which appeared during this year, are ascribed to Spenser, upon internal evidence. On the 10th of January 1752–3 he took the degree of A.B., and on the 26th of June 1576 that of A.M. From a letter of his friend Gabriel Harvey, himself a poet of some reputation in his time, it appears that, in consequence of having made enemies, who had both the will and power to injure him, he quitted Cambridge in despair of academical preferment. He had luckily some friends in the north of England, among whom he now found a temporary asylum. Whether he was received as an honoured guest, or compelled to turn his learning to account in the way of tuition, is unknown; but the latter supposition is the more probable of the two.

During his retirement in the north, Spenser wrote "The Shepherd's Calendar." Nothing is more common than for poets to deprecate the barbarity of a phantom, and to be reduced to despair, because some angelic nonenity turns a deaf ear to their entreaties; but it is said that Rosalind was a real mistress, at whose feet Spenser sighed in vain. The successful rival of the needy sonnetteer was, in all likelihood, some substantial yeoman. At this period of his history, Harvey advised him to try his fortune in London; and it is probable that he abandoned without reluctance, the scene of his unrequited passion. Upon his arrival in the metropolis, he was fortunate enough to obtain an introduction to Sir Philip Sidney, who invited him to become his guest at Penshurst, the seat of the family in Kent. As a token of gratitude for this hospitality the "Shepherd's Calendar," published in 1579, was "entituled to the noble and vertuous gentleman, most worthy of all titles, Maister Philip Sidney."

Till long after the time of Spenser, the poet depended upon the casual gratuities of distinguished persons, who sometimes exerted their influence in procuring for a favourite bard some less precarious means of subsistence. Recommended, as it is conjectured, by the Earl of Leicester, the poet went to Ireland with Arthur Lord Grey of Wilton, who was appointed deputy of that kingdom in 1580. Spenser was the secretary of the viceroy, and discharged the duties of his office with greater promptitude and exactness than poets usually display in the ordinary business of life. His "View of the State of Ireland," a treatise written in the form of a dialogue, displays no inconsiderable portion of political sagacity. By the interest of Lord Grey, Leicester, and Sidney, Spenser obtained, in 1586, a grant of three thousand and twenty-eight acres of the forfeited estates of the Earl of Desmond. This piece of good fortune was embittered by the death of his patron, the gallant Sidney, who fell in the same year at the battle of Zutphen. The pastoral elegy of Astrophel, sacred to the memory of the departed hero, although not published until 1591, was probably written when the grief of the poet was at the height. It was provided by the royal patent, that those who profited by the forfeiture should reside upon the lands that were allotted to them. According to this arrangement, Spenser proceeded to a place named Kilcolman, in the county of Cork. This exile, to what was then little better than a region of barbarians, was cheered by a visit from the renowned Sir Walter Raleigh. At the suggestion, it may be presumed, of his distinguished guest, whom perhaps he accompanied to England, the poet soon exchanged his Hibernian solitude for the splendours of a court. In 1590 were published the first three books of the Fairy Queen; and the poet was afterwards presented by Raleigh to Queen Elizabeth, who conferred upon him a pension of fifty pounds a-year, then no despicable sum. The grant of this pension was discovered in the chapel of the Rolls by Mr. Malone, who has thus been enabled to clear the reputation of Lord Burleigh from the stigma of having intercepted the bounty of his sovereign to the author of the Fairy Queen. Mr. Malone has also made it appear, that Queen Elizabeth had no poet-laureate; an appointment which was supposed to have been held by Spenser. In the sonnets annexed to the poem, is one to his new patron, "the right noble and valorous knight, Sir Walter Raleigh;" but Spenser does not forget to shed a grateful tear to the memory of Sidney. There is a sonnet addressed to the Countess of Pembroke, the darling sister of that accomplished person, for whose amusement he wrote his Arcadia. With mournful dignity, the poet acknowledges to the countess his many obligations to

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[1] Orme's Bibliotheca Biblica, p. 417. Edinb. 1824, 8vo.

> ——that most heroicke spirit,
> The heauens pride, the glory of our daies.

During his absence in Ireland, to which kingdom he returned after the publication of the Fairy Queen, was printed a collection of Spenser's minor pieces, entitled, "Complaints: containing sundrie small Poemes of the Worlds Vanitie. Whereof the next page maketh mention. By Ed. Sp." Lond. 1591, 4to. This production was followed by Daphnoida, an elegy on the death of Douglas Howard, daughter of Henry Lord Howard. It is dated January 1, 1591–2. About this period, he is supposed to have paid a visit to his native country; after which a considerable space intervenes unmarked by incidents.

Being no longer a pennyless rhymster, Spenser now wooed a kinder mistress than Rosalind. The lady, whose name is unknown, became his wife in 1594. The progress of this successful courtship is traced in his Amoretti, or Sonnets. In 1595 appeared the pastoral of "Colin Clout's come home again." The dedication of this production is erroneously dated 1591, as Mr. Todd satisfactorily proves. It is dedicated to Sir Walter Raleigh, who is introduced as the Shepherd of the Ocean. In 1596, he published four Hymns. He informs the Countess of Cumberland and the Countess of Warwick, to whom they are inscribed, that the two latter, composed in his riper years, and treating of heavenly love and beauty, were designed to atone for the two former, which were written in the heyday of his blood, and of which the subjects are sensual desire and earthly grace. In the same year were produced the fourth, fifth, and sixth books of the Fairy Queen. Of that magnificent poem, two additional imperfect cantos are all that can be found. Our limits prohibit the discussion of the question, whether the remaining six books, which would have completed the design, were destroyed by fire during the Irish rebellion, or left unfinished. Nor is there much utility in transcribing a long list of poems no longer extant, which are supposed to have shared their fate. In the course of this year, Spenser presented his *View of the State of Ireland* to the queen; but, for reasons not very clearly explained, that performance was not printed until thirty-five years after the author's death.

In a letter from Queen Elizabeth to the Irish government, dated September 30, 1598, which was discovered by Mr. Malone, Spenser is recommended to be sheriff of Cork. A royal recommendation is generally equivalent to a command; but the rebellion of Tyrone put a period to all the poet's hopes of dignity and emolument. To escape the fury of the insurgents, he abandoned his house in Kilcolman, leaving behind him one of his children, who had been forgotten in the terror of the moment. Having removed every thing else that it contained, the miscreants set fire to the building, and left the infant to perish in the flames. Spenser did not long survive these multiplied calamities. On the 16th of January 1598–9, soon after his arrival in England, he died at an inn in King Street, Westminster. The expenses of his funeral were defrayed by the unfortunate Earl of Essex, who buried him in Westminster Abbey, near the remains of Chaucer; a spot on which he had always desired to take his last repose.[1]

Spenser left two sons, Sylvanus and Peregrine. Hugolin, the son of the latter, was restored to his grandfather's estate by Charles II.; but, adhering to the infatuated successor of that monarch, he was outlawed, after the revolution, for high treason. The lands of the outlaw, however, were bestowed upon his cousin William, the son of Sylvanus, through the interest of Mr. Montague, afterwards Earl of Halifax. William Spenser was presented to the notice of Montague by Congreve. "The family of the Spensers," says Gibbon, "has been illustrated and enriched by the trophies of Marlborough, but I exhort them to consider the Fairy Queen as the most precious jewel in their coronet."

Of Spenser's personal character, we are in a great measure left to form our opinion from his works. Both the tendency and details of these are highly favourable to virtue; and the many chaplets he threw upon the hearse of Sidney prove that he cherished the memory of his benefactor with pious care. It is easy to imagine gratitude allied to every other noble quality, and it is mere misanthropy to question the sincerity of tears that fall to those who can give no more; for it is vain to seek

> ——pensions from the tomb,
> Or laurels from the dust.

There is, however, a dark spot on the fame of Spenser. From some original documents preserved in the Rolls Office at Dublin, it appears that the murder of his infant, his own ruin, despair, and death, are to be traced to his cupidity; for the outrage that was the immediate cause of these disasters, was perpetrated less from the hopes of plunder than the desire of vengeance for some unjust and oppressive attempts to add to his possessions.[2] Injustice and oppression were so habitual with the English settlers in Ireland, that it was not easy for Spenser to escape the general contamination.

This great poet is far from being a favourite of the general readers of modern times, who demand something of a more stimulating nature than the lives and adventures of the cardinal virtues. Indeed, to have made an interminable allegory interesting to thousands, must be allowed to be one of the greatest efforts of genius. This Spenser has accomplished; and his pages, if not devoured with trembling eagerness, are always perused with wonder, and often with delight, by the great majority of those whose suffrage is of any value. It has been urged that Arthur, the hero of the poem, instead of achieving the principal adventures, acts only as an auxiliary to others, and that either his character, or those of the twelve worthies, might with great propriety have been expunged; that the allegory often degenerates into mere description, without any occult meaning; and that the *ottava rima* of Tasso and Ariosto, with the addition of an Alexandrine, is a measure which is little adapted to the genius of the English language. There is however little rashness in predicting that the Fairy Queen will last as long as the English language itself.

An edition of Spenser's Works, with a glossary and a life of the author, and an essay on allegorical poetry, was published by John Hughes. Lond. 1715, 6 vols. 12mo. The Fairy Queen, with an exact collation of the two original editions, a life of the author by Dr. Birch, and a glossary, together with 32 plates from designs by Kent, must likewise be mentioned. Lond. 1751, 3 vols. 4to. Another edition of this poem, with notes critical and explanatory, was soon afterwards published by Ralph Church, A.M. Lond. 1758, 4 vols. 8vo. And about the same time appeared a new edition, with a glossary and notes explanatory and critical, by John Upton, A.M. Lond. 1758, 2 vols. 4to. An elaborate and complete edition of Spenser's Works was at length published by Mr. Todd. Lond. 1805, 8 vols. 8vo. Nor must we fail to direct the reader's more particular attention to Mr. Warton's "Observations on the Faerie Queen of Spenser," in 2 vols. 8vo. As a proof of the poet's continental reputation, we may here refer to *Spenser's Sonnetten, übersetzt durch Joseph von Hammer*. Wien, 1814, 8vo.

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[1] Ben Jonson, in his Conversations with Drummond, stated, "that the Irish having rob'd Spenser's goods and burnt his house and a little child new born, he and his wyf escaped; and after, he died for lake of bread in King Street, and refused twenty pieces sent to him by my Lord of Essex, and said, 'He was sorrie he had no time to spend them.'"

[2] Hardiman's Irish Minstrelsy, or Bardic Remains of Ireland, vol. i. p. 320. Lond. 1831, 2 vols. 8vo.

SPERMACETI, a whitish, unctuous, flaky substance, prepared from oil, but chiefly from the brains of a species of whale called *physeter macrocephalus*.

SPEUSIPPUS, an Athenian philosopher, the nephew and successor of Plato. Contrary to the practice of his master, Speusippus required from his pupils a stated gratuity. He placed statues of the Graces in the school which Plato had built. On account of his infirm state of health, he was commonly carried to and from the Academy in a vehicle. On his way thither he one day met Diogenes, and saluted him: the surly philosopher refused to return the salute, and told him, that such a feeble wretch ought to be ashamed to live; Speusippus replied, that he lived not in his limbs, but in his mind. At length being wholly incapacitated, by a paralytic stroke, for the duties of the chair, he resigned it to Xenocrates. He is said to have been of a violent temper, fond of pleasure, and exceedingly avaricious. Speusippus wrote many philosophical works, which are now lost, but which Aristotle thought sufficiently valuable to purchase at the expense of three talents. From a few fragments which remain of his philosophy, it appears that he adhered very strictly to the doctrine of his master.

SPEY, a river of Scotland, rises from a lake of the same name in Badenoch, and after a serpentine course of seventy-six miles, passes by Rothes castle, and falls into the German ocean at Garnoch near Elgin.

SPHERE is a solid contained under one uniform round surface, every point of which is equally distant from a certain point in the middle called its *centre;* and is formed by the revolution of a semicircle about its diameter.

SPHERE, in *Astronomy*, that concave orb or expanse which invests our globe, and in which the heavenly bodies appear to be fixed, and at equal distance from the eye.

SPHEROID, in *Geometry*, a solid approaching to the figure of a sphere. It is generated by the entire revolution of a semi-ellipsis about its axis. When the revolution is made round the largest axis, the spheroid is called *prolate;* and when round the shortest, *oblate*. This last is the figure of the earth, and probably of all the planets.

SPHINCTER, in *Anatomy*, a term applied to a kind of circular muscles, or muscles in form of rings, which serve to close and draw up several orifices of the body, and prevent the excretion of the contents.

SPHINX, in fabulous history, a monster which had the head and breasts of a woman, the body of a dog, the tail of a serpent, the wings of a bird, the paws of a lion, and a human voice. It sprang from the union of Orthos with the Chimæra, or of Typhon with Echidna. The sphinx had been sent into the neighbourhood of Thebes by Juno, who wished to punish the family of Cadmus, which she persecuted with immortal hatred; and it laid this part of Bœotia under continual alarms, by proposing enigmas, and devouring the inhabitants, if unable to explain them. In the midst of their consternation the Thebans were told by the oracle, that the sphinx would destroy herself as soon as one of the enigmas which she proposed was explained. In this enigma, she wished to know what animal walked on four legs in the morning, two at noon, and three in the evening. Creon king of Thebes promised his crown and his sister Jocasta in marriage to him who could deliver his country from the monster by a successful explanation of the enigma. It was at last happily explained by Oedipus, who observed, that man walked on his hands and feet when young, or in the morning of life; at the noon of life he walked erect; and in the evening of his days he supported himself by leaning on a stick. The sphinx no sooner heard this explanation than she dashed her head against a rock, and immediately expired. Some mythologists wish to unriddle the fabulous traditions about the sphinx by the supposition, that one of the daughters of Cadmus, or Laius, infested the country of Thebes, by her continual depredations, because she had been refused a part of her father's possessions. The lion's paw expressed, as they observe, her cruelty, the body of the dog her lasciviousness, her enigmas the snares which she laid for strangers and travellers, and her wings the dispatch which she used in her expeditions.

Among the Egyptians the sphinx was the symbol of religion, by reason of the obscurity of its mysteries; and on the same account the Romans placed a sphinx in the pronaos or porch of their temples. Sphinxes were used by the Egyptians to show the beginning of the water's rising in the Nile: as it had the head of a woman and the body of a lion, it signified that the Nile began to swell in the months of July and August, when the sun passes through the signs of Leo and Virgo. There are several of these still to be seen; one in particular, near the Pyramids, much spoken of by the ancients. It is of a prodigious size, and cut out of the rock; the head and neck appear only at present, the rest of the body being hid in the sand. This, according to Thevenot, is twenty-six feet high, and fifteen feet from the ear to the chin: but Pliny assures us, the head was no less than 102 feet in circumference, and sixty-two feet high from the belly, and that the body was 143 feet long, and was thought to be the sepulchre of King Amasis. The learned Mr. Bryant observes, that the sphinx seems to have been originally a vast rock of different strata; which, from a shapeless mass, the Egyptians fashioned into an object of beauty and veneration.[1] The Egyptians used this figure in their building; from them the Greeks derived it, and afterwards improved it into an elegant ornament. It is also frequently used in modern architecture.

It may be proper to observe, that the sphinx of the Egyptians is said in the *Asiatic Researches*[2] to have been found in India. Colonel Pearse was told by Murari Pandit, a man of learning among the Hindoos, that the sphinx, there called *singh*, is to appear at the end of the world, and as soon as he is born will prey on an elephant; he is therefore figured seizing an elephant in his claws; and the elephant is made small, to show that the *singh*, even a moment after his birth, will be very large in proportion to it. But in opposition to this account given by Murari Pandit, the late Sir William Jones, the learned and illustrious president of the Asiatic Society, was assured by several Brahmins, that the figure taken for a sphinx was a representation of a lion seizing a young elephant.

SPICE, any kind of aromatic drug that has hot and pungent qualities; such as pepper, nutmeg, ginger, cinnamon, and cloves.

SPILSBY, a market-town of Lincolnshire, in the hundred of Bolingbroke and the division of Lindsay, thirty-one miles from the city of Lincoln, and 132 from London. It stands on an eminence, commanding an extensive view towards the south. It is composed of four streets, uniting at the market-place, which is a square with a cross, consisting of a plain octagonal shaft, with a quadrangular base; and near to it is the town-hall, rebuilt in 1764, in which the quarter sessions for the division of Lindsay are held. The parish church is a large old edifice, including a chapel with some ancient monuments. There is a good market on Saturday. The population was, in 1801, 932; in 1811, 963; in 1821, 1234; and in 1831, 1384.

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[1] Bryant's Ancient Mythology, vol iii. p. 532.

[2] Vol. ii. p. 334.

SPINAGE, or SPINACH. See HORTICULTURE.

SPINDLE, in *Geometry*, a solid body generated by the revolution of some curve line about its base or double ordinate; in opposition to a conoid, which is generated by the rotation of the curve about its axis or absciss, perpendicular to its ordinate. The spindle is denominated circular, elliptic, hyperbolic, or parabolic, according to the figure of its generating curve.

SPINET, or SPINNET, (Ital. *Spinetta*), an old-fashioned musical instrument, of which the brass and steel wires were struck by quills fixed to the tongues of the jacks that were moved by finger-keys. It was the predecessor of the harpsichord and the piano-forte.

SPINNING is the art of forming continuous threads by drawing out and twisting together filamentous materials. This was at first a manual art, and was practised in the earliest ages. The simple tool first made use of, consisted of a piece of wood, with its lower extremity of a conical form like a boy's top, and its upper portion long and tapering to a point, to which the fibres to be spun were fixed; this was termed a spindle, and in using was spun like a top to twist the threads. To the spindle an addition was soon made of the distaff, consisting of a piece of wood, round which the material to be spun was lapped. The distaff was held in the one hand of the spinner, while the other hand was engaged in drawing the fibres from the mass, and ever and anon giving fresh impetus to the motion of the spindle. This simple apparatus must have been early used, as, among the sculptures of the early Egyptian tombs, we find representations of females forming threads with the spindle; and singular though it be, the same apparatus may yet be found in a few places in Scotland, affording, in its toilsome progress, a striking contrast to the whirling wonders of the cotton-mill.

A great improvement in the use of the distaff and spindle, by which the spinner's hands were in a great measure left free to regulate the formation of the thread, was made by mounting the spindle in a frame, and using a larger wheel to drive it by a belt; and this again was further improved by using a treadle to effect the movement of the wheel by the foot of the spinner. No attempt, however, to introduce mechanism to supply the place of the skill and dexterity in manipulation, which the spinner could acquire only by assiduous practice, appears to have been made before the beginning of the eighteenth century. At that time there were in common use two kinds of spinning implements. The one, called the *large wheel*, was used in the spinning of wool and cotton, consisting of a large wheel or rim mounted in a frame, and having a belt to drive the spindle which projected from the side of the frame, and had the material to be spun affixed to its end. In spinning, the operator, usually a female, laid hold of the wool or cotton with the finger and thumb of her left hand, at a few inches distant from the spindle, and drew it towards her, while she turned the wheel with her right hand; she thus extended and twisted repeated portions, and as they were twisted, she, by guiding with her hand the thread she had formed, allowed it to be wound upon the spindle. Thus, from the carded cotton or wool, a loose flabby thread or *rove* was formed, which was again subjected to a similar drawing or extension, and twisted until reduced to a fine and compact thread. The other implement, called the *small* or *Saxon wheel*, was a more perfect apparatus, and was used for the spinning of flax; it had on its spindle a bobbin, on which the thread was wound, and a flyer revolving with greater rapidity than the bobbin to give the thread twist; a fixed distaff, on which the prepared flax was loosely rolled; and a treadle by which a rotatory motion was given to the wheel by the foot of the operator, whose hands were thus left at liberty to draw out the fibres of the flax in the requisite number to form the thread; in doing this, the fibres were, from time to time, moistened with saliva, to make them more readily combine.

Such were the implements used in Britain and elsewhere, when, about the year 1738, an ingenious mechanist, John Wyatt, made an attempt to substitute mechanism for the hands and the skill of the spinner. To him is due the honour of discovering the principle of roller-spinning; a principle which, forty years afterwards, was fully developed by the genius of Arkwright. The following account of Wyatt's invention, by his son Mr. Charles Wyatt, will shew to what extent he carried the principle of roller-spinning.

"In the year 1730, or thereabouts, living then at a village near Litchfield, our respected father first conceived the project, and carried it into effect; and in the year 1733, by a model of about two feet square, in a small building near Sutton Coldfield, without a single witness to the performance, was spun the first thread of cotton ever produced without the intervention of the human fingers, he, the inventor, to use his own words, '*being all the time in a pleasing, but trembling, suspense.*' The wool had been carded in the common way, and was *passed between two cylinders, from whence the bobbin drew it by means of the twist.*

"This successful experiment induced him to seek for a pecuniary connexion equal to the views that the project excited, and one appeared to present itself with a Mr. Lewis Paul, which terminated unhappily for the projector; for Paul, a foreigner, poor and enterprising, made offers and bargains which he never fulfilled, and contrived, in the year 1738, to have a patent taken out in his own name for some additional apparatus, a copy of which I send you; and in 1741, or 1742, a mill turned by two asses walking round an axis was erected in Birmingham, and ten girls were employed in attending the work. Two hanks of the cotton then and there spun are now in my possession, accompanied with the inventor's testimony of the performance. Drawings of the machinery were sent, or appear to have been sent, to Mr. Cave, for insertion in the *Gentleman's Magazine.*

"This establishment, unsupported by sufficient property, languished a short time, and then expired; the supplies were exhausted, and the inventor much injured by the experiment, but his confidence in the scheme was unimpaired. The machinery was sold in 1743. A work upon a larger scale, on a stream of water, was established at Northampton, under the direction of Mr. Yeoman, but with the property of Mr. Cave. The work contained 250 spindles, and employed fifty pairs of hands.

"The work at Northampton did not prosper. It passed, I believe, into the possession of a Mr. Yeo, a gentleman of the law, in London, about the year 1764; and, from a strange coincidence of circumstances, there is the highest probability that the machinery got into the hands of a person who, with the assistance of others, knowing how to apply it with skill and judgment, and to supply what might be deficient, raised upon it, by a gradual accession of profit, an immense establishment, and a princely fortune."

The principles of Wyatt's invention are contained in that portion of Paul's specification which we here quote: "The wool or cotton being thus prepared (by carding into slivers), one end of the mass, rope, thread, or sliver, is put betwixt a pair of rowlers, cillinders, or cones, or some such movements, which being twined round by their motion, draws in the raw mass of wool or cotton to be spun in proportion to the velocity given to such rowlers, cillinders, or cones. As the prepared mass passes regularly through or betwixt these rowlers, cillinders, or cones, a *succession* of other rowlers, cillinders, or cones, moving proportionably faster than the first, draw the rope, thread, or sliver, into any degree of fineness which may be required. Sometimes these successive rowlers, cillinders, or cones (but not the first) have another rotation besides that which diminishes the thread, yarn, or worsted, viz., that they give it a small degree of twist betwixt each pair, by means of the thread itself passing through the axis and center of that rotation. In some other cases only the first pair of rowlers, cillinders, or cones, are used, and then the bobbyn, spole, or quill, upon which the thread, yarn, or worsted is spun, is so contrived as to draw faster than the first rowlers, cillinders, or cones give, and in such proportion as the first mass, rope, or sliver is proposed to be diminished."

To appreciate rightly Wyatt's invention, we must take into consideration the state of the art at his day. No machine, except the household wheels, already described, then existed, and their useful effect depended on the skill and dexterity of the spinner. Wyatt's invention contained the germ of a self-acting and self-regulating principle; and the means which he used were so unlike any operation performed by the hands, that although unfortunately his success was only partial, he is yet entitled to our admiration for the originality of his genius. He did much for the art, if what he did prepared a foundation for Arkwright's superstructure.

The next invention was one in which an effort was made directly to imitate the action of the spinster, as exemplified in the wool-wheel, in drawing away the roving of wool until extended to the proper length, and, after having twisted it, winding it on the cope or spindle. This was the "Jenny" of Hargreaves, a poor weaver of Lancashire.

If we imagine many spindles to be set in motion by one wheel, and the ends of the rovings connected with these to be inserted between two pieces of wood, which, like the jaws of a vice, would hold them firmly, and by which they could all be drawn back at one time by the left hand of the spinner, while with his right hand he could drive the wheel which gives the spindles their motion, we shall have a good idea of the first spinning-jenny, which was indeed, no more than this. In process of time, however, the machine was rendered very different from the one first constructed. The spindles were increased from eight (the number in Hargreaves's original machine) to eighty, and upwards; the clove or clasp by which the slivers or rovings were held was improved in form, and mounted on a carriage, and made to run on a railway in the framing, the effect of which was more perfect equality of the thread, and a greater degree of precision in the process. The yarn when spun was built up in a conical form on the cope or spindle by a proper apparatus, and altogether the machine was very much improved. Still, with all its improvements, it was only a hand-wheel of many spindles. But as a hand-wheel it probably effected more good than it would have done had it been more complete. It still remained a domestic implement of small cost, and its use rapidly extended. The jenny was imperfect in so far that it could only be brought to act upon rovings, which required to be formed on the hand-wheel already described. This defect was soon remedied by the introduction of the *slubbing billy*, in which the parts of the jenny were reversed, the place of the clove or clasp being supplied by rollers, and the spindles being mounted in a frame running on a railroad. The card rolls or slivers were in this machine placed continuously on an inclined plane, formed by a travelling canvas, which conducted them up to the feeding rollers, placed at its highest point; and on passing through the feeding rollers the slivers were attached to the spindles, which, receding from the rollers, twisted the slivers and formed rovings for the jenny. This machine is still used for forming the rove in wool-spinning.

The problem of automatic spinning, however, remained yet to be practically solved, and this solution was reserved for the genius of another man in poor circumstances,—Richard Arkwright.

The bad success of roller-spinning in the hands of Wyatt, a most ingenious man, would have deterred most men from again attempting it; but partial failure appears to have ever stimulated the persevering Arkwright to fresh exertion. He, a poor man, a barber by trade, unaided, almost uneducated, and totally unacquainted with mechanics, perfected a system of machine-spinning which ultimately raised the manufactures of his country to a height unexampled, and obtained for him honour and wealth.

Arkwright's principle of roller-spinning need not here be particularly described, as we shall have occasion to illustrate it more fully afterwards. It is only necessary generally to observe, that in this mode of spinning the material is extended to the requisite degree by rollers, and twisted and wound up by a flyer and bobbin, as in the small flax wheel, the drawing, the twisting, and the winding up being simultaneously carried on. Important as the invention of roller-spinning is, it is not on it alone that the fame of Arkwright rests, but also on the power of mind displayed in remodelling the habits of people accustomed to desultory working, and, in short, in establishing the factory system.

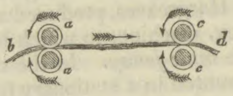
The next great invention was also produced by a man in humble circumstances,—Samuel Crompton, a weaver at Hall-in-the-wood near Bolton. This ingenious individual, combining the drawing roller of Arkwright with the jenny of Hargreaves, produced a beautiful, though somewhat complex, machine, to which he gave the appropriate name of the *mule-jenny*. In the mule-jenny the drawing rollers are mounted in a stationary frame, and the twisting spindles in a moveable carriage; the rovings are passed through the rollers and attached to the spindles; the rollers and spindles are then made to revolve, and the carriage to recede from the rollers, carrying away and twisting the attenuated rove. When a sufficient quantity of rove has been given out, the motion of the rollers is suddenly stopped and that of the spindles of the carriage increased to nearly double its former velocity, the carriage itself still receding from the rollers, but at about one-half its former speed; thus the greatest extension only takes place as the rove receives twist to enable it to bear it.

These machines were all the offspring of the cotton manufacture; but it may be well supposed that the principle on which they act would soon be adopted in the spinning of wool, flax, and silk. It is not here necessary to trace the different steps through which, by slow degrees, the parts of these machines were brought to suit the peculiarities of other manufactures. We shall, therefore, proceed to the elucidation of the principles of spinning the various textile materials by machinery, observing first, that, to fit these materials for spinning, they are made to undergo several preparatory processes; the effect of which, when well performed, is to separate the fibres, to unravel those which are entangled, and, except in the case of flax, to present the whole mass in a continuous sliver or ribbon of an equal width and density throughout its whole extent. On this sliver the operation of spinning is performed.

If we take hold of a portion of such a sliver with the hands rather farther apart from each other than the average length of the fibres of which it is composed, we shall find that, by the sliding of the fibres on each other, we can extend it a little without breaking it. Suppose then that we thus extend a few successive portions, and lay them together, and combine them by slightly twisting them, so that the tortion shall generate a certain compression among the co-fibres, we shall now find that we are able to extend the mass considerably farther without breaking, and so by continued drawing and twisting we may attenuate the sliver until it become a fine thread. There are two circumstances which limit its extensibility. The first is that state of it when many of the fibres which compose it end together at the same place, and which it is one of the objects of carding, and the purpose of some of the after processes, to prevent. The second is when the friction produced by the twisting becomes so great that the fibres will sooner break than slide on each other.

The operations, then, to be performed by the spinning-machinery, are, to extend the mass of sliver as it comes from the preparatory machines, by repeated operations, or *drawings*, as they are termed, into a narrower and narrower ribbon; to twist this ribbon into a loose thread or *rove*, to enable it to bear greater extension; and, further, to extend this rove to the last degree of attenuation required, twisting it, at the same time, so *hard*, that, when the operation is finished, and the thread perfectly formed, the fibres will sooner break through, than separate, by sliding on each other. All these operations are, however, more or less mixed up with each other in practice. Thus, the carding engines, besides disentangling the fibres, draw the broad sheet of loose filaments into a narrower and more compact sliver; the drawing-frames extend this into a still narrower ribbon; in the roving-frames the drawing still proceeds, and by an additional apparatus the sliver is twisted; and this drawing and twisting are carried on together in the spinning-frame and in the mule-jenny until the completion of the thread.

The manner in which the drawing is effected may be conveniently represented by a figure. Let *a a* in the figure represent a pair of rollers, which are called retaining rollers; let these revolve in the direction of the arrows with a given velocity, and receive between them the sliver *b d;* they will thus impart to it the rate of motion of their own surfaces; let *c c* be another pair of rollers, which are called drawing rollers, revolving with twice the speed of *a a*, and receiving between them the sliver. Imparting to it now their own motion, they will cause it to move forward twice as fast as it is yielded by *a a*, which it can only do by the fibres sliding asunder. If, therefore, a given length of sliver be passed through the roller, it will be drawn out to twice its original length, and its sectional area will be but half of what it was. The drawing rollers have here been supposed to move twice as fast as the retaining rollers, but their relative speed may be in other proportions. Thus the drawing rollers may move three, four, or five times faster than the other pair, and extend the sliver to three, four, or five times its original length. This difference of speed is termed the draught of the machine, and a machine is said to have a draught of two, three, four, five, or six, as the speed of the surface of the drawing rollers is so many times greater than that of the retaining rollers. It is obvious that, to effect the lengthening of the sliver, the distance between the drawing and retaining rollers must be somewhat greater than the average length of the fibres which compose the sliver. For were the distance less than this, the consequence would be disruption of the fibres themselves, from both rollers having hold of the opposite ends of the same fibres at the same time. But the distance may be too great, which would tend to make the fibres separate entirely at the middle point between the rollers, or at least to make the greatest attenuation take place there.



It is obvious, too, that the amount of extension which a single sliver can endure must be small, from the danger of the ends of many fibres occurring at the same place. Hence there exists a necessity for laying many slivers of the first drawing together, for the second drawing, and many of these again for the third drawing. This laying together of the drawings, which is termed doubling, possesses the advantage of ensuring greater equality in the thread, from the inequalities of the separate drawings contemperating each other. The oftener this doubling is repeated, the more compact and equal, or *level*, the thread will be, and the more capable of enduring attenuation from the interspersion of the endings of the fibres.

As an example, in figures, of the effect of the drawing and doubling processes, suppose the velocity of the drawing rollers to that of the retaining rollers, or, in other words, the draught of the machine to be as 5 to 1, let the length of the sliver before drawing be 1, and its density 1; after the drawing we shall have the length increased to 5, and the density diminished to ·2. Suppose a doubling consisting of 8 of those new drawings to be put through the rollers, we shall have a new sliver formed, length 25, density ·32; and the result of this doubling being repeated four times, the ratios being the same, that is in figures, $\frac{8}{5} \times \frac{8}{5} \times \frac{8}{5} \times \frac{8}{5} = \frac{4096}{625} = 6{\cdot}5$. will be a length of 625, and a density 6·5; that is to say, there will be 6·5 times as many fibres in the same space as there were originally, and the length will be increased to 625, this length of 625 being made up of 4096 separate slivers, or ends, as they are termed.

Such is the process of drawing without twist, in its simplest form, and as it is applied to cotton, wool, and silk waste. In flax spinning the nature of the material renders a more complicated apparatus necessary. Each fibre of flax, on minute examination, will be found to be made up of a number of smaller parallel filaments bound together. The separation of these bundled filaments is partially effected by the hackling process; but it is evident, that the thread is not capable of its greatest degree of attenuation, until the total separation of the filaments be completed. For this reason, a hackle, which shall separate the filaments, is an essential part of the drawing apparatus for flax; and, in the repeated doublings of the slivers, a succession of machines is used, in which the hackles are gradually finer.

From the length of the fibres of the flax, the rollers require to be at a considerable distance from each other, and the hackles are placed in the interval between them. They are fixed to an endless chain, working over rollers, and their points are made to move through the sliver, with a speed a little greater than that of the retaining rollers. They thus have a double action. Entering the sliver immediately on its emission from the retaining rollers, and moving faster than it does, they split down the bundles of the fibres, and allow the sliver to be extended by the rollers. As they proceed onwards, the action of the drawing-rollers makes the extending sliver move many times faster than the hackles, and, by this means, straightens and lays parallel those fibres which may happen to be doubled, or to lie obliquely in the sliver. This ingenious apparatus is called the Gill, from the name of its inventor.

The process which succeeds these repeated drawings, whether made by the simple rollers or by the gill, is twisting the sliver into a rove. For this purpose, an addition of a bobbin and flyer is made to the drawing machine. The bobbin is made to revolve with such speed, as to wind up the rove as fast as it is yielded by the last pair of rollers, and the flyer with so much additional speed as to give to the sliver the desired twist while moving between the roller and the bobbin. As the diameter of the bobbin is continually increasing by the accumulation of the rove, and as the speed of the rollers remains constant, it is necessary to vary the speed of the bobbin, so that, as it increases in diameter, it may diminish in speed, and wind up the rove at the same rate throughout. The mechanism for effecting this is, in some machines, very complicated.

The next operation is forming the thread from the rove. For this there are two kinds of machines used,—one, the throstle, which is a simplification of Arkwright's spinning-frame, and consists of a set of drawing rollers with bobbins and flyers as in the roving frame; the other is that combination of the drawing rollers with the jenny, which is termed the *mule*. In the roving and throstle frames the twisting apparatus is stationary, and merely twists, and the twisting succeeds the drawing. In the mule the twisting apparatus recedes from the rollers faster than they yield the sliver, and consequently has a drawing as well as a twisting power. In the throstle, the rove being pulled by the bobbin through the flyer, is, while yet tender, subjected to a continual strain. In the mule the rove is only subjected to strain, as it receives twist enough to enable it to bear the strain without injury. The mule, too, by the peculiarity of its mode of action, destroys those inequalities of the rove which result from defects in the drawing, or injury sustained in the roving. To understand how it does so, it is necessary to observe, that, when a thread of unequal thickness is twisted, the fibres which compose the thick parts, forming larger and more oblique spirals than those which compose the small parts of the thread, require a greater force to twist them, and consequently remain soft, while the small parts become comparatively hard twisted. If a considerable length of such a thread were pulled, the fibres of the thick parts would slide upon each other; while those of the smaller parts, being mutually compressed, by their greater degree of torsion would resist the drawing asunder. The drawing would thus take place only in the thick parts; and, as they diminished in size, the twist would gradually become equally diffused. The mule, acting in this manner, with a drawing and twisting power, upon a considerable length of unequally sized, and consequently unequally twisted rove, reduces its inequalities, and renders it level and uniformly twisted throughout.

Having thus endeavoured to make the reader acquainted with the general principles on which these machines act, we shall now proceed to describe the machines themselves. Arkwright's first machine was called the water-twist frame, from having originally been driven by water-power. It consisted of a pair of retaining rollers and a pair of drawing rollers, such as those we have used for the sake of illustration, which effected the extension of the sliver. From the drawing rollers the sliver passed to another pair of rollers, called the delivering rollers, which, moving with the same velocity as the drawing rollers, had no extending power, but merely compressed the sliver and delivered it to the twisting apparatus. This consisted of the bobbin and flyer of the Saxon or flax wheel, improved in respect of the flyer being rendered automatic in spreading the thread on the bobbin, in the manner which will be seen in the descriptions and drawings of the roving and spinning machines; and this automatic action was shortly afterwards, with good effect, transferred from Arkwright's machine to the hand-wheel by a Mr. Antis. Each system of rollers and twisting apparatus in Arkwright's machine was separate, and was driven by a separate system of gearing, and pulleys and bands, rendering the machine, when of great extent, exceedingly complicated. One of the greatest improvements of modern days, is the simplification of the moving parts, by making each roller continuous along the whole length of the machine, and using only one set of driving apparatus at the one or other extremity, and by making the shaft for driving the twisting machinery also continuous, as will be seen in the drawing of the frame for flax spinning.

We have seen that the parts of the machine which perform the operations of drawing and twisting, viz. the rollers, and the bobbin and flyer apparatus, are very simple. The complexity arises, therefore, from the number of parts required to communicate motion to these parts, and to regulate their movements; and the arbitrary nature of the form and arrangements of the parts for communicating motion, causes the great differences which exist in the various spinning machines. In a brief sketch like the present, it is obviously impossible to notice the many beautiful arrangements which, from time to time, have been introduced. In addition to those machines figured in Plates CLXXVII. CLXXVIII. CLXXIX. Art. COTTON MANUFACTURE, we shall present our readers with some of the spinning machines used in the flax manufacture, and also with the latest improvements in the cotton and worsted spinning machines, which we are enabled to do in the most perfect manner, having, through the kindness and liberality of Mr. Smith of Deanston, been furnished with beautiful drawings of the self-actor cotton and woollen mules, of which he is the inventor and patentee.

Spreading machine.

Referring then to the above-mentioned Plates, we proceed to the description of the machines contained in Plates CCCCLXV. CCCCLXVI. CCCCLXVII. Plate CCCCLXV, fig. 1st, is an end view of the first machine used in the operation of flax spinning, and which is called the spreading machine. A is a board or table, called the spreading table, over the surface of which an endless web moves round rollers at its opposite ends; on this endless web the stricks of flax are spread, and are by it carried forward to the retaining rollers B. As it comes from between these rollers, it is acted on at the opposite side by the gills or moving hackles, which, with their moving apparatus, occupy the space between B and C the drawing rollers; the upper drawing roller C is moved by the friction of the under one, and is called the pressing roller; its surface is usually covered with leather. The pressure is communicated either by a lever and weight, as in the figure, or by a spring and screw. D the delivering rollers. These have no drawing power, and move just so fast as to keep the sliver tight between them and the drawing rollers, and by them the sliver is discharged into the can E, placed to receive it. All these rollers, when seen in front, as in fig. 2, exhibit the appearance of narrow wheels, as, were they made broader than is required for the mere action on the sliver, the flinty surface of the flax would speedily wear them down into channels, while, by being narrow, their whole surface is worn down equally, and funnel-shaped plates are placed in front of the rollers, to guide the sliver properly between them. The whole of the motions are taken from the drawing-roller shaft in the following manner. A belt from the main gearing of the mill works over a fast pulley on the drawing roller-shaft, which has also a corresponding loose pulley to receive the belt when the machine is to be stopped. To avoid complexity, these pulleys are not shewn in the drawings. A pinion *a*, on the end of the drawing roller-shaft, communicates motion through two intermediate stud wheels *b*, *c*, to a pinion *d*, on the end of the shaft which drives the gill apparatus; on the end of the shaft is fixed a small pinion *e*, fig. 3, to drive the under retaining roller B, through a spur-wheel *f*, whose axle carries a small pinion *g*, gearing into another spur wheel *h*, which gears into a spur-wheel *i*, fixed on the roller axle, and the upper retaining roller is driven by the friction of the under one. The pinion on the shaft of the spur-wheel *f*, also drives the inner roller of the spreading table through an intermediate spur-wheel *k*, working into a spur-wheel *l*, fixed on the roller axle. The lower delivering roller has on its end a pinion *m*, which is driven through the intermediate wheel *o* by the pinion *n* fixed on the end of the drawing roller-shaft *o*. From this pinion motion is also conveyed to other three portions of the machinery; first, through the wheels *p q*, to the cleaning roller which is seen at F in the figures; this roller is formed of wood covered with listing, which rubs on the surface of the pressing roller, and removes any filaments that may adhere to it; second, through an intermediate wheel and pinion *r*, to a wheel *s*, on the shaft of which a circular brush is fixed, whose purpose is to clean the gills, as is seen in the enlarged representation of that part of the apparatus at fig. 11; and, third, to another pinion *t*, whose shaft carries an endless screw working into the teeth of a small wheel *u*, called the measuring wheel. Its purpose is to give notice to the attendant of the machine, whenever a predetermined quantity of sliver has passed through the rollers: this it does by a stud fixed on its face coming in contact, at every revolution, with the tail of a lever *v*, whose other end is attached by a wire to the spring of a bell; when the stud, in its progress round, comes in contact with the upper end of the lever, the spring of the bell is drawn from its position, and the moment the stud escapes the lever, the spring is let back with a jerk, which rings the bell. The wheel can be substituted by others containing a greater or lesser number of teeth, according to the length of sliver required.

The only remaining part of the machine to be noticed is, a shaking motion, communicated to the cans while receiving the sliver, that it may be deposited in regular layers. This is best seen in fig. 1. The can is placed on a hinged bracket at *v*, and is steadied by another bracket at *x*, both brackets having semicircular arms, which partly embrace the can; to these brackets, and consequently to the can, a regular jolting motion is communicated as follows. On a rod which passes across the machine a short lever *y* works; on its outer end is hung a weight, and to its other end is attached a rigid rod, connecting it with an eccentric fixed on the drawing roller-shaft. The lever is by this means jolted alternately up and down in every revolution of the drawing roller, and being connected by rods with the brackets *v*, *x*, they, with their cans, are also moved in the same manner.

Drawing machine.

Flax, after having been passed through the spreading machine, is drawn twice or oftener. The drawing machine is the same as the spreading machine, except in having no spreading table, the sliver being drawn directly from the cans, which are carried from the spreading machine, and placed at the retaining roller end of the drawing machine at H, and in having three in place of two retaining rollers. The drawing machine, too, is of a lighter construction than the spreading machine, and its gill teeth are finer.

Figs. 4 and 5 shew the two sides of the machine. A is the drawing roller-shaft, and the motion is communicated from it to the other parts as in the spreading machine.

Roving machine.

The roving machine, fig. 6, is similar to the drawing machine, except that it is still lighter in construction, and that in it, in place of the delivering rollers, and the cans to receive the sliver, there is substituted the apparatus for twisting the rove seen detached in fig. 7. When the sliver leaves the drawing rollers of this machine, it is passed through the top part of the spindle, which is tubular, and called the eye of the spindle; it is then conducted by the flyers K to the bobbins L. The arms of the flyers are usually bent wires, with eyelits at their lower extremity, through which the thread is passed. Here they are represented to be tubular throughout their whole length, this being considered to make a smoother thread. The parts of the machine not already described are, the spindle rail M, the coping rail or shifting plate N, on which the lower disc of the bobbin rests. The coping rail has an alternating motion up and down through a space equal to the surface of the bobbins on which the threads are spread; and by carrying the bobbin through this space, the thread is spread equally over its surface. This alternating movement is variously effected. In the machine represented, it is done by a mangle wheel at O; but in other machines it is given by a heart wheel acting on the rail through a lever and chain. From the circumstances before described, it is necessary that the rotatory motion of the spindle and bobbin should be, to a certain extent, independent of each other; and, accordingly, while the speed of the spindle remains constant, the speed of the bobbin is made to diminish as its diameter increases by the accumulation of thread. In the ordinary construction of the machine, this differential movement is regulated by the attendant, by the friction of a string which can be made to embrace more or less of the periphery of the bottom disc of the bobbin, as represented in the figure of the spinning machine. The spindle and bobbin are both driven by a band passing over a pulley fixed to them; and while the speed of the spindle remains constant, that of the bobbin is gradually diminished as it fills, by the attendant moving the string successively along into the different teeth of a rack, so as to make it embrace more and more of the surface of the bottom disc, and thus create a friction which retards the speed. Thus the proper working of the machine depends entirely upon the vigilance of its superintendent; and a simple yet accurate differential movement is still a desideratum.

In the machine represented in the plate, the differential movement is exceedingly accurate and beautiful, but is so complex that it would require many detailed drawings, to give the reader a correct idea of it. This motion, and many other improvements in the spinning apparatus, are the invention, we believe, of Mr. Fairbairn of Leeds.

Spinni machi

Figs. 8 and 9 are a side and front view of a spinning frame, drawn from a machine constructed by Mr. Russell of Kirkaldy. A A is the bobbin rail on which the bobbins from the roving machine are placed; *b b*, the retaining rollers; *c c*, slip rollers for guiding the rove; *d d*, drawing rollers; *e*, the traverse shaft; *f*, the cylinder shaft.

The cylinder shaft is driven from the main gearing. A belt from a pulley on the end of the cylinder shaft gives motion to a pulley, which is called the speed pulley, because all the motions are calculated from it. The speed pulley shaft carries a pinion gearing into a wheel *b*, on the end of the drawing roller shaft, which again, by a train of wheels, communicates motion to the retaining rollers. The spindles are driven by small bands from the cylinders of the cylinder shaft passing over wharves on the spindle shaft; and the differential motion of the bobbin is produced by the friction obtained from a small cord or temper-band, as it is called, embracing more or less of the periphery of the under disc of the bobbin, as before described.

The motion of the heart-wheel, which, through the lever and chain, gives the traverse motion to the bobbin, is taken by wheel and pinion from the retaining roller shaft. The speed of the spindle is from 3200 to 3500 revolutions per minute. The average work of this machine is two hasps of yarn, of average quality, for each spindle in a working day of twelve hours.

The machines for drawing and spinning tow are the same, or nearly the same, as those for spinning flax. From the shortness of the fibre of tow, the drawing and retaining rollers are set much closer together, and the gills are circular.

In the fine spinning of flax, the thread is moistened, by being made to pass through a trough containing water; a practice probably derived from the custom of spinsters moistening the thread with saliva in household spinning. By the modern improvement of the substitution of hot for cold water, a much finer, smoother, and more even thread can be spun from the same quality of flax than before.

The flax-spinning machinery has recently been introduced with great success into the spinning of silk waste, which was formerly treated in the same manner as cotton. As the gills are used in the spreading, the drawing, and the roving machines, and as it is in the use of the gills that flax machines differ from the machines for spinning cotton, we have given in figs. 10, 11, and 12, the two kinds in ordinary use.

Fig. 10 shews the common chain gill. A A are the gill rollers; B the gill chain, consisting of a series of links, jointed together at their lower extremity, as is better seen in the separate representation of them at C. There is one of these gill chains at each side of the machine, and they are connected together by the guard bars *d d*, which extend across the machine. The gills are attached to the gill stocks *e e*, which stretch across the machine, and whose ends work through the slit in the links of the gill chain, and extend beyond the links into the slit of the guide frame *f*, of which there is one on each side of the machine. These slits are called the gill slides, and perform the office which we will immediately see. As the gill stocks are carried round by the links of the gill chain, it is evident that they will be elevated or depressed according as the path of the links agrees with the line of the slides. Their path and the slides are so made to agree from *a* to *b*, that the stocks occupy the highest point of the links, and the hackles are protruded to their greatest extent, and work through the sliver in its passage between the retaining and drawing rollers. At the point *b*, the slides suddenly diverge from their former line, and nearly at right angles, by which divergence the gill stocks' ends are suddenly moved from the highest to the lowest point of the link, and the hackles are withdrawn from the sliver nearly at right angles. In following further the course of the guides, it will be seen that the circles of the slides are of the same size as those of the inner ends of the links, and consequently the gills are retained at the inner end of the links until the divergence of the slide at *a* again protrudes the hackles through the sliver in a direction nearly at right angles to its course. When the gills are withdrawn, their points fall just beneath the level of the guard bars which sustain the sliver, and in the case of entanglement, prevent it from being drawn down along with the gills.

Such is the common flax gill; and its defects are, first, that the teeth of the gills cannot be made to approach close enough to the drawing rollers, or to enter the sliver immediately after leaving the retaining rollers; and, second, that they do not leave and enter the sliver at right angles to its course. To remedy these defects, the screw gill has been introduced. Of this a longitudinal section is given at fig. 11, and a transverse section at fig. 12. *a a*, *a a*, are four screws; the two upper screws have their threads lying in the reverse directions of the under ones; *b b* are the gill bars, stretching across between the opposite pairs of screws, and having their ends working in the screw threads. When the upper screws are moved round their axis, the gill bars are carried forward through the sliver, being supported in their position by the bracket pieces *c c*, under the screws. These bracket pieces and the threads of the screw terminate, just at the drawing roller, so that when the gill bar has arrived at that point, it is no longer supported by the bracket, and falls down to a lower bracket *d d*, which guides it in the same manner for the under screws. In its fall the gill bar is aided by a cam on the screw-shaft striking it when it has reached the termination of the screw, and it is guided in its descent, and pressed into the thread of the lower screw, by a strap of iron forced against it by a lever. The threads of the lower screws are so arranged as to carry the gills along on its bracket piece towards the retaining rollers, and when it has reached the termination of the screw, a cam on the screw-shaft, with a guiding apparatus as before, raises the gill again to the upper bracket, to be acted on again by the upper screws.

As an introduction to the description of Mr. Smith's self-acting mule, it is necessary to give the reader a general idea of the hand-mule jenny, a representation of which will be found at Plate CLXXVIII, fig. 12. By consulting that figure, the reader will see that the mule consists of two distinct parts; first, the beam at the right hand of the figure carrying the drawing rollers; and, second, the carriage upon which the spindles are mounted for the purpose of giving twist, the beam being stationary, and the carriage capable of moving upon iron races along the extent of the machine, as may be seen by the dotted lines on the figure. Motion is communicated to the different parts by mechanism, mounted on a frame-work placed across the mule, either at one end or in the centre. This frame-work, with its apparatus, is called the headstock.

Cotton mule-jenny.

When the mule is put in motion to perform the operation of spinning, the rollers are moved by wheel-work from the headstock, and the carriage is gradually moved outwards, keeping pace with the delivery of the rollers; and while this process is going on, the spindles are put into a rapid motion by belts and bands proceeding from the fly-wheel of the headstock, and which can be adjusted to give such an amount of twist as may be necessary. The whole of the twist may be thrown in during the outcoming of the carriage, as is generally done in spinning wefts, or as in twist-spinning, when part is thrown in during the slubbing, and the remainder after the carriage has reached its limit, and the rollers have stopped. In the outward movement of the carriage, the mule is driven by power communicated from the main gear to the fly-wheel shaft of the headstock, by a belt with a fast pulley, and when the stretch or draw has been completed, the machine is entirely stopped, by the belt being thrown on a loose pulley adjoining. The spinner then lays hold of the fly-wheel with one hand, and turns it back so far as to throw off all the coils from the stems of the spindles, which is technically called *backing off*, while with the other hand he puts down the faller or guide to the proper position for winding the threads on the copes. He then pushes the carriage towards the beam, directing the faller with one hand, so as to guide the threads in proper form on the cope, while with the other hand he turns forward the fly-wheel with such force, as to cause the threads to be wound upon the copes with a uniform and proper tension. When the carriage has arrived at the beam, he lifts up the faller wire, so as to throw the threads in coils from the copes to the points of the spindles, thus completing the draw or stretch, as it is called, and leaving the whole in proper order to commence a new draw. The driving belt being then thrown on the fast pulley, the machine is again put in motion, and so goes on successively.

Smith's self-acting cotton mule-jenny.

All these motions are in Mr. Smith's machines performed at the proper instant by the machines themselves. Plate 466 fig. 1, shews a side elevation of the headstock, and an end elevation of the carriage. Fig. 2 is a bird's-eye view of the carriage, race-rods, &c. The other figures in the same plate exhibit details of the mechanism, which will be referred to in their proper place.

The same letters refer to the same parts in all the figures. A A A A is the framing of the headstock, B the beam upon which the rollers are mounted, C the race-rods upon which the carriage runs, D the frame-work of the ends of the carriage, E the wooden rails of the carriage.

The motion of all the parts of the machine is derived by belts and pullies from the driving shaft F, which is itself driven by a belt from the main gearing acting on its fast pulley G, and when it is necessary to stop the whole machine, the belt is thrown on the loose pulley H. The driving shaft carries two pullies; a belt from the larger one I drives the pulley K of the speed-shaft T, and a belt from the smaller one L drives the pulley of the change-shaft M. These two shafts also carry loose pullies, on which the belts are thrown at the proper instant for stopping the motion of the shafts, by levers and apparatus whose action will be better described while noticing the action of the machine.

The regular outward motion of the carriage, its time of rest when at its outward limit, to allow time for the twisting of the threads, and its rapid inward motion during the winding of the threads on the copes, is obtained from the change-shaft N in the following manner. The near end of the change-shaft carries a pinion O, which, through the wheels *a b c*, drives the shaft *c*. The shaft *c* is carried in the lower, and the shaft of the wheel *p* in the upper socket of a frame, called the vibrating frame, from its having a vibrating motion, by its axis turning in bearings *d d*. The further end of the shaft *c* carries a pinion of eight, nine, or more leaves, which works into the teeth of a peculiarly formed wheel P, called the regulating wheel; and it is this wheel, by the motion derived from its singular line of teeth, which effects the varied movements of the carriage, by the spur-wheel *e* attached to it working into the teeth of the carriage-rack Q Q. When the pinion is working into the outer ring of the teeth, which, it will be observed, are reversed, the regulating wheel and its spur-wheel move in a regular manner, and roll the carriage outward. When the carriage has arrived at its outward limit, the pinion will have begun to act on those teeth of the wheel which are eccentric, and which, lying nearly in the direction of a radius of the wheel, cannot give it rotatory motion; it therefore stops, and the carriage of course is also stationary, while the pinion, rolling along the radial line of teeth, forces the vibrating frame, which carries its shaft, to vibrate round its axis, to enable the pinion to approach nearer to the centre of the regulating wheel. When it arrives at that part where the teeth begin to get concentric, it again puts the regulating wheel in motion, but in an opposite direction to its former motion, for the teeth are now outward. This causes the inward movement of the carriage, which is much more rapid than its outward movement, from the smallness of the circle of teeth. When the carriage, in its inward motion, has nearly reached the drawing rollers, the pinion will have begun to work into the opposite eccentric line of teeth; this, as before, will be followed by a reverse vibration of the frame, and the simultaneous stopping of the regulating wheel, until the pinion have again arrived at the reversed teeth of the outer circle, when the same series of movements is again ready to take place, and these changes in the motion of the carriage are, by the peculiar form of the line of teeth, made in the most gentle manner. It is necessary that the carriage maintain perfect parallelism with the line of the drawing rollers throughout its course; nor will this appear to be easily effected, when we consider that it is sometimes fifty or sixty feet long, and that the force for moving it is applied either at one end or at the middle of its length. This parallelism of the carriage, which is technically called *squaring*, is effected in hand-mules by means of bands, called *squaring bands;* but in this machine it is effected in the following manner. A long shaft or cylinder *f f*, which, for the sake of lightness, is constructed of iron or tin-plate, passes along the whole length of the carriage, and carries upon it at each end, and sometimes, in long carriages, in the middle also, toothed wheels *g g*, which, working into racks *h h*, attached to the races or railroad on which the carriage runs, insure perfect parallelism in its movements.

From the spur-wheel *e*, attached to the regulating wheel, the motion of the drawing rollers R is derived through the wheels *i k l;* but as the motion of the rollers is only in one direction, and continues only during the outward motion of the carriage, while the regulating wheel has a forward and backward motion, there is required a means of disconnecting them, when it is necessary that the rollers should stop Accordingly, the wheel *k*, through which the roller shaft *b* is driven, runs loose on that shaft, but has within it a ratchet wheel fixed to the shaft, and the pauls of the ratchet are attached to the wheel *k*. Hence it follows, that when the spur-wheel is driven in that direction in which the pauls will slip over the ratchet, the ratchet-wheel, and consequently the shaft *l*, and the rollers, will remain stationary, and this they do while the regulating wheel is performing its backward motion; but when the regulating wheel is moving in the opposite direction, the pauls of the spur-wheel catch on the ratchet-wheel, and give motion to it and to the rollers.

Having thus described the manner in which the motion of the carriage and rollers is effected, we will now show how the twisting and winding-on motion is communicated to the spindles of the carriage. The speed-shaft K, we have seen, is driven directly from the driving-shaft pulley I; from the pulley R of the speed-shaft a band proceeds and passes over the stud pulley in the frame at R′, and over the guide pullies of the carriage at S, and thence to the drums 43, which act on the spindles in the usual way; by this a uniform revolving motion is communicated to the spindles, while the carriage is running out, and during its pause at the end of the course. The speed-shaft must then be stopped, that the *backing off* may take place, and while the carriage continues its inward motion, as, although the speed-shaft moves and drives the spindles during this inward motion, for the purpose of winding on the thread, yet the winding-on motion being variable in speed, and the speed of the shaft being constant when driven by the driving-shaft pulley, it is necessary for winding on, to drive it by some other means. Accordingly, an apparatus is provided, which at this juncture throws the driving belt of the speed-shaft upon its loose pulley, and at the same time lets fall a break *m* upon a break pulley fixed upon the shaft, and thus allows the new moving parts or winding-on apparatus to come into play. The break is attached to the short end of a lever *n*, to the upper part of whose long end a spiral spring is attached. The action of the spring tends constantly to force the breaks upon the pulley, but it is restrained by a catch which is withdrawn at the proper moment by the action of an apparatus to be afterwards described; and when the winding on is completed, the break is withdrawn from the pulley, and the break lever again put on its catch, by the action of a cam fixed to the under socket of the vibrating frame pressing down the lever friction-pulley, as is better seen in detached fig. 3. To communicate the winding-on motion to the speed-shaft, when its twisting motion is stopped, there are three or more pauls *o*, attached within the rim of the break pulley, which, when the speed shaft is at rest, fall into a ratchet-wheel *o′*, to which is attached a spur-wheel *p*, fitted loose upon the shaft; but when the speed shaft is in full motion, the pauls, by the action of the centrifugal force, are thrown out of the ratchet-wheel, which, with the spur-wheel, may thus remain at rest, or be driven at any slower or quicker rate by the spur wheel *q* of the winding-on shaft *r*, which derives its motion from the roller shaft *t*, through the spur-wheels *s*, *r′*, and it is plain that when the belt of the speed-shaft T is thrown on the loose pulley, causing the shaft to stop, and the pauls of the break pulley to fall into the ratchet-wheel *o′*, then the motion transmitted from the roller shaft to the spur-wheel *p*, to which the ratchet-wheel *o′* is attached, will be by it communicated to the speed shaft T. The motion thus transmitted from the roller shaft *t*, which is itself moved by the regulating wheel P, to the spindles, is capable of adjustment by a peculiar mechanism, so that the motion of the spindles, and the degree of tension which the threads undergo in winding on, may be modified in the degree required. This elegant differential movement, carried by the shaft *r*, is seen at fig. 4. An arm 1 is carried by the shaft *r*, from which a stud 2 projects, carrying a pinion 3; this pinion on the one side gears into a series of inverted teeth, extending round near the periphery of the friction pulley t, and on the other into a series of external teeth 4; the pulley t, and the wheel 4, are both fitted loose on the shaft r; when the shaft r, with its arm 58, move round, the pinion being in gear both with the teeth of the pulley t, and the wheel 4, has a tendency to carry both of them in rotation with it; but if either of them be held fast, it is evident that the motion of the pinion will communicate so much additional motion to that which is loose, by acquiring from the stationary wheel a motion round its own centre, as well as its motion round the shaft. In this way, whatever part of the motion of the one is restrained, will be imparted to the other. This restraint is imparted to the pulley t, by a band or strap passing round it in its groove. The band is of cotton thread, made fast at one end to a stud t, projecting from the frame, and passed round the pulley and carried along to the opposite end of the headstock, where it is attached to the cross-tail t' t' of the lever u; and the degree of tension communicated to the friction-band can be modified within certain limits, by the lever u having a moveable weight u' adjustable in any position by means of the pinching screw. When the threads are winding upon the bare stems of the spindles, at the beginning of a new set of copes, and for a few stretches after the commencement, it is necessary to increase the motion of the spindles suddenly at the beginning of each winding on, until the bottom of the cope has acquired some volume. For this purpose an additional pressure is applied to the lever v, through the connecting rod proceeding from the lever w, upon the lower surface of which pressure is thrown by a simple apparatus connected with the building bar of the carriage, to be afterwards described.

The mode by which the amount of twist is regulated, is as follows. On the outer end of the driving shaft F, there is an endless screw F, working into a screw-wheel X, on the end of an upright shaft. The number of teeth on the screw-wheel is so regulated, as to cause it to perform one revolution during the time when the twist is throwing into the threads, after the carriage has reached its limits at the head; and it stops the twist by a cam X′, on its upright shaft acting on the levers, which throw the belts from the fast to the loose pulley of the speed-shaft.

The next thing to be considered is the apparatus attached to the carriage for *backing off*, and for building the threads regularly on the copes during the winding on. When the carriage has arrived at the utmost limit of its outward stretch, and the spindles have been stopped by the break, then before the faller wire can be put down to guide the threads upon the spindles, the operation of *backing off* or unwinding the spiral coils of thread from the spindles, takes place. The usual mode of effecting this, is by causing the spindle to make three or four backward revolutions; but a more simple mode is here adopted. An under faller shaft U, with its arms and wire, stretches along the whole length of the carriage, and is placed behind the building faller shaft V; but its arms are so much longer, that its wire is in front of the building wire, and the wire is kept in such a position, while the carriage is coming out, as to be at about a quarter of an inch distance below the threads, and by being raised at the proper moment, it strips the spiral coils from off the spindles. To the further end of the under faller shaft, there is attached a lever y, carrying an adjustable nut to the lower part of which the upper part of a spiral spring is attached by a hook, and its lower end to the framework below. The effect of the spring is to draw down the lever, and consequently to raise the under faller wire. This is however counteracted until the proper moment for stripping off the coils, by a projecting lever z at the other end of the under faller shaft, being held down by a moveable rod z': the upper end of the rod is attached to the lever z by a stud bolt passing through an opening in the arc head of the lever, and its lower end rests on an inclined plane, forming part of the building-on apparatus to be afterwards described. On the rod there is an adjustable stud, made fast by a pinching screw, which, resting on the top of a lever W, prevents the spring from drawing up the under faller. When this lever is turned round its fulcrum, in the manner we shall afterwards see, it allows the rod to fall, and the under faller consequently to rise, and the faller is again depressed at the proper instant, by the inclined plane z'' attached to the building-on apparatus, which we shall afterwards describe, raising the rod into its original position, in which it is again retained by the lever W. From the near end of the building wire shaft V there projects a toothed arc 5, gearing into a vertical rack 6. This rack has a small projection on the back, to which is jointed the folding arm 7, whose opposite end is jointed to the folding leg 8. The lower extremity of the folding leg carries a friction pulley, which rests on the upper surface of the curved piece 9; and it also carries a T-headed nut, which works in a vertical groove on the spur piece 10 attached to the carriage, and so guides the lower end of the folding leg in a vertical line, while it is moved up and down by the action of the curved piece. If the bent arm and leg be drawn into the same straight line, while the friction pulley of the leg remains in its position, the rack to which the upper joint of the arm is attached will move up, and acting upon the toothed rack of the building wire shaft, will turn that shaft round, and depress the wire; and the depression of the wire will be greater or less, as the foot of the folding leg is at a higher or lower point of its vertical slit. To force the folding leg and arm into the same straight line, the following apparatus is employed. A sliding bar X called the poker, resting upon a bearing at 11, is attached by a joint to the connecting arm 12, whose other end is attached by a joint to the folding leg. When the carriage is nearly at the limit of its backward motion, the end of the poker to which the arm 12 is attached, catches against, and is retained by the end of the lever 13, while the carriage runs back to its full stretch. The poker is thus sent home, and as a consequence, carries with it the arm 12, and the jointed leg and arm 8 and 7; and it carries these a little beyond the vertical position or line of centres, from which they are again disengaged, and fall into the position represented in the drawing, when the carriage, having arrived nearly at the limit of its inward course, causes the adjustable nut at the other end of the poker to strike against the bracket piece Y of the frame. In considering the next apparatus described, we shall show that the point upon which the folding leg rests, is subject to being raised and lowered, and consequently the sliding bar is also raised and lowered; the effect of which is to make the nut at the end of the poker strike on different vertical points of the restraining bracket Y; so that by making the surface of this bracket upon which the points strike to lie in an oblique direction, the exact period of liberating the jointed leg and the building faller can be regulated with precision. Thus, when the building takes place at the bottom of the spindles, the faller is made to be liberated sooner than when the building approaches nearer to the point, and by this means the due tension of the thread is preserved at the lifting of the faller. A palm from the arm 12, reaches to the supporting lever W of the under faller, and carries a stud which works through the curved slit in the tail of the lever, and retains it in its position; and a small spiral spring, seen in the drawing, being attached to the end of the palm, and to a pin upon the folding leg, serves to keep the arm 12 in its place. From this arrangement it follows, that as the lower end of the folding leg is moved up in its vertical slit, it will carry the stud of the palm nearer to the fulcrum of the lever W; and that when the jointed arm and leg are brought into the same straight line, the stud of the palm will force the lever W round its fulcrum more or less quickly, as the stud of the palm is at a greater or less distance from the lever's fulcrum, or, what is the same thing, as the lower end of the folding leg is more or less elevated in its vertical slit.

The form of the copes when finished is conical; and to build the thread in this form, it is necessary that the building wire should at first have a very limited range of motion, guiding the thread over that part of the bobbin alone where the body or thickest part of the cope is to be, and gradually extending the surface on which the thread is to be deposited at every successive layer, until the cope be completed. To effect this, it is necessary that the apparatus of the jointed rods which we have described, should first have a very limited range of motion. The friction pulley at the foot of the rod, rests, as has been said, on the curved surface of the piece 9. This piece turns on a joint in the building frame at 14, and has a tongue 15, passing down to a pin 16, which moves in a horizontal slit in the headpiece 17. This pin projects from the frame, and carries a nut 16, through which a screw, held in bearings in the headpiece 17, works. On the end of the screw there is a ratchet-wheel 18, which is moved round a tooth at every traverse of the carriage, by the lever of its paul being acted upon by an inclined plane 19, attached to the carriage; and thus the screw carries the nut 16 and its pin along the slit in the headpiece, under the end of the tongue of the curved piece 15. A diagonal bar 20 in the building frame rests also upon the nut pin. The lower surface of this diagonal bar is nearly a straight line. As the pin moves along under this surface, the building frame 21 is allowed to drop gradually in proportion to the obliquity of the diagonal; but as the surface of the tongue 15, which rests on the pin, forms an angle with the line of the plane of the diagonal, so the tongue-piece, and the curved surface-piece to which it is attached, will be allowed to drop more than the building frame, as the nut passes along; and the curved surface will thus be more and more declined from the horizontal position, thereby allowing a greater vertical movement of the folding leg at each successive draw, the effect of which will be to increase the range of the falling wire, and consequently to give the body of the copes a longer form. When the pin has been carried to a certain point, it escapes the tongue-piece, and proceeds along the surface of the diagonal only, which being straight, and at a regular inclination, allows the building frame to fall down through equal spaces at each successive draw, producing also equal increase on the range of motion of the falling wire. When a set of copes has been completed, the pin is wound back by the winch attached to the end of the screw. The whole of this apparatus is attached to a sliding bar 22, working on studs fixed to the frame of the carriage, and having at its further end a rack, into which a pinion, attached to a wheel on the axis of the carriage, works. This wheel moving in unison with the carriage, by means of the pinion and rack, causes the sliding bar to perform a traverse of six inches at each draw. The curved piece 9 is thus moved under the friction pulley at the foot of the folding leg, and forces it to move in its vertical slit, to the extent regulated by the screw apparatus which we have just described. To this building apparatus is attached the simple addition before alluded to, for throwing an additional pressure on the lever *v*. It consists of a small lever 23, jointed at 24, and having a nose-piece on its opposite end resting upon the nut pin 16. From the nose-piece end there projects a pin, 25, at right angles, which, when the carriage is at its outward limit, passes along the under surface of the lever *o*, and by means of the rod connecting this rod with the lever U, throws an additional tension upon the tension-band; and as the nut 16, by the action of the ratchet-wheel, is drawn back, it relieves the nose-piece of the lever, which falls down into the position shown in the drawing, and its pin ceases to act on the lever *o*, until one set of the copes being finished, the nut and pin 16 are again brought forward by the screw and winch, and raise the nose-piece, ready to commence a new set of copes. The apparatus which forces the poker home is the spinner lever 13, whose inner end is attached by a universal joint to one end of another lever, 26, the other end of which is attached to the bottom of the vibrating frame. When the regulating wheel ceases to move, the vibrating frame vibrates nearer to its centre, and by means of the lever 26, moves the outer end of the spinner lever toward the carriage, which is at that time nearly at the limit of its outward course; and the lever thus lays hold of a projecting piece on the end of the poker before alluded to, and so slides it home.

Leaving the minor parts to be incidentally noticed, we shall proceed to describe the general action of the machine during the completion of a stretch or draw. The carriage being at the roller beams, the machine is put in motion; and the pinion working in the outer teeth of the regulating wheel, brings out the carriage with a slow and uniform motion, while the rollers move in exact unison, and the speed shaft is in full motion to give twist to the thread, as the slubbing is given out by the rollers. When the carriage is nearly at its utmost limit, a finger piece 27, attached to the pulley bearer of the carriage S, comes in contact with the tail of a hanging lever 28, which is connected by a wire 29, to a cross-tail 30, on the bottom of the axis of the lever. This causes the lever 31 to move round its fulcrum, and throw the driving belt of the pinion shaft from the fast pulley M to the loose pulley M, whereby the movement of the regulating wheel, and all the movements taken from it, are stopped; but the speed-shaft T being driven directly from the main-shaft, continues to revolve. When the proper quantity of twist at the head has been given, the cam x will have arrived at the point of the lever 32, and pushing it round upon its fulcrum, will cause its opposite end 33, to draw the wire 34, attached to the guide lever 35. This shifts the belt from the fast pulley K, of the speed-shaft T, on to the loose pulley K′; and the cam immediately moves the lever 36, which, through the medium of the wire 37, draws off the break lever-catch 38, and allows the break to fall down upon the break pulley, and stop the movement of the speed-shaft and spindles. At the same instant, the cam x' having reached the adjusting point of the lever 31, moves this lever, and throws the belt again upon the fast pulley of the change-shaft. Thus the shaft is again in motion, and its pinion travelling down the radial series of teeth of the regulating wheel, causes the vibrating frame to vibrate towards the centre of the wheel. The cam on the bottom of the vibrating frame, in its progress, passes over the friction pulley of the break lever, and relieves the break; and at the same time the spinner lever, which is attached by its rod 26, to the bottom of the vibrating frame, turns round its fulcrum, and shoves forward the sliding bar or poker, thereby relieving in the first instance the under faller, which immediately rises and strips the coils, and the continued motion of the spinner lever and sliding bar forces up the folding leg into its vertical position, and consequently forces the building wire into its building position. When this movement is about to be completed, the pinion of the regulating wheel has arrived at that part when the motion of the wheel begins to be reversed, and the carriage begins gradually to move inwards. At this instant, the winding-on motion, which is taken from the regulating wheel, begins to act, and the movement of the carriage and winding-on continue to operate, until the carriage has reached its inward limit at the beam. The adjustable pin at the end of the poker then comes in contact with the bracket piece Y of the framework, and relieves the building faller; and a projecting finger 38, attached to the upper bearer of the guide-pulley of the carriage, comes in contact at 39, with the cross lever of the belt guide 35, and throws the belt again on the fast-pulley of the speed-shaft, and the machine is again in order to commence another stretch or draw.

Of Smith's self-acting woollen mule, several parts are the same as those of the machine already described. To these we merely refer, reserving for particular description such parts as are peculiar. Fig. 1 is a side elevation; fig. 2 bird's eye view; the other figures represent detached portions of the mechanism A A A is the general framework of the headstock, B B B the general framework of the carriage, C the main driving pulley, C' the corresponding loose pulley, D the driving shaft, which in this case lies along the framework, E E' bevel wheels, through which motion is communicated from the driving-shaft to the shaft E', called the fly-wheel shaft, on which the drum F, and the fly-wheel G, are fixed. The drum F by a belt communicates motion to the driving-shaft H, through its fast pulley H^2; H' is the corresponding loose pulley; I is a pinion upon the near end of the driving-shaft, which communicates motion through the wheels I^1 and I^2, to the stud wheel K, on the central shaft K', of the vibrating frame L. From the wheel K motion is communicated to the wheel M, of the vibrating shaft M'. Upon the opposite end of this shaft the mangle pinion N' is fixed. This pinion drives the mangle or regulating wheel N, as described in the former machine. The mangle wheel in this machine moves the carriage rack by the eccentric wheel O, fixed on the end of its shaft gearing into the other eccentric wheel O', whose shaft carries a spur-wheel P, which gears into the carriage rack P' P'. Round the periphery of the mangle wheel are external teeth, which, through the stud wheel Q, drive the pinion Q', fixed upon a small cross shaft R, called the roller shaft. Near the opposite extremity of this roller shaft there is fixed a disc R', working in the bosom of the toothed wheel S: this disc carries pauls, which work on a ratchet-wheel, fixed also in the bosom of the wheel S. The wheel S being loose upon the shaft, is allowed to remain at rest, when the disc moves in such a direction that the pauls slip over the teeth of the ratchet. The wheel S gears into the stud wheel T, which again gears into the wheel U, upon the end of the rollers U'. The stud-wheel T moves upon a stud carried by the radial lever T', whereby it is permitted to move out and in of gear with the wheel S. These movements are regulated by the disc lever V, which, resting with its outer end on a disc pulley on the end of the wiper pulley X, raises and depresses the point of the radial lever T', by the movement of the mangle wheel shaft. The place of the wiper on the face of the disc X, can be shifted to adjust the point of movement. The roller shaft R carries another wheel a, which, through the intermediate wheel a', drives the wheel b' fixed on the differential shaft b. This shaft carries the differential box c, which is the same as in the former machine, and through which motion is communicated to the twist shaft d, by its wheel e, for winding-on: its pulley is restrained by a band and lever, as in the former machine. f is the break pulley on the shaft d, with its ratchet-wheel f', acting as described in the former machine. The manner in which the break is pressed on the pulley in this case, is seen in the detached drawing, fig. 3. Returning to the driving shaft H, there is a pulley g running loose upon the shaft for raising the driving belt. Its nave carries a series of small pullies of different diameters, for communicating motion to the cross shaft h, which carries a corresponding inversed series of pullies h', by which a considerable difference of speed can at any time be attained. The outer end of the shaft h carries a small pinion i, which, through the intermediate stud-wheel j, drives the wheel j', running loose upon the driving shaft H, but which, by means of a disc k, with a set of catches and a ratchet-wheel, as in the case of the wheel S. can be made fast to the driving shaft. By this means, when the belt is thrown upon the loose pulley g, motion is communicated by the pulleys fixed on its nave to the pulleys h', and consequently to the shaft h, which, again, acting by its pinion i on the wheels $j\,j'$, communicates a very slow movement to the driving shaft, and through it to the vibrating frame pinion, which works in the mangle wheel, which is necessary for regulating the back movement of the carriage, while the twist is throwing into the yarn; and its speed can be easily and quickly modified to suit any grist of yarn, by shifting the band upon the grooved pullies g, k'. The amount of twist is regulated, as in the former machine, by the worm screw l, upon the main driving-shaft D, working into the crown wheel l'. The shaft of this wheel carries on its lower end the wheel m, which is called the change wheel, because its place may be substituted by wheels of various numbers of teeth, to suit the amount of twist due to the grist and hardness of the yarns to be spun. This wheel, through the intermediate wheel m', drives wheel n on the top of the cam shaft n, upon which are placed the cams or wipers for moving the levers. On the lower part of the cam shaft there is a bevel wheel o, working into a corresponding wheel on the cross shaft p, called the stripping shaft. This shaft carries a radial wiper p', which, as the shaft revolves, comes at a particular point in its course to press upon the lever q, which, being suspended and acted upon by the spiral spring q', is retracted to its former position, when the wiper p' has raised it. The point of this lever operates upon the horizontal plane r, which is made to extend to a length exceeding the greatest distance that the carriage requires to be removed backwards during the throwing of the twist, so that the stripping wiper q may always press upon some part of the plane.

On the inner end of the twist shaft d there is fixed the pulley s, to drive the cylinder pulley of the carriage s'. The band having been wrapped nearly round the pulley s, has its one end passed over one of the stud pullies t, at the right-hand side of the framing, and carried from it over the cylinder pulley s', while its other end is passed round the other pulley t', and thence over the tightening pulley t^2. The tightening pulley t^2 moves on a stud, which can be slid along the horizontal slit in the projecting part of the framework, so as to slacken or tighten the cylinder band. Having noticed the principal parts of the headstock, we proceed to the description of the carriage. The frame of the carriage is indicated by BBBB. 1, is the driving pulley, 2, the upper faller rod with its fingers and guide-wires. The apparatus for moving the building fallers is the same as that already described for the former machine. But the stripping-faller apparatus is somewhat different. Two radial sockets 3, project from the under faller-rod 4, near each end; and in these are fitted a running-nut, which can be adjusted to any required extent of leverage, by turning round the screw; and at the lower side of each nut there is a hook, to which the spiral springs 5, are attached, their lower ends being attached to the framework of the carriage. The springs are so adjusted, that they tend to pull round the under faller-rod, which raises the faller-wire with a due force of tension. A radial lever 6, extends from the one end of the under faller-rod, and has an adjustable stud 7, to which a rod 8, is fixed. This rod terminates at its lower end in a socket with a friction-pulley, which, coming upon the inclined plane at the side of the race-road, shoves the under faller to its resting position, when the carriage goes up to the rollers. The end of the stud 9, projects beyond the socket of the upright rod, and rests upon a moveable tappit or sector 10, which is thus turned upon its centre, by the movement of the radial lever 6, attached to the folding-leg, when the poker is moved to put down the upper faller. By this escapement, through the movement of the tappit, the spiral springs are permitted to pull up the under faller wire with considerable force, by which the coils of yarn, which surround the stems of the spindles during the prócess of giving the twist, are stripped off or uncoiled, to permit the building-faller to press down the threads to the proper point for commencing the build at each successive stretch.

We now proceed to shew the manner in which the different parts of the machine come successively into action during one stretch or draw. The carriage being supposed at the beam, the fly-wheel shaft is put in motion; and the belts from the fly-wheel and drum of that shaft being upon the respective fast pullies of the shafts which they drive, the various gear work connected with those shafts is put in motion, and, consequently, twist is thrown into the thread by the spindles, while the rollers slowly yield the slubbing or sliver, and the regulating wheel, with its eccentrics, moves back the carriage, with a motion equivalent at first to the out-give of the sliver by the rollers, but gradually increasing, so as to take up the extension of the sliver, which is caused by the throwing out of the twist. When a sufficient quantity of slubbing has been given out, the cam disc upon the outer end of the mangle wheel shaft allows the roller lever to drop towards its centre, which, disengaging the intermediate wheel that conveys motion to the rollers, instantly stops them; but the twist continues to be thrown uniformly in, and the outward motion of the carriage continues gradually extending the thread, and proportionally diminishing its grist, in the manner regulated by the eccentric wheels, that is, with a motion at first about equal to the delivery of the rollers, and gradually becoming slower and slower. When the carriage approaches its utmost limit outward, the cam piece 11 attached to it, comes in contact with the tail of the hanging lever 12, which, being connected by a wire with a stud in the opposite end of the driving-belt lever 13, shifts the belt from the fast pulley to the pulley 9, giving the slow motion to the vibrating shaft which we have already noticed, which, as its pinion has passed the returning point, moves the mangle wheel backwards, and, of course, the carriage towards the beam, with a very slow and steady motion, giving in to the tension of the threads as the twist is thrown in. As soon as the desired amount of twist has been given, the cam of the cam shaft will come in contact with the escapement lever 14, attached to the bracket 15, and allow the weight to pull the belt lever one notch, throwing the belt upon the loose pulley 9^2, whereby the movements derived from this shaft cease. Simultaneous with this, one of the wipers of the cam shaft pulls the twist belt lever, so as to disengage the twist shaft; and another wiper acts upon the apparatus, which presses the break against the break pulley, and stops the motion of the spindles. The motion of the cam shaft now causes the wiper of the stripping shaft to press upon the stripping lever, the point of which, pressing upon the cross head or horizontal plane, strips the coils of yarn from the spindles, and puts down the upper faller-wire into a proper position for guiding the threads upon the copes. As soon as this has been performed, one of the wipers of the cam shaft will have arrived at a position to draw off the last notch of the escapement lever, whereby the driving belt is thrown upon the fast pulley of the driving shaft, which with its connections are again put in motion. The pinion of the mangle wheel, now passing along the teeth of the inner range, produces an accelerated motion of the carriage toward the beam; and the winding-on motion is at the same time communicated through the differential box to the twist-shaft and spindles. When the carriage is nearly at its inward limit, a tappit lever, at the point of the vibrating frame, comes in contact with the cross-tail of the twist-belt lever, and throws that belt upon the fast pulley, to put the spindles again in motion for twisting; and at the same instant the mangle pinion has arrived at that point of its eccentric path, at which it takes in to the inverted teeth, and produces the outward motion of the carriage, and the whole train of motions consequent upon it. (B. S.)

SPINOZA, **Benedict**, was born at Amsterdam the 24th November 1632. His father was a Jew of Portugal, and by profession a merchant. After being taught Latin by a physician, the son applied himself for many years to the study of theology, and afterwards devoted himself entirely to philosophy. He began very early to be dissatisfied with the Jewish religion; and as his temper was open, he did not conceal his doubts from the synagogue. The Jews, it is said, offered to tolerate his infidelity, and even promised him a pension of a thousand dollars per annum, if he would remain in their society, and continue outwardly to practise their ceremonies. But if this offer was really made, he rejected it, perhaps from his aversion to hypocrisy, or rather because he could not endure the restraint which it would have imposed. He also refused being constituted heir to an independent fortune, to the prejudice of the natural claimants; and he learned the art of polishing glass for spectacles, that he might be enabled to maintain himself by the labour of his own hands.

His retreat from the synagogue was hastened by an alarming incident. As he was returning home one evening from the theatre, he was stabbed by a Jew: the wound was slight, but the attempt naturally led Spinoza to conclude that the Jews had formed the design of assassinating him. After leaving the synagogue he professedly became a Christian, and frequented the churches of the Lutherans and Calvinists. He now devoted himself more than ever to his favourite philosophical speculations; and finding himself frequently interrupted by the visits of his friends, he left Amsterdam, and settled at the Hague, where he often continued for three months together without ever stirring from his lodging. During his residence in that city, his hostess, who was a Lutheran, asked him one day if she could be saved while she continued in her religion? "Yes," replied Spinoza, "provided you join to your religion a peaceable and virtuous life." From this answer, it has been concluded, that he was a Christian in appearance only, while in reality he regarded all religions as indifferent. But this conclusion would be too severe, even if the woman had been a Mahommedan. His "Tractatus theologico-politicus" (Hamb. 1670, 4to.) is a better proof of his insincerity than a thousand such conclusions; for this book contains all those doctrines in embryo which were afterwards unfolded in his posthumous works, and which are generally considered as a system of atheism. His fame, which had now spread far and wide, obliged him sometimes to interrupt his philosophical reveries. Learned men visited him from all quarters. While the prince of Condé commanded the French army in Utrecht, he intreated Spinoza to visit him; and though he was absent when the philosopher arrived, he immediately returned and spent a considerable time with him in conversation. The elector Palatine offered to make Spinoza professor of philosophy at Heidelberg; but this offer he thought it expedient to decline. He died of consumption at the Hague on the 21st February 1677, at the age of forty-five. His life was a perpetual contradiction to his opinions. He was temperate, liberal, and remarkably disinterested; he was sociable, affable, and friendly. His conversation was agreeable and instructive, and never deviated from the strictest propriety.

Soon after his death appeared a thick volume entitled "B. d. S. Opera Posthuma." [Amstelodami] 1677, 4to. A collective edition of his works has been published in the course of the present century: "Benedicti de Spinoza Opera quae supersunt omnia. Iterum edenda curavit, praefationes, vitam auctoris, nec non notitias quae ad historiam scriptorum pertinent, addidit Henr. Eberh. Gottlob Paulus, Ph. ac Th. D. hujus Prof. Ord. Jenensis." Jenae, 1802-3, 2 tom. 8vo. Spinoza has generally been considered as the author of a tract entitled "Lucii Antistii Constantis de Jure Ecclesiasticorum liber singularis." Alethopoli, 1666, 8vo. It has also been ascribed to Meyer, his friend and physician; but Leibnitz believed the author to have been Van den Hoof, who wrote "L'Intérêt de la Hollande," and various other works.[1]

SPIRAL, in *Geometry*, a curved line of the circular kind, which in its progress recedes from its centre.

SPIRE, or SPEYER, a city of Bavaria, in the province of the Rhine, the capital of a canton of the same name. It contains no less than fifteen Catholic and two Lutheran churches, though not more than 740 houses with 3900 inhabitants, having greatly declined from its former extent and celebrity. Here the reformers of Germany, in 1529, entered a protest against the proceedings of the Diet, and thus obtained the name of Protestants. Lat. 49. 18. 51. Long. 8. 31. 13. E. The bishopric, which was very rich, was secularized in 1795, when the French seized the country, and occupied it till the general peace in 1814.

SPIRE, in *Architecture*, was used by the ancients for the base of a column, and sometimes for the astragal or tore; but among the moderns it denotes a steeple that continually diminishes as it ascends, whether conically or pyramidally.

SPIRIT, in *Metaphysics*, an incorporeal being or intelligence; in which sense God is said to be a spirit, as are angels and the human soul.

SPIRIT, in *Chemistry* and *Pharmacy*, a name applied to every volatile liquid which is not insipid like phlegm or water; and hence the distinction into acid, alkaline, and vinous spirits.

SPLICING, in the sea-language, is the untwisting the ends of two cables or ropes, and working the several strands into one another by a fidd, so that they become as strong as if they were but one rope.

SPLUGEN, a village of Switzerland, remarkable from its position as the highest inhabited part of the most ancient road across the Alps, leading into the Austrian part of Italy from the countries through which the river Rhine passes. It is in the canton of the Grisons, and in the bailiwick of Schams. It contains a good hotel, which is also the post-house, where relays of horses are always to be procured. It is 5928 feet above the level of the sea, and is surrounded with mountains of which the summits are perpetually covered with snow. The descent from this spot, on both sides, excites the admirati[illegible] of all travellers. To the south the road has been formed by the Austrian government. It is carried in traverses along the front of the rocky precipices, is of great breadth, with a very gradual descent; and in several parts there are long galleries, covered with bomb-proof arches, to prevent the road from being choaked by avalanches, or by the enormous masses of rocks that sometimes are liable to fall from the lofty summits. The road that [illegible]cends on the northern side has been formed by the canton of the Grisons, and is tolerably good, but is not equal to the Austrian portion. The descent to Andeer is made with neither risk nor difficulty, and at that village, where there is a good hotel and post-house, the most picturesque scenery commences. This road leads to Tussis, through what from antiquity has received the name of the *Via mala.* It follows the course of the Rhine, sometimes far above it, sometimes close to its gulf, and frequently passing over it by strongly built bridges. It has two arched passages, cut with vast labour out of the solid rock. Splugen is sixteen miles from Chiavinna, in the Austrian territory; and twenty from Tussis, in the canton of the Grisons.

SPOILS, whatever is taken from the enemy in time of war. Among the ancient Greeks, the spoils were divided among the whole army, only the general's share was the largest; but among the Romans, the spoils belonged to the republic.

SPOLANK, a village on the south coast of Java, near to which are hot mineral springs, which raise Fahrenheit's thermometer to 122°. It is 104 miles south from Samarang.

SPOLETO, one of the delegations into which the dominions of the church in Italy are divided. It extends over 1401 square miles, contains six cities, fourteen towns, and 204 villages, with 102,053 inhabitants. The capital is the city of the same name, at the foot of a hill, and on a brook which flows to the Maragia. It is the seat of a bishop, and likewise of the civil tribunals. Besides a cathedral and twenty-two parish churches, it contains twenty-two monasteries, with some hermitages and establishments of brotherhoods of devotion. The streets are narrow and crooked, the houses old and many of them dilapidated; but the city contains 7000 inhabitants. A magnificent aqueduct supplies it with water. There are many interesting remains of antiquity, and among others, a triumphal arch of Hannibal, ruins of a theatre, of a temple of Concord, of Jupiter, and of Mars, and of a palace of Theodoric. Lat. 42. 44. 50. Long. 13. 1. E.

SPONDEE, in ancient poetry, a foot consisting of two long syllables, as *omnes.*

SPONGIA, SPONGE; a genus of animals. It is fixed, flexible, and very torpid, growing in a variety of forms, composed either of reticulated fibres, or masses of small spines interwoven together, and clothed with a living gelatinous flesh, full of small mouths or holes on its surface, by which it sucks in and throws out the water. As early as the days of Aristotle, sponges were supposed to possess animal life; the persons employed in collecting them having observed them shrink when torn from the rocks, thus exhibiting symptoms of sensation. The same opinion prevailed in the time of Pliny; but no attention was paid to this subject till Marsigli examined them, and declared them vegetables. Dr. Peysonell, in a paper which he sent to the Royal Society in the year 1752, and in a second in 1757, affirmed they were not vegetables, but the production of animals; and he has accordingly described the animals, and the process which they performed in making the sponges Mr. Ellis, in the year 1762, was at great pains to discover these animals. For this purpose he dissected the spongia urens, and was surprised to find a great number of small worms of the genus of nereïs or sea scolopendra, which had pierced their way through the soft substance of the sponge in quest of a safe retreat. That this was really the case he was fully assured, by inspecting a number of specimens of the same kind of sponge, just fresh from the sea. He put them into a glass filled with sea-water; and then, instead of seeing any of the little animals which Dr. Peysonell described, he observed the papillæ or small holes with which the papillæ are surrounded contract and dilate themselves. He examined another variety of the same species of sponge, and plainly perceived the small tubes inspire and expire the water. He therefore concluded that the sponge is an animal, and that the ends or openings of the branched tubes are the mouths by which it receives its nourishment, and discharges its excrements.

SPONSORS are those persons who, in the office of baptism, answer or are sureties for the persons baptized.

SPONTANEOUS, a term applied to such motions of the body and operations of the mind as we perform of ourselves without any constraint.

SPOONING, in the sea-language, is said of a ship which, being under sail in a storm at sea, is unable to bear it, and consequently forced to go right before the wind.

SPORADES, among ancient astronomers, a name given to such stars as were not included in any constellation.

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[1] Leibnitz, Essais de Theodicée, p. 371.

SPORADIC DISEASES, among physicians, are such as seize particular persons at any time or season, and in any place; in which sense they are distinguished from epidemical and endemical diseases.

SPOTSWOOD, John, archbishop of St. Andrews, was descended from the lairds of Spotswood in the county of Berwick, and was born in the year 1565, being the son of John Spotswood, minister of Calder, and one of the superintendents. He was educated in the university of Glasgow, and succeeded his father in the parsonage of Calder when but eighteen years of age. In 1601 he attended Lodowick duke of Lennox as his chaplain, in an embassy to the court of France for confirming the ancient amity between the two nations, and returned in the ambassador's retinue through England. When he entered upon the archbishopric of Glasgow, he found there was not a L.100 sterling of yearly revenue left; yet such was his care for his successors, that he greatly improved it, and much to the satisfaction of his diocese. After having filled this see eleven years, he was raised to that of St. Andrews in 1615, and thus became primate and metropolitan of all Scotland. He presided in several assemblies for bringing the Church of Scotland to some degree of uniformity with that of England. He continued in high esteem with King James VI., nor was he less valued by King Charles I., who was crowned by him in 1633, in the abbey-church of Holyroodhouse. In 1635, upon the death of the earl of Kinnoull, chancellor of Scotland, the primate was advanced to that post; but he had scarcely held it four years, when the confusions beginning in Scotland, he was obliged to retire into England; and being broken with age, grief, and sickness, died at London on the 26th of December 1639, and was interred in Westminster Abbey. The only work which he is known to have published bears the title of "Refutatio Libelli de Regimine Ecclesiæ Scoticanæ." Lond. 1620, 8vo. This was an answer to a tract of Calderwood, who replied in the Vindiciæ subjoined to his Altare Damascenum. A more considerable work was published several years after his death: "The History of the Church and State of Scotland, beginning the year of our Lord 203, and continued to the end of the reign of James the VI. of ever blessed memory." Lond. 1655, fol. An Appendix was afterwards added by Thomas Middleton.

The character of Spotswood is thus delineated by Laing: "In prosperity his behaviour was without moderation, in adversity without dignity; but the character of a leading, aspiring prelate has either been unduly extolled, or unjustly degraded. As a scholar and an historian he excelled his contemporaries; and it was his peculiar felicity, that his erudition was neither infected with the pedantry, nor confined to the polemical disputes of the age. His abilities recommended him first to preferment; but his ambitious views were chiefly promoted by the supple, insinuative habits of craft and intrigue. His revenge was formidable to the nobility and officers of state, oppressive to the clergy, and, joined with an inordinate ambition, ultimately ruinous to his own order."[1]

SPRAT, Thomas, bishop of Rochester, was born in 1636 at Tallaton in Devonshire. He received his education at Oxford, and after the Restoration entered into holy orders. He became fellow of the Royal Society, chaplain to George duke of Buckingham, and chaplain in ordinary to King Charles II. In 1667 he published the History of the Royal Society, and a Life of Mr. Cowley; who, by his last will, left to his care his printed works and MSS., which were accordingly published by him. In 1668 he was installed prebendary of Westminster; in 1680, was appointed canon of Windsor; in 1683, dean of Westminster; and in 1684, consecrated to the bishopric of Rochester. He was clerk of the closet to King James II.; in 1685, was made dean of the chapel royal; and the year following, was appointed one of the commissioners for ecclesiastical affairs. In 1692 his lordship, with several other persons, was charged with treason by two men, who drew up an association, in which they whose names were subscribed declared their resolution to restore King James; to seize the princess of Orange, dead or alive; and to be ready with 30,000 men to meet King James when he should land. To this they put the names of Sancroft, Sprat, Marlborough, Salisbury, and others. The bishop was arrested, and kept at a messenger's, under a strict guard, for eleven days. His house was searched, and his papers seized, among which nothing was found of treasonable appearance, except one memorandum, in the following words: *Thorough-paced doctrine.* Being asked at his examination the meaning of the words, he said, that about twenty years before, curiosity had led him to hear Daniel Burgess preach; and that being struck with his account of a certain kind of doctrine, which he said "entered at one ear, and pacing through the head went out at the other," he had inserted the memorandum in his table-book, that he might not lose the substance of so strange a sermon. His innocence being proved, he was set at liberty, when he published an account of his examination and deliverance; which made such an impression upon him, that he commemorated it through life by an yearly day of thanksgiving. He lived to the seventy-seventh year of his age, and died May 20, 1713. His works, besides a few poems of little value, are, "The History of the Royal Society;" "The Life of Cowley;" "An Answer to Sorbiere;" "The History of the Rye-house Plot;" "The Relation of his own Examination;" and a volume of "Sermons." Dr. Johnson says, "I have heard it observed with great justness, that every book is of a different kind, and that each has its distinct and characteristical excellence."

SPRAY, the sprinkling of the sea, which is driven from the top of a wave in stormy weather. It differs from spoondrift, as being only blown occasionaly from the broken surface of a high wave; whereas the latter continues to fly horizontally along the sea, without intermission, during the excess of a tempest or hurricane.

SPRING, in *Natural History*, a fountain or source of water rising out of the ground. Many have been the conjectures of philosophers concerning the origin of fountains, and great pains have been taken both by the members of the Royal Society and those of the Academy of Sciences at Paris, in order to ascertain the true cause. It was Aristotle's opinion, and held by most of the ancient philosophers after him, that the air contained in the caverns of the earth, being condensed by cold near its surface, was thus changed into water; and that it made its way where it could find a passage. But we have no experience of any such transmutation of air into water.

Those who imagine that fountains owe their origin to waters brought from the sea by subterraneous ducts, give a tolerable account how they lose their saltness by percolation as they pass through the earth: but they find great difficulty in explaining by what power the water rises above the level of the sea to near the tops of mountains, where springs generally abound; it being contrary to the laws of hydrostatics, that a fluid should rise in a tube above the level of its source. They have however found two ways by which they endeavoured to extricate themselves from this difficulty. The one is that of Des Cartes, who imagines that after the water has become fresh by percolation, it is raised out of the caverns of the earth in vapour towards its surface; where meeting with rocks near the tops of mountains in the form of arches or vaults, its adheres to them, and, like water in an alembic, runs down their sides, till it meets with proper receptacles, from which it supplies the fountains. Now this is a mere hypothesis, without foundation or probability: for, in the first place, we know of no internal heat of the earth sufficient to cause such evaporation; or if that were allowed, yet it is quite incredible that there should be any caverns so smooth and void of protuberances as to answer the ends of an alembic, in collecting and condensing the vapours together in every place where fountains arise. Varenius, and others, suppose that the water may rise through the pores of the earth, as through capillary tubes, by attraction. But here they show that they are quite unacquainted with what relates to the motion of a fluid through such tubes: for when a capillary tube opens into a cavity at its upper end, or grows larger and larger, so as to cease to be capillary at that end, the water will not ascend through that tube into the cavity, or beyond where the tube is capillary; because that part of the periphery of the cavity, which is partly above the surface of the water, and partly below it, is not of the capillary kind. Nay, if the cavity is continually supplied with water, it will be attracted into the capillary tube, and run down it as through a funnel, if the lower end is immerged in the same fluid, as in this case it is supposed to be.

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[1] Laing's History of Scotland, vol. iii. p. 154.

It has been a generally received opinion, and much espoused by Mariotte, a diligent observer of nature, that the rise of springs is owing to the rains and melted snow. According to him, the rain-water which falls upon the hills and mountains, penetrating the surface, meets with clay or rocks contiguous to each other; along which it runs, without being able to penetrate them, till, having descended to the bottom of the mountain, or to a considerable distance from the top, it breaks out of the ground, and forms springs.

In order to examine this opinion, Mr. Perrault, De la Hire, and Sideleau, endeavoured to make an estimate of the quantity of rain and snow that falls in the space of a year, with the view of ascertaining whether it would be sufficient to afford a quantity of water equal to that which is annually discharged into the sea by the rivers. The result of their inquiries was, that the quantity of rain and snow which fell in a year into a cylindrical vessel would, if secured from evaporating, fill it to the height of about nineteen inches. This quantity, Sideleau shewed, was not sufficient to supply the rivers; for those of England, Ireland, and Spain, discharge a greater quantity of water annually, than the rain, according to that experiment, is able to supply. Another observation was made by them at the same time, viz., that the quantity of water raised in vapour, one year with another, amounted to about thirty-two inches, which is thirteen more than falls in rain; a plain indication that the water of fountains is not supplied by rain and melted snow.

Thus the true cause of the origin of fountains remained undiscovered, till Dr. Halley, in making his celestial observations upon the tops of the mountains at St. Helena, about eight hundred yards above the level of the sea, found, that the quantity of vapour which fell there, even when the sky was clear, was so great, that it very much impeded his observations, by covering his glasses with water every half-quarter of an hour; and he attempted to determine by experiment the quantity of vapour exhaled from the surface of the sea, as far as it rises from heat, in order to try whether that might be a sufficient supply for the water continually discharged by fountains. The process of his experiment was as follows. He took a vessel of water salted to the same degree with that of sea water, in which he placed a thermometer; and by means of a pan of coals brought the water to the same degree of heat which is observed to be that of the air in our hottest summer; he then fixed the vessel of water with the thermometer in it to one end of a pair of scales, and exactly counterpoised it with weights on the other. At the end of two hours, he found, by the alteration made in the weight of the vessel, that about a sixtieth part of an inch of the depth of the water was gone off in vapour; and therefore, in twelve hours, one tenth of an inch would have gone off. Now, this accurate observer allows the Mediterranean sea to be forty degrees long, and four broad, the broader parts compensating for the narrower, so that its whole surface is one hundred and sixty square degrees; which, according to the experiment, must yield at least 5,280,000,000 tons of water. In this account no regard is had to the wind and the agitation of the surface of the sea, both which undoubtedly promote the evaporation. It now remained to compare this quantity of water with that which is daily conveyed into the same sea by the rivers. The only mode of proceeding was to compare them with some known river, and accordingly he takes his computation from the river Thames; and, to avoid all objections, makes allowances, probably greater than what were absolutely necessary.

The Mediterranean receives the following considerable rivers, viz., the Ebro, the Rhone, the Tiber, the Po, the Danube, the Niester, the Borysthenes, the Tanais, and the Nile. Each of these he supposes to bring down ten times as much water as the Thames, and he thus makes an allowance for smaller rivers which fall into the same sea. The Thames, then, he finds by measuration, to discharge about 20,300,000 tons of water a-day. If, therefore, the above nine rivers yield ten times as much water as the Thames, it will follow, that all of them together yield but 1827 millions of tons in a day, which is little more than one-third of what is proved to be raised in vapour out of the Mediterranean in the same time. Here, therefore, we have a source abundantly sufficient for the supply of fountains.

Now, having found that the vapour exhaled from the sea is a sufficient supply for the fountains, he proceeds, in the next place, to consider the manner in which they are raised, and how they are condensed into water again, and conveyed to the source of springs. He considers, that if an atom of water expanded into a shell or bubble, so as to be ten times as large in diameter, as when it was water, that atom would become specifically lighter than air; and therefore would rise so long as the warmth which first separated it from the surface of the water should continue to distend it to the same degree; and consequently, that vapours may be raised from the surface of the sea in that manner, till they arrive at a certain height in the atmosphere, at which they find air of equal specific gravity with themselves. Here they will float, till, being condensed by cold, they become specifically heavier than the air, and fall down in dew; or, being driven by the winds against the sides of mountains (many of which far surpass the usual height to which the vapours would of themselves ascend,) are compelled by the stream of the air to mount up with it to the tops of them; where, being condensed into water, they presently precipitate, and gleeting down by the crannies of the stones, part of them enters into the caverns of the hills; which being once filled, all the overplus of water that comes thither, runs over by the lowest place, and breaking out by the sides of the hills, forms single springs. Many of these running down by the valleys between the ridges of the hills, and coming to unite, form little rivulets or brooks; many of these again meeting in one common valley, and gaining the plain ground, being grown less rapid, become a river; and many of these being united in one common channel, make such streams as the Rhine and the Danube; which latter, he observes, one would hardly think to be a collection of water condensed out of vapour, unless we consider how vast a tract of ground that river drains, and that it is the sum of all those springs which break out on the south side of the Carpathian mountains, and on the north side of the immense ridge of the Alps, which is one continued chain of mountains from Switzerland to the Black Sea.

Thus one part of the vapours which are blown on the land is returned by the rivers into the sea from whence it came. Another part falls into the sea before it reaches the land; and this is the reason why the rivers do not return so much water into the Mediterranean as is raised in vapour. A third part falls on the low lands, where it affords nourishment to plants; yet it does not rest there, but is again exhaled in vapour by the action of the sun, and is either carried by the winds to the sea to fall in rain or dew there, or else to the mountains to become the sources of springs.

It is not however to be supposed that all fountains can be referred to one and the same cause. Some proceed from rain and melted snow, which, subsiding through the surface of the earth, makes its way into certain cavities, and thence issues out in the form of springs; because the waters of several are found to increase and diminish in proportion to the rain which falls. Others, again, especially such as are salt, and spring near the sea-shore, owe their origin to sea-water percolated through the earth; and some to both these causes; though without doubt most of them, and especially such as spring near the tops of high mountains, receive their waters from vapours, as before explained.

This reasoning of Dr. Halley's is confirmed by more recent observations and discoveries. It is now found, that though water is a tolerable conductor of the electric fluid, dry earth is an electric *per se*, consequently the dry land must always be in an electrified state, compared with the ocean. It is also well known, that such bodies as are in an electrified state, whether *plus* or *minus*, will attract vapour, or other light substances that come near them. Hence the vapours that are raised from the ocean must necessarily have a tendency to approach the land in great quantity, even without the assistance of the wind, though this last must undoubtedly contribute greatly towards the same purpose, as Dr. Halley justly observes. In like manner, the higher grounds are always in a more electrified state than the lower ones; and hence the vapours having once left the ocean and approached the shore, are attracted by the high mountains; of which Mr. Pennant gives an instance in Snowdon. Hence we may see the reason why springs are so common in the neighbourhood of mountains, they being so advantageously formed in every respect for collecting and condensing the vapours into water.

The heat of springs is generally the same with the mean temperature of the atmosphere. The mean temperature of the south of England is 48°; in Scotland, near Edinburgh, it is 45°; in the north of Ireland it is 48°, and on the south coast about 51°. At Upsala, in Sweden, it is 43°, and in Paris 53°. According to accurate experiments made by eminent philosophers, the heat of the springs in these different countries corresponds with the medium temperature. We have not heard that similar experiments have been made in other countries, or we should have been careful to collect them. We do not however doubt but they have been made in most countries of Europe; yet we suspect little attention has been paid to this subject within the tropical regions.

Though this coincidence of the heat of springs with the mean temperature of the climate where they flow, seems to be a general fact, yet it admits of many exceptions. In various parts of the world there are springs which not only exceed the mean temperature, but even the strongest meridian heat ever known in the torrid regions. The following table will give a distinct notion of the degrees of heat which different springs have been found to possess, according to the experiments of philosophers. It is necessary to remark that experiments made upon the same springs, by different persons, vary a little from one another, which may be owing to many accidents easily accounted for. Where this is the case, we shall mention both the lowest and highest degree of heat which has been ascribed to the same spring, according to Fahrenheit's thermometer.

Places.	Springs.	Highest degree of heat.	Lowest degree of heat.
Bristol,..................	St. Vincent's or the hot well,	84	76
Buxton,..............	Gentleman's bath,....	82	...
Matlock,.......	...	69	...
Bath,..................	King's bath,..........	119	113
Aix-la-Chapelle,.....	...	146	136
Barege,..............	...	122	...
Pisa,..................	...	104	...
Caroline baths in Bohemia,........	Prudel or furious,....	165	...
Iceland,..............	Geyser,..............	212	...

In cold countries where congelation takes place, the heat of the earth is considerably above the freezing point, and continues so through the whole year. From experiments that have been made in mines and deep pits, it appears that this heat is uniform and stationary at a certain depth. But as the heat of these springs far exceeds the common heat of the internal parts of the earth, it must be occasioned by causes peculiar to certain places; but what these causes are, it is no easy matter to determine. We are indeed certain that hot springs receive their heat from some subterranean cause; but it is a matter of difficulty to investigate how this heat is produced and preserved. Theories have however been formed on this subject. The subterranean heat has been ascribed to the electrical fluid, and to a great body of fire in the centre of the earth; but we suspect that the nature of the electrical fluid and its effects are not sufficiently understood. As to the supposition that the heat of springs is owing to a central fire, it is too hypothetical to require any refutation. From what then does this heat originate, and whence is the fuel which has produced it for so many ages? To enable us to answer these questions with precision, more information is necessary than we have hitherto obtained respecting the structure of the internal parts of the earth. It is peculiarly requisite that we should be made acquainted with the fossils which are most common in those places where hot springs abound. We should then perhaps discover that hot springs always pass through bodies of a combustible nature. It is well known to chemists, that when water is mixed with vitriolic acid, a degree of heat is produced superior to that of boiling water. It is also an established fact, that when water meets with pyrites, that is, a mixture of sulphur and iron, a violent inflammation takes place. If therefore we could prove that these materials exist in the strata from which hot springs are derived, we should be enabled to give a satisfactory account of this curious phenomenon. As some apology for this supposition, we may add, that most of the hot springs mentioned above, have been found by analysis to be impregnated with sulphur, and some of them with iron. It must however be acknowledged, that the hot springs of Iceland, which are 212°, the heat of boiling water, according to an accurate analysis of their contents by the ingenious Dr. Black, were neither found to contain iron nor sulphur. It will be necessary that we should wait with patience, and continue to collect facts, till the sciences of chemistry and mineralogy shall be so far advanced as to enable us to form a permanent theory on this subject.

Springs are of different kinds. Some are perennial, or continue to flow during the whole year; others flow only during the rainy season; some ebb and flow. At Torbay there is one of this kind, which ebbs and flows five or six inches every hour. There is another near Coriso in Italy, which ebbed and flowed three times a-day in the time of Pliny, and continues to do so still. A spring near Henley sometimes flows for two years together, and then dries up for an equal period.

Spring, in *Mechanics*, denotes a thin piece of tempered steel, or other elastic substance, which, being wound up, serves to put machines in motion by its elasticity, or endeavours to unbend itself. Such is the spring of a watch, clock, or the like.

Spring, *Ver*, in cosmography, denotes one of the seasons of the year; commencing, in the northern parts of the world, on the day when the sun enters the first degree of Aries, which is about the 10th day of March, and ending when the sun leaves Gemini; or, more strictly and generally, the spring begins on the day when the distance of the sun's meridian altitude from the zenith, being on the increase, is at a medium between the greatest and least. The end of the spring coincides with the beginning of summer.

SPRIT, a small boom or pole which crosses the sail of a boat diagonally, from the mast to the upper hindmost corner of the sail, which it is used to extend and elevate; the lower end of the sprit rests in a sort of wreath or collar, called the *smotter*, which encircles the mast in that place.

SPURZHEIM, John Gaspar, the pupil and colleague of Dr. Gall in the elucidation of the structure and functions of the brain, was born near Treves, on the 31st of December 1776. His father, who cultivated a farm in that district, at first intended him for the church; but, after prosecuting his studies with this view, a change of purpose took place, and young Spurzheim went in 1799 to acquire a medical education at Vienna, where he soon became acquainted with Dr. Gall. The views of that physician concerning the brain proved so interesting to him, that, after bestowing attention upon them for several years, he at length, in 1804, became the associate of his master. In the following year, when Gall was forced by the Austrian government to leave Vienna (See Gall, F. J.), Spurzheim accompanied him in his travels through Germany, France, and Denmark. In 1807 they settled in Paris, and next year presented to the Institute a memoir of their anatomical discoveries. A committee, of which Cuvier was the leading member, was appointed to give an opinion of it: a translation of their unfavourable, and, as the phrenologists say, uncandid report, will be found in the Edinburgh Medical and Surgical Journal for January 1809. This report being unsatisfactory to Gall and Spurzheim, they published their memoir, and a defence of it, under the title of "Recherches sur le Système Nerveux en général, et sur celui du Cerveau en particulier," 4to, 1809. In 1810 was commenced the publication of the "Anatomie et Physiologie du Système Nerveux en général, et du Cerveau en particulier; par F. J. Gall et G. Spurzheim," 4to; a work which was not completed till 1819. The third and fourth volumes were published after Spurzheim's separation from Gall in 1813, and bear the name of the latter alone. It is illustrated by a magnificent folio atlas, containing 100 plates. The physiological portion of this work was afterwards reprinted in 6 vols. 8vo, by Dr. Gall, with his own name only, under the title "Sur les Fonctions du Cerveau."

Having left Dr. Gall, Spurzheim, after taking his degree of doctor of physic at Vienna, came over to Britain in 1814, for the purpose of diffusing the new doctrines about the brain. His first step was the publication of "The Physiognomical System of Drs. Gall and Spurzheim," 8vo, London, 1815; followed by "Outlines of the Physiognomical System," 12mo, 1815, and "Observations on the Deranged Manifestations of Mind, or Insanity," 8vo, 1817. The anatomical and physiological views expounded in the first of these works, having been violently assailed by the late Dr. John Gordon in the 25th volume of the Edinburgh Review, Spurzheim suddenly made his appearance in the northern metropolis, and in the lecture-room of his opponent demonstrated by dissection the accuracy of his anatomical assertions. To the hostile article referred to, he also replied at considerable length in his "Examination of the Objections made in Britain against the Doctrines of Gall and Spurzheim," 8vo, Edinb. 1817. After lecturing in London, Dublin, Edinburgh, and other towns in the United Kingdom, he returned in 1817 to Paris, where he continued to lecture and publish till 1825. The works which he produced during this period are, "Observations sur la Folie, ou sur les Dérangemens des Fonctions Morales et Intellectuelles de l'Homme," 8vo, 1818; "Observations sur la Phrénologie, ou la Connaissance de l'Homme Morale et Intellectuel, fondée sur les Fonctions du Système Nerveux," 8vo, 1818; and "Essai Philosophique sur la Nature Morale et Intellectuelle de l'Homme," 8vo, 1820. His English work, entitled, "View of the Elementary Principles of Education, founded on the Study of the Nature of Man," 12mo, appeared at Edinburgh in 1821, and was reprinted, with considerable additions, in 8vo, at London, in 1828. A French edition was published at Paris in 1822. A prohibition in 1824, by the French government, of the delivery of lectures without its special permission, obliged Spurzheim to confine himself to private conversations in his own house, and induced him in the following year to revisit Britain. While residing in London, where he gave several courses of lectures and dissections of the brain, he produced his "Phrenology, or the Doctrine of the Mind and of the Relations between its Manifestations and the Body," and "A View of the Philosophical Principles of Phrenology," both 8vo, 1825: these are extended editions of some of the chapters of the Physiognomical System. He returned to Paris, but again visiting England in 1826, lectured to overflowing audiences in the London Institution, and in the same year published "Phrenology in Connexion with the Study of Physiognomy," 8vo, with 34 plates; also "The Anatomy of the Brain, with a General View of the Nervous System," 8vo, with 11 plates. Towards the end of this year, he lectured at Cambridge; and after expounding his views in Bath and Bristol, delivered, in April 1827, a course of lectures to seven hundred auditors, in the London Institution. His "Outlines of Phrenology" were published in the same year, at the close of which he visited Hull, whence he once more proceeded to Edinburgh, delivering in that city two courses of popular lectures, besides a professional course on the anatomy, physiology, and pathology of the brain. From Edinburgh he proceeded to Glasgow, and afterwards to London, where he had now fixed his residence. In 1828 appeared his "Sketch of the Natural Laws of Man," 12mo; and on 14th May 1829, a paper of his on the brain was read before the Royal Society, into whose Transactions, however, it was refused admittance. It was published by Dr. Spurzheim as an appendix to his "Anatomy of the Brain," along with some pretty free "Remarks on Mr. Charles Bell's Animadversions on Phrenology." He this year lectured in many English towns, and in the following spring accepted of an invitation to Dublin, where he was created an honorary member of the Royal Irish Academy. After again lecturing there in 1831, he fixed his residence in Paris, and published in 1832 a small "Manuel de Phrénologie," which is the last of his works. For the twofold purpose of diffusing phrenology and studying the American character and institutions, he sailed for the United States on 20th June 1832. Unfortunately the climate proved detrimental to his constitution, which was injured still more by over-exertion, and incautious exposure while lecturing at Boston; the consequence was a fever, which terminated in his death on the 10th of November 1832. His remains were honoured at Boston with a public funeral, at which an oration was delivered by Dr. Follen, professor of German in Harvard University.

As a phrenologist, Dr. Spurzheim is generally regarded by his British disciples as having improved the philosophical aspect of phrenology, by classifying the facts better than Dr. Gall, and also by pursuing them farther into their philosophical, moral, and practical results. At the same time, it appears to be the opinion of many, that he sometimes proceeded to systematize prematurely, and that in his latter years he occasionally modified his views rather through caprice than from reason, or from the accumulation of new observations. It is justly objected to his writings, in comparison with those of Gall, that in announcing his discoveries, he details neither the circumstances in which they were made, nor the cases by which they are supported. There has been much controversy on the relative merits of these two physicians, in extending the boundaries of phrenology, and elucidating the anatomy of the brain. On this subject, the curious reader may consult the Phrenological Journal, ii. 185, vi. 307, and xi. 225; also the preface to Spurzheim's Anatomy of the Brain.[1] (C. F.)

SPY, a person hired to watch the actions, motions, &c. of another; particularly what passes in a camp. When a spy is discovered, he is generally treated without mercy.

SQUADRON, in military affairs, denotes a body of horse whose number of men is not fixed, but is usually from one hundred to two hundred.

Squadron of Ships, either implies a detachment of ships employed on any particular expedition, or the third part of a naval armament.

SQUADS, in a military sense, are certain divisions of a company into so many squads, generally into three or four. The use of forming companies into as many squads of inspection as it has serjeants and corporals, is proved by those regiments who have practised that method; as by it the irregularity of the soldiers is considerably restrained, their dress improved, and the discipline of the regiment in general most remarkably forwarded. Every officer should have a roll of his company by squads.

SQUALL, a sudden and violent blast of wind, usually occasioned by the interruption and reverberation of the wind from high mountains. These are very frequent in the Mediterranean, particularly that part of it which is known by the name of the Levant, as produced by the repulsion and new direction which the wind meets with in its passage between the various islands of the Archipelago.

SQUARE, among *Mechanics*, an instrument consisting of two rules or branches, fastened perpendicularly at one end of their extremities, so as to form a right angle. It is of great use in the description and mensuration of right angles, and laying down perpendiculars.

Square-Rigged, an epithet applied to a ship whose yards are very long. It is also used in contradistinction to all vessels whose sails are extended by stays or lateen-yards, or by booms and gaffs, the usual situation of which is nearly in the plain of the keel; and hence,

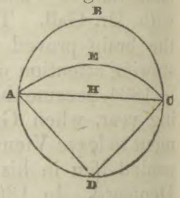
Square-Sail, is a sail extended to a yard which hangs parallel to the horizon, as distinguished from the other sails which are extended by booms and stays placed obliquely. This sail is only used in fair winds, or to scud under in a tempest. In the former case, it is furnished with a large additional part, called the *bonnet*, which is then attached to its bottom, and removed when it is necessary to scud.

SQUARING, or *Quadrature of the Circle*, signifies the finding a square exactly equal to the area of a given circle. This problem, however, has not been, and probably cannot be, strictly resolved by the commonly admitted principles of geometry; mathematicians having hitherto been unable to do more than to find a square that shall differ from the area of any proposed circle by as small a quantity as they please. The problem is of the same degree of difficulty, and indeed may be regarded as identical with another geometrical problem, namely, the *rectification of the circle*, or the finding a straight line equal to its circumference; for the area of a circle is equal to that of a rectangle contained by the radius and a straight line equal to half the circumference; therefore, if a straight line exactly equal to the circumference could be found, a rectilineal space precisely equal to the area might also be found, and the contrary. But although no perfectly accurate resolution of the problem has been obtained under either form, we can always find approximate values of the area and circumference; and it is now customary to apply the terms *quadrature* and *rectification* of the circle also to these.

The problem of the quadrature of the circle appears to have engaged the attention of geometers at a very early period; for we are told that Anaxagoras, who lived about five hundred years before Christ, attempted its solution while confined in prison on account of his philosophical opinions. We are ignorant of the result of his researches; but although we cannot suppose they were attended with any success, we may reasonably conclude that we are indebted to them for the discovery of some of the properties of the figure, which are now known as elementary propositions in geometry.

Hippocrates of Chios was likewise engaged in trying to resolve the same problem, and it was no doubt in the course of his inquiries into this subject, that he discovered the quadrature of the curvilineal space, which is now known by the name of the *Lune* of Hippocrates. The nature of this discovery may be briefly explained as follows. Let ABCD be a circle, H its centre, AC its diameter, ADC a triangle inscribed in the semicircle, having its sides, AD, DC equal to one another. On D as a centre, with DA or DC as a radius, let the quadrantal arch AEC be described, then shall the curvilineal space bounded by the semicircle ABC and the quadrantal arch AEC (which is the *Lune* of Hippocrates), be equal to the rectilineal triangle ADC.

Fig. 1.



Although Hippocrates's discovery has led to no important conclusion either relating to the quadrature of the circle or that of any other curve, yet at the time it was made, it might be regarded as of some consequence, chiefly because it shewed the possibility of exhibiting a rectilineal figure equal to a space bounded by curve lines, a thing which we have reason to suppose was then done for the first time, and might have been fairly doubted, considering the insuperable difficulty that was found to attend the quadrature of the circle or its rectification.

Aristotle speaks of two persons, namely, Bryson and Antiphon, who, about his time, or a little earlier, were occupied with the quadrature of the circle. The former appears, according to the testimony of Alexander Aphrodiseus, to have erred most egregiously; he having concluded that the circumference was exactly $3\frac{3}{4}$ times the diameter. And the latter seems to have proceeded in the same manner as Archimedes afterwards did in squaring the parabola, that is, by first inscribing a square in the circle, then an isoceles triangle in each of the segments of the curve, having for its base a side of the square; and next again a series of triangles in the segments, having for their bases the sides of the former series, and so on. This mode of procedure, however, was not attended with success, as these spaces do not, as in the case of the parabola, admit of being absolutely summed.

It may be supposed that Archimedes exerted his utmost efforts to resolve this problem; and probably it was only after long meditation on the subject that he lost all hopes of success, and contented himself with that approximation to the ratio of the diameter to the circumference which is contained in his treatise *De Circuli Dimensione.* He found his approximation to the ratio, by supposing a regular polygon of ninety-six sides, to be described about the circle, and another of the same number, to be inscribed in it, and by shewing that the perimeter of the circumscribing polygon was less than $3\frac{10}{70}$, or $3\frac{1}{7}$ times the diameter, but that the perimeter of the inscribed figure was greater than $3\frac{10}{71}$ times the diameter; now, the circumference of the circle being less than the perimeter of the one polygon, but greater than that of the other; it follows that the circumference must be less than $3\frac{1}{7}$ times the diameter, but greater than $3\frac{10}{71}$ times; so that, taking the first of these limits, as being expressed by the smallest numbers, the circumference will be to the diameter as $3\frac{1}{7}$ to 1, or as 22 to 7 nearly.

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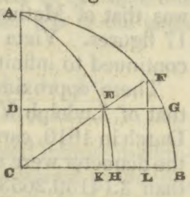
[1] Phrenological Journal, vol. viii; Memoir by Carmichael. Foreign Quarterly Review, vol. ii.

Although the ratio found by Archimedes be the oldest known in the western world, yet one more accurate was known at a much earlier period in India. This we learn from the Institutes of Akbar *(Ayeen Akberry)*, where it is said that the Hindoos suppose the diameter of a circle to be to its circumference as 1250 to 3927. Now, this ratio must have required the inscription of a polygon of 768 sides in the circle, and must have been attended with nine extractions of the square root, each carried as far as ten places of figures.

We learn from Simplicius that Nicomedes and Apollonius both attempted to square the circle, the former by means of a curve, which he called the *quadratrix;* the invention of which, however, is ascribed to Dinostratus, and the latter, by the help of a curve, denominated the sister to the tortuous line, or *spiral,* and which was probably the quadratrix of Dinostratus; the nature of which, and the manner of its application to the subject in question, we shall briefly explain.

Fig. 2.



Let AFB be a quadrant of a circle, (fig. 2), and C its centre; and conceive the radius CF to revolve uniformly about C, from the position CA, until at last it coincide with CB; while at the same time a line DG is carried with an uniform motion from A towards CB; the former line continuing always parallel to the latter, until at last they coincide; both motions being supposed to begin and end at the same instant; the point E, in which the revolving radius CF, and the moveable line DG intersect one another, will generate a certain curve line AEH, which is the *quadratrix* of Dinostratus.

Draw EK, FL both perpendicular to CB; then because the radius AC and the quadrantal arch AFB, arc uniformly generated in the same time by the points D and F, the contemporaneous spaces described will have to one another the same ratio as the whole spaces; that is, AD : AF : : AC : AB; hence we have AC : AB : : DC, or EK : FB. Now, as the moveable point F approaches to B, the ratio of the straight line EK to the arch FB will approach to, and will manifestly be ultimately the same as the ratio of the straight line EK to the straight line FL, which again is equal to the ratio of CE to CF; therefore the ratio of the radius AC to the quadrantal arch AFB is the limit of the ratio of CE to CF, and consequently equal to the ratio of CH to CB, H being the point in which the quadratrix meets CB. Since therefore CH : CB : : CA, or CB : quad. arch AFB, if by any means we could determine the point H, we might then find a straight line equal to the quadrantal arch, (by finding a third proportional to CH and CB), and consequently a straight line equal to the circumference. The point H, however, cannot be determined by a geometrical construction, and therefore all the ingenuity evinced by the person who first thought of this method of rectifying the circle, (which certainly is considerable), has been unavailing.

Squaring.

The Arabs, who succeeded the Greeks in the cultivation of the sciences, would no doubt have their pretended squavers of the circle. We however know nothing more than that one of them believed he had discovered that the diameter being unity, the circumfernnce was the square root of 10; a very gross mistake; for the square root of 10 exceeds 3·162; but Archimedes had demonstrated that the circumference was less than 3·143.

It appears that, during the dark ages, some attempts were made at the resolution of this famous problem, which, however, have always remained in manuscripts, buried in the dust of old libraries. But upon the revival of learning, the problem was again agitated by different writers, and particularly by the celebrated Cardinal De Cusa, who distinguished himself by his unfortunate attempt to resolve it. His mode of investigation, which had no solid foundation in geometry, led him to conclude, that if a line equal to the sum of the radius of a circle, and the side of its inscribed square were made the diameter of another circle, and an equilateral triangle were inscribed in this last, the perimeter of this triangle would be equal to the circumference of the other circle. This pretended quadrature was refuted by Regiomontanus.

It would be trespassing too much upon the patience of our readers, were we to mention all the absurd and erroneous attempts which have been made during the last three centuries to square the circle. In a supplement to Montucla's *Histoire des Mathematiques*, we find upwards of forty pretenders to the honour of this discovery enumerated. They were almost all very ignorant of geometry; and many of them were wild visionaries, pretending to discover inexplicable relations between the plain truths of mathematics and the most mysterious doctrines of religion. From such persons as have generally pursued this inquiry, no improvement whatever of the science was to be expected; although, in some instances, it has derived advantage from the labours of such as have undertaken to expose the absurdity of their conclusions; as in the case of Metius, who in refuting the quadrature of one Simon à Quercu, found a much nearer approximation to the ratio of the diameter to the circumference than had been previously known in Europe, namely, that of 113 to 355.

Among the most remarkable of those who have undertaken to resolve this problem, we cannot fail to enumerate Joseph Scaliger, a man of stupendous erudition. Full of confidence in his own powers, he believed that, entering upon the study of geometry, he could not fail to surmount by the force of his genius, those obstacles which had completely stopped the progress of all preceding inquirers. He gave the result of his meditations to the world in 1592, under the title *Nova Cyclometria;* but he was refuted by Clavius, by Vieta, and others, who shewed that the magnitude which he had assigned to the circumference was a little *less* than the perimeter of the inscribed polygon of 192 sides, which proved beyond a doubt that he was wrong. Scaliger, however, was not to be convinced of the absurdity of his conclusion; and indeed, in almost every instance, pretenders to this discovery have not been more remarkable for their egregious errors, than for their obstinacy in maintaining that they were in the right, and all who held a contrary opinion in the wrong.

The famous Hobbes came also upon the field about the year 1650, with pretensions not only to the quadrature of the circle, but also to the trifection of an angle, the rectification of the parabola, &c.; but his pretended solutions were refuted by Dr. Wallis. And this circumstance afforded him occasion to write not only against geometers, but even against the science of geometry itself.

We find it recorded by Montucla, as a sort of phenomenon, that one Richard White, an English Jesuit, having happened upon what he conceived to be a quadrature of the circle, which he published under the title, *Chrysæspis, seu Quadratura Circuli*, suffered himself at last to be convinced by some of his friends that he was wrong. But a solution of the same problem, found out by one Mathulen of Lyon, did not end in so much advantage to its author. This man in 1728 announced to the world that he had discovered both the quadrature of the circle, and a perpetual motion; and he was so certain of the truth of these discoveries, that he he consigned 1000 *ecus* (about L.125), to be paid to any one who should demonstrate that he was deceived in either. The task was not difficult. Nicole of the Academy of Sciences demonstrated that he was wrong, and he himself allowed it; but he hesitated to pay the money, which Nicole had relinquished in favour of the Hotel Dieu of Lyon. The affair went before a court of justice, which adjudged the money to be paid, as Nicole had destined it, to the poor. At a later period, namely, in 1753, the Chevalier de Causans, a French officer, and a man who was never supposed to be a mathematician, suddenly found a quadrature of the circle in procuring a circular piece of turf to be cut; and rising from one truth to another, he explained by his quadrature the doctrine of original sin, and the Trinity. He engaged himself, by a public writing, to deposit with a notary the sum of 300,000 francs, to be wagered against such as should oppose him, and he actually lodged 10,000, which were to devolve to him who should demonstrate his error. This was easily done, as it resulted from his discovery that a circle was equal to its circumscribing square, that is, a part to the whole. Some persons came forward to answer his challenge, and in particular a young lady sued him at one of the courts of law; but the French king judged that the chevalier's fortune ought not to suffer on account of his whim; for, setting aside this piece of folly, in every other respect he was a worthy man. The procedure was therefore stopped, and the wager declared void.

We shall not enter further into the history of these vain and absurd attempts to resolve this important problem, but proceed to state what has actually been done by men of sound minds and real mathematical acquirements towards its solution. And in the first place, it may be observed that the problem admits of being proposed under two different forms; for it may be required to find either the area of the whole circle, or, which is the same thing, the length of the whole circumference; or else to find the area of any proposed sector or segment, or, which is equivalent, the length of the arch of the sector or segment. The former is termed the *definite*, and the latter the *indefinite* quadrature of the circle. The latter evidently is more general than the former, and includes it as a particular case. Now, if we could find by any means a finite algebraic equation that should express the relation between any proposed arch of a circle, and some known straight line, or lines, the magnitude of one or more of which depended on that arch, then we would have an absolute rectification of the arch, and consequently a rectification or quadrature of the whole circle. We here speak of an analytical solution; the ancients, who were almost entirely ignorant of this branch of mathematical science, must have endeavoured to treat it entirely upon geometrical principles. It is now well known, however, that all geometrical problems may be subjected to analysis; and that it is only by such a mode of proceeding they have in many cases been resolved.

With respect to the definite quadrature of the circle, no unexceptionable demonstration of its impossibility has hitherto been published. It is true, that James Gregory, in his *Vera Circuli et Hyperbolæ Quadratura*, has given what he considered as such a demonstration; but it was objected to by Huygens, one of the best geometers of his time. It is certain that the ratio of the diameter to the circumference, also, that the ratio of the square of the diameter to the square of a straight line equal to the circumference, cannot be expressed by rational numbers, for this has been strictly demonstrated by Lambert in the Berlin Memoirs for 1761. A demonstration is also given in Legendre's *Geometrie*. As to the indefinite quadrature, if Newton's demonstration of the twenty-eighth lemma of the first book of his *Principia*, be correct, the thing ought to be absolutely impossible. For the object of that proposition is to prove, that in no oval figure whatever, that returns into itself, can the area cut off by straight lines at pleasure, be universally found by an equation of a finite dimension, and composed of a finite number of terms. If this be true, then it will be impossible to express any sector of a circle taken at pleasure in finite terms. It is however to be remarked, that the accuracy of the reasoning by which Newton has attempted to establish the truth of the general proposition, has been questioned by no less a geometer than D'Alembert; and indeed we know one oval curve, which returns into itself, and which according to Newton's proposition ought therefore not to admit of an indefinite quadrature; yet this is by no means the case, for it does really admit of such a quadrature. The curve we mean is the *lemniscata*, whose figure is nearly that of the numeral character 8. Upon the whole, then, we may infer that an unexceptionable demonstration of the impossibility of expressing either the whole circle, or any proposed sector of it, by a finite equation, is still among the *desiderata* of mathematics.

Of the different methods which have been found for approximating to the area or to the circumference, that of Archimedes is the only one found by the ancients in the western world that has descended to modern times, and it appears to have been the most accurate known, until about the year 1585, when Metius, in refuting a pretended quadrature, found the more accurate ratio of 113 to 355, as we have already noticed. About the same time Vieta and Adrianus Romanus published their ratios, the former carrying the approximation to ten decimals instead of six, (which was that of Metius's ratio), and the latter extending it to 17 figures. Vieta also gave a kind of series, which being continued to infinity, gave the value of the circle.

These approximations, however, were far exceeded by that of Ludolph Van Ceulen, who, in a work published in Dutch in 1610, carried it as far as 36 figures, showing that if the diameter were unity, the circumference would be greater than 3.14159,26535,89793,23846,26433,83279,50288, but less than the same number with the last figure increased by an unit. In finding this approximation, Van Ceulen followed the method of Archimedes, doubling continually the number of sides of the inscribed and circumscribed polygons, until at length he found two which differed only by an unit in the 36th place of decimals in the numbers expressing their perimeters. This was rather a work of patience than of genius; indeed the labour must have been prodigious. He seems to have valued highly this singular effort; for in imitation of Archimedes, whose tomb was adorned with a sphere and cylinder, he directed that the ratio he had found might be inscribed on his tomb.

Snellius abridged greatly the labour of calculation; and although he did not go beyond Van Ceulen, yet he verified his result. Des Cartes also found a geometrical construction, which being repeated continually, gave the circumference, and from which he might easily have deduced an expression in the form of a series. Gregory of St. Vincent distinguished himself also on this subject; he however committed a great error in supposing he had discovered the quadrature of both the circle and hyperbola. Gregory's mistake was the cause of a sharp controversy carried on between his disciples on the one side, and by Huygens, Mersenne, and Lestaud, on the other; and it was this that gave Huygens occasion to consider particularly the quadrature of the circle, and to investigate various new and curious theorems relating to it, which are contained in his *Theoremata de Quadratura Hyperboles, Ellipsis, et Circuli*, 1651; and in his work *De Circuli Magnitudine inventa*, 1654. In particular he showed, that if c denote the chord of an arch, and s its sine, then the arch itself will be greater than $c+\frac{1}{3}(c-s)$, but less than $c+\frac{4c+s}{2c+3s}\times\frac{1}{3}(c-s)$: he also showed that the arch is less than the sum of $\frac{2}{3}$ of its sine and $\frac{1}{3}$ of its tangent.

James Gregory, in his *Vera Circuli et Hyperbolæ Quadratura*, gave several curious theorems upon the relation of the circle to its inscribed and circumscribed polygons, and their ratios to one another; and by means of these he found with infinitely less trouble than by the ordinary methods, and even by those of Snellius, the measure of the circle as far as 20 places of figures. He gave also, after the example of Huygens, constructions for finding straight lines nearly equal to arches of a circle, and of which the degree of accuracy was greater. For example, he found that if A be put for the chord of an arch of a circle, and B for twice the chord of half the arch, and C be taken such that $A+B:B::B:C$, then the arch itself is nearly equal to $\frac{8C+8B-A}{15}$, but a little less, the error in the case of a complete semicircle being less than its $\frac{1}{3500}$ part; and when the arch does not exceed 120°, it is less than its $\frac{1}{40000}$ part; and finally, for a quadrant the error is not greater than its $\frac{1}{300000}$ part. And farther, that if D be such that $A:B::B:D$, then the arch is nearly equal to $\frac{12C+4B-D}{15}$, but a little greater, the error in the semicircle being less than its $\frac{1}{1000}$ part, and in a quadrant less than its $\frac{1}{600000}$ part.

Dr. Wallis gave, in his *Arithmetica Infinitorum*, a singular expression for the ratio of the circle to the square of its diameter. He found that the former was to the latter as 1 to the product

$$\frac{3\times3\times5\times5\times7\times7\times9\times9\times11\times11,\ \&c.}{2\times4\times4\times6\times6\times8\times8\times10\times10\times12}$$

the fractions $\frac{3}{2}$, $\frac{3}{4}$, $\frac{5}{4}$, $\frac{5}{6}$, &c., being supposed infinite in number. The products being supposed continued to infinity, we have the ratio exactly; but if we stop at any finite number of terms, as must necessarily be the case in its application, the result will be alternately too great and too small, according as we take an odd or an even number of terms of the numerator and denominator.

An expression of another kind for the ratio of the circle to the square of the diameter was found by Lord Brounker. He showed that the circle being unity, the square of the diameter is expressed by the continued fraction

$$1+\cfrac{1}{2+\cfrac{9}{2+\cfrac{25}{2+\cfrac{49}{2+,\ \&c.}}}}$$

which is supposed to go on to infinity, the numerators 1, 9, 25, 49, &c., being the squares of the odd numbers 1, 3, 5, 7, &c. By taking two, three, four, &c., terms of this fraction, we shall have a series of approximate values, which are alternately greater and less than its accurate value.

Such were the chief discoveries relating to the quadrature of the circle made before the time of Newton; many others, however, were quickly added by that truly great man, as well as by his contemporaries. In particular, James Gregory found, that t being put for the tangent, the arch is expressed by the very simple series

$$t-\frac{t^3}{3}+\frac{t^5}{5}-\frac{t^7}{7}+\frac{t^9}{9}-\ \&c.$$

By supposing that $t=1$, in which case the arch is one-eighth of the circumference, we have the corresponding arch expressed by the series

$$4(1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}+\ \&c.)$$

which was also given by Leibnitz as a quadrature of the circle in the *Acta Eruditorum* in the year 1682, but was discovered by him 1673. Gregory had however found the series under its general form several years before. This series is altogether inapplicable in its present form, on account of the slowness of its convergency; for Newton has observed, that to exhibit its value exact to twenty places of figures, there would be occasion for no less than five thousand millions of its terms, to compute which would take up above a thousand years.

The slowness of the convergency has arisen from our supposing $t=1$. If we had supposed t greater than 1, then the series would not have converged at all, but on the contrary diverged. But by giving to t a value less than 1, then the rate of convergency will be increased, and that so much the more, as t is smaller.

If we suppose the arch of which t is the tangent to be 30°, then t will be $\sqrt{\frac{1}{3}}=\frac{1}{3}\sqrt{3}$, and therefore half the circumference to radius unity, or the circumference to the diameter unity, will be

$$\sqrt{12}(1-\frac{1}{3.3}+\frac{1}{5.3^2}-\frac{1}{7.3^3}+\frac{1}{9.3^4}-\ \&c.).$$

Mr. Machin, enticed by the easiness of the process, was induced, about the beginning of the last century, to continue the approximation as far as 100 places of figures, thus finding the diameter to be to the circumference as 1 to 3.14159,26535,89793,23846,26433,83279,50288,41971,69399,37510,58209,74944,59230,78164,06286,20899,86280,34825,34211,70680. After him, De Lagny continued it as far as 128 figures. But he has also been outdone; for in Radcliffe's library at Oxford, there is a manuscript in which it is carried as far as 150 figures!

Although this last series, which was first proposed by Dr. Halley, gives the ratio of the diameter to the circumference with wonderful facility when compared with the operose method employed by Van Ceulen, yet others have been since found which accomplish it with still greater ease.

We have given such a method in our treatise on ALGEBRA, (see article 272.) In the same treatise, (article 273), we have given a very elementary method, which may be understood by the mere elements of geometry. For the analytical methods, see FLUXIONS.

SRAVANA BALGUTA, a village of Hindustan, in the northern province of Mysore, celebrated as the principal seat of the Jain worship, which at one time prevailed all over the south of India, but which has now greatly declined, from the influence of the Brahmins. There are two hills adjoining the town, on one of which, named Indra Betta, is situated the temple; the other is cut into a colossal statue, seventy feet in height. The village is almost wholly inhabited by Jainas. Long. 76. 43. E. Lat. 12. 45. N.

SRI MUTTRA, a considerable town of Hindustan, province of Agra. It is situated on a naked rock of red granite, of which material all the houses are constructed. The streets are very narrow, and the working of the red stone into slabs furnishes employment to the greater part of the inhabitants. Long. 77. 20. E. Lat. 26. 41. N.

SRI PERMATURA, a town of the south of India, in the province of the Carnatic, celebrated as the birth-place of Rama Anuja Acharya, the great Brahmin saint and reformer, and the founder of a sect. He preached successfully against the doctrines of the Jains and the Boodhists. Long. 80. 2. E. Lat. 12. 59. N.

STABAT MATER, a musical composition upon the Latin text of a sacred cantata, beginning with these words. Pergolesi, Jomelli, and Haydn, have each set these words to music in an admirable manner.

STADE, a town of the kingdom of Hanover, in the province of Bremen, of which province it is the capital. It stands on the river Schwinge, which falls into the Elbe about one mile below the town, whence large vessels must load and discharge by the aid of river craft. Stade, which was once fortified, contains the provincial courts of law and boards of administration. It contains 5350 inhabitants, who are occupied as brewers, distillers, manufacturers of coarse woollen and hosiery, and in equipping ships for the whale fishery. Opposite the town a Hanoverian ship of war is stationed, which collects a small toll on each vessel that passes upwards to Hamburg or Altona. Lat. 53. 36. 5. Long. 9. 18. 10. E.

STADIUM, an ancient Greek measure, containing 125 geometrical paces, or 625 Roman feet, corresponding to our furlong. The Greeks usually measured distances by stadia, which they called *σταδιασμός*. Stadium also signified the course on which their races were run.

STADTHOLDER, formerly the principal magistrate or governor of the Seven United Provinces. This office is now abolished, and that of king substituted.

STAFF, an instrument ordinarily used to rest on in walking. The staff is also frequently used as a kind of natural weapon, both of offence and defence, and for several other purposes.

Staff, a light pole erected in different parts of a ship, for hoisting the colours.

Staff, in *Music*, five lines, on which, with the intermediate spaces, the notes of a song or piece of music are marked.

STAFFA, one of the Hebrides or Western Islands of Scotland, remarkable for its basaltic pillars. It was visited by Sir Joseph Banks, who communicated the following account of it to Mr. Pennant: "The little island of Staffa lies on the west coast of Mull, about three leagues north-east from Iona, or Icolumbkill: its greatest length is about an English mile, and its breadth about half a one. On the east side of the island is a small bay where boats generally land, a little to the southward of which the first appearance of pillars is to be observed; they are small; and instead of being placed upright, lie down on their side, each forming a segment of a circle. From thence you pass a small cave, above which the pillars, now grown a little larger, are inclining in all directions: in one place in particular, a small mass of them very much resembles the ribs of a ship. From hence having passed the cave, which, if it is not low water, you must do in a boat, you come to the first ranges of pillars, which are still not above half as large as those a little beyond. Over against this place is a small island, called in Erse *Boo-sha-la*, separated from the main by a channel not many fathoms wide. The whole island is composed of pillars without any stratum above them; they are still small, but by much the neatest formed of any about the place.

"The first division of the island, for at high water it is divided into two, makes a kind of a cone, the pillars converging together towards the centre: on the other they are in general laid down flat: and in the front next to the main, you see how beautifully they are packed together, their ends coming out square with the bank which they form. All these have their transverse sections exact, and their surfaces smooth, which is by no means the case with the large ones, which are cracked in all directions. I must question, however, if any part of this whole island of Boo-sha-la is two feet in diameter.

"The main island opposite to Boo-sha-la, and farther towards the north-west, is supported by ranges of pillars pretty erect, and though not tall, (as they are not uncovered to the base), of large diameters; and at their feet is an irregular pavement, made by the upper sides of such as have been broken off, which extends as far under water as the eye can reach. Here the forms of the pillars are apparent; these are of three, four, five, six, and seven sides; but the numbers of five and six are by much the most prevalent. The largest I measured was of seven; it was four feet five inches in diameter.

"The surfaces of these large pillars, in general, are rough and uneven, full of cracks in all directions; the transverse figures in the upright ones never fail to run in their true directions. The surfaces upon which we walked were often flat, having neither concavity nor convexity; the larger number, however, was concave, though some were very evidently convex. In some places, the interstices within the perpendicular figures were filled up with a yellow spar: in one place, a vein passed in among the mass of pillars, carrying here and there small threads of spar. Though they were broken and cracked through in all directions, yet their perpendicular figures might easily be traced: from whence it is easy to infer, that whatever the accident might have been that caused the dislocation, it happened after the formation of the pillars.

"From hence proceeding along shore, you arrive at Fingal's Cave. Its dimensions I have given in the form of a table:

	Feet.	In.
Length of the cave from the rock without,	371	6
From the pitch of the arch, . .	250	0
Breadth of ditto at the mouth, .	53	7
At the farther end, . .	20	0
Height of the arch at the mouth, .	117	6
At the end, . . .	70	0
Height of an outside pillar, .	39	6
Of one at the north-west corner, .	54	0
Depth of water at the mouth, .	18	0
At the bottom, . . .	9	0

"The cave runs into the rock in the direction of north-east-by-east by the compass.

"Proceeding farther to the north-west, you meet with the highest ranges of pillars, the magnificent appearance of which is past all description. Here they are bare to their very bases, and the stratum below them is also visible: in a short time it rises many feet above the water, and gives an opportunity of examining its quality. Its surface is rough, and has often large lumps of stone sticking in it as if half immersed: itself, when broken, is composed of a thousand heterogeneous parts, which together have very much the appearance of a lava; and the more so, as many of the lumps appear to be of the very same stone of which the pillars are formed. This whole stratum lies in an inclined position, dipping gradually towards the south-east. As hereabouts is the situation of the highest pillars, I shall mention my measurements of them, and the different strata in this place, premising, that the measurements were made with a line held in the hand of a person who stood at the top of the cliff, and reaching to the bottom; to the lower end of which was tied a white mark, which was observed by one who stayed below for the purpose: when this mark was set off from the water, the person below noted it down, and made signal to him above, who made then a mark in his rope: whenever this mark passed a notable place, the same signal was made, and the name of the place noted down as before: the line being all hauled up, and the distances between the marks measured and noted down, gave, when compared with the book kept below, the distances, as for instance in the cave:

“No. 1, in the book below, was called from the water to the foot of the first pillar in the book above; No. 1 gave 36 feet 8 inches, the highest of that ascent, which was composed of broken pillars.

“No. 1. Pillar at the west corner of Fingal's cave.

	Feet.	In.
1. From the water to the foot of the pillar,	12	10
2. Height of the pillar,	37	3
3. Stratum above the pillar,	66	9

“No. 2. Fingal's cave.

1. From the water to the foot of the pillar,	36	8
2. Height of the pillar,	39	6
3. From the top of the pillar to the top of the arch,	31	4
4. Thickness of the stratum above,	34	4
By adding together the three first measurements, we got the height of the arch from the water,	117	6

“No. 3. Corner pillar to the westward of Fingal's cave.

Stratum below the pillar of lava-like matter,	11	0
Length of pillar,	54	0
Stratum above the pillar,	61	6

“No. 5. Another part to the westward.

Stratum below the pillar,	17	1
Height of the pillar,	50	0
Stratum above,	51	1

“No. 5. Another pillar farther to the westward.

Stratum below the pillar,	19	8
Height of the pillar,	55	1
Stratum above,	54	7

“The stratum above the pillars, which is here mentioned, is uniformly the same, consisting of numberless small pillars, bending and inclining in all directions, sometimes so irregular that the stones can only be said to have an inclination to assume a columnar form; in others more regular, but never breaking into or disturbing the stratum of large pillars, whose tops everywhere keep an uniform and regular line.

“Proceeding now along the shore round the north end of the island, you arrive at *Oua na scarve*, or the Corvorant's Cave. Here the stratum under the pillars is lifted up very high; the pillars above are considerably less than those at the north-west end of the island, but still very considerable. Beyond is a bay, which cuts deep into the island, rendering it in that place not more than a quarter of a mile over. On the sides of this bay, especially beyond a little valley, which almost cuts the island into two, are two stages of pillars, but small; however, having a stratum between them exactly the same as that above them, formed of innumerable little pillars, shaken out of their places, and leaning in all directions.

“Having passed this bay, the pillars totally cease; the rock is of a dark-brown stone, and no signs of regularity occur till you have passed round the south-east end of the island, (a space almost as large as that occupied by the pillars), which you meet again on the west side, beginning to form themselves irregularly, as if the stratum had an inclination to that form, and soon arrive at the bending pillars where I began.

“The stone of which the pillars are formed, is a coarse kind of basaltes, very much resembling the Giant's Causeway in Ireland, though none of them are near so neat as the specimens of the latter which I have seen at the British Museum, owing chiefly to the colour, which in ours is a dirty brown, in the Irish a fine black; indeed the whole production seems very much to resemble the Giant's Causeway.”

Views of Fingal's Cave are given in plates CCCLXIV and CCCLXV, under the head MINERALOGY.

STAFFORD, the county town of Staffordshire, is 135 miles from London. It consists of two parishes, and returns two members to Parliament. It stands on the river Sow, and was once fortified. It is now well built. The principal buildings are the assize hall, the county jail, and the infirmary. It has a good free-school, several alms-houses, and on Saturday a good market, well attended. The canal encourages some trade; but the chief occupation of the inhabitants is making shoes, and some cloth is also made. The population was in 1801, 3927; in 1811, 4898; in 1821, 5775; and in 1831, 6998.

STAFFORDSHIRE, an inland English county of an oblong form. Its greatest length from north-east to south-west is about sixty, and its greatest breadth about thirty-eight, miles. It contains 1148 statute square miles, or 734,720 acres. It is bounded on the north by Cheshire, west by Shropshire, south by Worcester and Warwickshire, and east by Derbyshire. The great divisions are five hundreds; but as each of these is subdivided into the north and south portions, there are effectively ten hundreds. These contain one hundred and eighty-one parishes, twenty-three market towns, and one city. The whole of the county, with the exception of two parishes, is within the diocese of Lichfield, and comprehended within the archdeaconry of Stafford.

The population of this county at the four decennial periods of enumeration, was found to be as follow: in 1801, 239,153; in 1811, 295,153; in 1821, 341,040; and in 1831, 410,400.

In 1831, the occupiers of land employing labourers were	3,781
The occupiers not employing labourers	3,649
Labourers employed in agriculture	16,812
Labourers employed in manufactures	26,755
Labourers employed in retail trade or handicraft	24,766
Capitalists, bankers, &c	3,569
Labourers not agricultural	22,690
Other labourers under twenty years of age	4,245
Males at and above twenty years	101,632
Male servants	1,959
Female servants	12,739

In the same year, the number of families, chiefly employed in agriculture, was found to be 18,156; of those chiefly employed in trade, manufactures, and handicraft, 43,646; and of those not comprised in either of the preceding classes, 21,789. The number of inhabited houses was 78,049, occupied by 83,593 families. The uninhabited houses were 4088, and those building 573. The annual value of the real property of the county, as assessed for the purposes of the property tax in the year 1813, was L.1,150,285.

The towns and townships within this county, and their population in 1831, were as follows, but some of them may be better described as large villages than towns.

Wolverhampton	48,184	Wednesbury	8437
Stoke-upon-Trent	37,220	Newcastle-under-Lyne	8196
Sedgley	20,577	Stone	6918
West Bromwick	15,066	Stafford	6998
Kingswinford	15,156	Darlaston	6647
Walsall	15,066	Lichfield (city)	6499
Tipton	14,951	Handsworth	4944
Burslem	11,250	Uttoxeter	4864
Wolstanton	10,853	Eccleshall	4471
Leek, the town,	4,374	Burton-on-Trent	4399
but the parish	10,780	Penkridge	2991

The middle and southern portions are generally level, but interspersed with gentle eminences. The northern division

Staffordshire.

is of an opposite character, the surface being for the most part bleak and hilly. The general elevation of this district above the southern part of the county is about two or three hundred feet; but some points rise to the height of from 1200 to 1500. Of those the most elevated are Bunster and the Weever Hills. In the valleys on the banks of the rivers are some tracks of country equal to the most beautiful parts of the island. Among these, the district betwixt Lichfield and Stone, and the picturesque banks of the Dove, especially at Ilam, are very remarkable.

The soil is various, but the strong clays are the most predominant; next in extent is the sandy soil, chiefly to the south of the Trent. There is no chalk, and only a small district is calcareous. The meadows, especially on the banks of the Trent, are most rich and luxuriant; and, though on some spots there is much inert peat, yet, when it is properly drained, it becomes valuable pasture and meadow land. The climate is generally raw and moist: the rain that falls on an average of several years is about thirty-six inches. The quantity of snow, in the winter on the moorlands, is very great, which may contribute to the general coldness of the district.

The Trent, the third river in England, is the principal stream of the county. It rises at Newpool on the confines of Cheshire, and enters Derbyshire below Burton, after having formed a junction with the Dove. Through the whole of its course in this county, it is a clear and rather rapid stream. The Dove is celebrated for the picturesque scenery through which it flows. In its course it receives the Manifold and the Hamps, two streams which are lost in subterraneous channels, but again emerge at the distance of some miles, and rejoin it. The smaller rivers are the Tame, the Blythe, the Sow, and the Penk, all of which empty themselves into the Trent. No part of Great Britain is so intersected with navigable canals as Staffordshire, and in no county have their beneficial effects been so extensively experienced. The Grand Trunk was planned and executed by Mr. Brindley, the most eminent engineer that ever exerted talent in this peculiar branch of inland navigation. This canal is about ninety-one miles in length. The fall of water to the north is 326 feet, and to the south 316 feet. It is twenty-nine feet wide at the top, and about four feet deep. It unites by navigation the internal trade of the great marts of London, Liverpool, Hull, and Bristol. The branches that extend from it in every direction are very numerous, and serve to connect the great shipping ports with all those districts, in the centre of the kingdom, which produce those heavy commodities of which the weight would make them almost worthless without the means of cheap conveyance to distant markets.

That great work, the railroad from Liverpool to Birmingham, has been completed. In proceeding northward it enters this county about a mile from Birmingham, and continues in it for the distance of forty-five miles, when it enters Cheshire. The whole distance of ninety-seven miles is commonly performed in four hours and a half, including stoppages. The towns which, though not on the immediate line of the road, are in communication with it, and at only a few miles distance, are, in this county, West Bromwick, Walsall, Wolverhampton, Stafford, Stone, Eccleshall, Uttoexeter, Newcastle-under-Lyne, Stoke-upon-Trent, and the Potteries. After passing through Cheshire and entering Lancashire, it separates into two branches at Newton, the right proceeding to Manchester, and the left to Liverpool, at the distance of ten miles from each of these towns.

The chief mineral productions of the county are iron and coal, and these are so copious that they appear to be almost inexhaustible. Upwards of 50,000 acres have been already ascertained to have beneath them beds of coal; and notwithstanding the length of time, and the extent to which they have been worked, it is calculated that not one-tenth of their contents has been yet consumed. The strata of this mineral, in the mines already worked, vary in thickness from twenty-four to thirty-six feet. Every portion of the coal district abounds in iron ore; and the strata of that mineral are generally found beneath a stratum of coal. Copper and lead are also raised, but not to an extent nearly approaching that of iron. Limestone, freestone, alabaster, marble, ochre, gypsum, and clays of various descriptions, applicable to the purposes of the potteries, are most abundantly extracted from the bowels of the earth. Though salt springs are both copious and richly impregnated with that mineral, no rock salt has yet been discovered; but it is supposed there are some abundant repositories of it beneath the surface.

The relative proportion of the employment of the several families, shows the great preponderance of manufacturing labour in this county. The whole of the southern part is occupied in the different working of metals. Wolverhampton is the chief seat of the manufacture of locks, keys, hinges, bolts, and the heavier kinds of iron ware. Walsall furnishes buckles, bitts, stirrups, spurs, and all the kinds of hardware used by saddlers. Wednesbury supplies guns, iron axle-trees, saws, trowels, hammers, edge tools, and cast-iron work of every kind. Almost all the villages in the vicinity of these towns contribute in a greater or less degree to supply part of the work for which the town nearest to them is the great mart.

The northern part of Staffordshire is celebrated for the excellence of its earthenware, with which it supplies the consumption of the greater portion of the civilized world. The great extension of this manufacture has been owing to the scientific skill and persevering energy of one distinguished individual, the late Mr. Wedgewood; whose combinations of the different earths, and study of the arts of design, have given a value to that which before was almost worthless, and increased to a most wonderful extent the wealth of his neighbourhood, and the number and comfort of its inhabitants. By means of the canals, the pipe-clay from Dorsetshire and Devonshire, and the flints from Kent, are brought to the spots where the clays and coal abound; and the finished goods, by the same means, are conveyed to the great shipping ports, from whence they are distributed to all parts of the globe. Salt is made from natural springs at Shirleyweck, and of late, at Lord Talbot's works at Ingestrie, to such an extent as to supply all those parts of the middle of the kingdom which are not in more close connection with the refineries of Northwich or Droitwich. There are some respectable establishments at Cheadle for making brass and copper goods. Shoes are manufactured on an extensive scale at Stafford and at Newcastle. At Tamworth are great works for printing calicoes. Burton has ale-breweries of great celebrity, with manufactures of hats, and of several kinds of cotton goods. At Leek there are large and flourishing establishments for ribbons, handkerchiefs, ferrets, galloons, and other kinds of silk goods.

In order to exhibit the proportion of employment in the several branches of industry, we extract the notices from the returns under the population of 11 Geo. IV, cap. 30. "Eastward of West Bromwich, 1000 males are employed in the further preparation of iron for the forges and workshops; 2200 are employed at Tipton, 1200 at Walsall, 740 at Willenhall, 157 at Wednesfield, 444 at Wednesbury, and 200 at Rowley Regis, in making guns and other fire-arms, gas-tubes, chains, spades, locks and keys, &c. &c. &c.; and in producing the more various and complex aids of human industry, which are comprehended under the name of machinery. At the villages of Smithwick and Handworth, near to Birmingham, 150 men are similarly occupied. Wolverhampton contains 2000 men, who, in addition to articles before mentioned, are employed in making domestic fire-irons, and turned and japanned iron-ware. Sedgley contains 500, and Kingswinford 200 manufacturers of the same kinds of goods. At Tettenhall sixty men, and at Brewood 190 men are employed, with 500 in villages, in the less refined manufacture of stock-locks; and in most of the places here enumerated, the more domestic manufacture of iron nails, furnishes employment to 2500 men, and to a part of their families.

"The other great manufacturing branch of the county, the pottery, is spread over the vicinity of Newcastle; in which the town of Burslem contains 900 men and their families; Shelton, a larger number; Longtown and Lane End, nearly 1000; Parkhall, 700; Handley, 360; Fenton Calvert, 300; and Sneyd, 150; all within the parish of Stoke-upon-Trent. In the town of Stafford 800 men are employed in making shoes, and in the district of the potteries is some cotton trade. The working of the coal mines alone, is a great source of occupation for men and machinery."

The cultivated lands of this county are nearly all enclosed by good hedges, chiefly of the white thorn, in fields of from twenty to thirty acres. The general rotation of crops in the clayey soil is, 1st, fallow; 2d, wheat; 3d, oats, after which they are laid down with clover, trefoil, and rye-grass, for two or more years. On breaking up an old sward, the usual course is, 1st, oats; 2d, fallow; 3d, wheat; 4th, oats; and then the grasses. On the more friable soils the rotation is, 1st, fallow; 2d, wheat; 3d, beans, or pease; 4th, oats, and then the grasses. On the light soil, the Norfolk system of turnips, barley, clover, and then wheat, is most commonly followed.

The black cattle are generally of the long-horned breed, and of late years have been much improved by the spirited exertions of some distinguished individuals. The sheep are of different races; the new Leicesters are said to be the most predominant. About Cannoch and Sutton Coldfield they have a breed much resembling the South Downs. On the moorland there is a breed with white faces, without horns, and long combing wool. The county is well stocked with timber, especially on the estates of some of the great proprietors. The lands in an unimproved state are still estimated to amount to nearly one-tenth part of the whole county.

The Roman antiquities are the Watling Street and the Ichnield roads, which pass through the county; and the remains of ancient stations or encampments. Here the Saxons have left few remains that merit particular attention.

This county gives titles to the following peers: that of marquis of Stafford, to the eldest son of the duke of Sutherland; those of earls to Ferrers, Talbot, Harrowby, and Lichfield. For parliamentary purposes, the county has been formed into two divisions, distinguished by their position as North and South; each of which elects two members to the House of Commons. The election for the northern division is held at Stafford; and the other polling places are Leek, Newcastle-under-Lyne, Cheadle and Abbots Bromley. The election for the southern division is held at Walsall; and the other polling places are Lichfield, Wolverhampton, Penkridge, and Kingswinford. By the Reform Bill, the towns of Wolverhampton and Stoke-upon-Trent have been entitled to elect two members each, and Walsall to elect one.

The most remarkable noblemen and gentlemen's seats are the following:—Trentham, duke of Sutherland; Beaudesert, marquis of Anglesea; Ingestrie, earl Talbot; Sandon, earl of Harrowby; Sandwell, earl of Dartmouth; Emville, earl of Stamford; Shugborough, earl of Lichfield; Wrothesley, Sir. J. Wrothesley; Wolsely Hall, Sir Charles Wolsely; Tixall, Sir T. H. Clifford; Etruria, Josiah Wedgewood, Esq.; Weston, earl of Bradford.

See Plott's History of Staffordshire; Pitt's Agricultural Survey of Staffordshire; Aikin's History of Manchester; Shaw's History and Antiquities of Staffordshire; Jackson's History of Lichfield; Beauties of England and Wales.

STAGE, in the modern drama, the place of action and representation, included between the pit and the scenes, and answering to the proscenium or pulpitum of the ancients. See PLAYHOUSE and THEATRE.

STAHL, GEORGE ERNEST, an eminent German chemist, was born at Anspach, on the 21st of October 1660, and chosen professor of medicine at Halle, when a university was founded in that city in 1694. The excellency of his lectures while he filled that chair, the importance of his various publications, and his extensive practice, soon raised his reputation to a very great height. He received an invitation to Berlin in 1716, which having accepted, he was made counsellor of state and physician to the king. He died in 1734, in the seventy-fifth year of his age. Stahl is without doubt one of the greatest men of which the annals of medicine can boast: his name marks the commencement of a new and more illustrious era in chemistry. He was the author of the doctrine of phlogiston, which, though now completely overturned by the discoveries of Lavoisier and others, was not without its use, as it served to combine the scattered fragments of former chemists into a system, and as it gave rise to more accurate experiments and a more scientific view of the subject, to which many of the subsequent discoveries were owing. This theory maintained its ground for more than half a century, and was received and supported by some of the most eminent men which Europe has produced; a sufficient proof of the ingenuity and the abilities of its author. He was the author also of a theory of medicine, founded upon the notions which he entertained of the absolute dominion of mind over body; in consequence of which he affirmed, that every muscular action is a voluntary act of the mind, whether attended with consciousness or not. This theory he and his followers carried a great deal too far; but the advices at least which he gives to attend to the state of the mind of the patient, are worthy of the attention of physicians.

"Stahl," says Dr. Cullen, "has explicitly founded his system on the supposition, that the power of nature, so much talked of, is entirely in the rational soul. He supposes that, upon many occasions, the soul acts independently of the state of the body; and that, without any physical necessity arising from that state, the soul, purely in consequence of its intelligence, perceiving the tendency of noxious powers threatening, or of disorders anyways arising in the system, immediately excites such motions in the body as are suited to obviate the hurtful or pernicious consequences which might otherwise take place. Many of my readers may think it was hardly necessary for me to take notice of a syssem founded upon so fanciful a hypothesis; but there is often so much seeming appearance of intelligence and design in the operations of the animal economy, that many eminent persons, as Perrault in France, Nichols and Mead in England, Porterfield and Simson in Scotland, and Gaubius in Holland, have very much countenanced the same opinion, and it is therefore certainly entitled to some regard."[1]

His principal works are, 1. *Experimenta et Observationes Chymicæ et Physicæ*, Berlin, 1731, 8vo. 2. *Dissertationes Medicæ*. Halle, 2 vols. 4to. 3. *Theoria Medica vera*. 1737, 4to. 4. *Opusculum Chymico-physico-medicum*. 1740, 4to. 5. A Treatise on Sulphur, both Inflammable and Fixed, written in German. 6. *Negotium Otiosum*. Halle, 1720, 4to. It is in this treatise chiefly that he establishes his system concerning the action of the soul upon the body. 7. *Fundamenta Chymiæ Dogmaticæ et Experimentalis*.

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[1] Cullen's First Lines of the Practice of Physic, vol. i. p. 12.

Nürnberg, 1747, 3 vols. 4to. 8. A Treatise on Salts, written in German.

STAINDROP, a town of Darlington ward in the county of Durham, 246 miles from London. It had once a market, which of late years has been disused. Near to it is the splendid mansion of the Duke of Cleveland, Raby Castle, built by John de Neville in 1378. The inhabitants of the town were, in 1801, 1156; in 1811, 1087; in 1821, 1273; and in 1831, 1478.

STAINES, a town in the hundred of Spelthorne and county of Middlesex, seventeen miles from London. It is on the left bank of the Thames, over which a stone bridge has recently been erected. Just above the bridge is the termination of the boundary of the London corporation on the river, marked by a stone, formerly by stones, from which the town takes its name. There is a good corn market on Friday, and several posting houses. The inhabitants were, in 1801, 1750; in 1811, 2042; in 1821, 1957; and in 1831, 2486.

STAIRCASE, in *Architecture*, an ascent inclosed between walls, or a balustrade consisting of stairs or steps, with landing places and rails, serving to make a communication between the several storeys of a house. See ARCHITECTURE.

STALACTITES, in *Mineralogy*, crystalline spars formed into oblong, conical, round, or irregular bodies, composed of various crusts, and usually found hanging in form of icicles from the roofs of grottoes, &c.

STALBRIDGE, a town of the hundred of Brownshall and the division of Sherborne, in the county of Dorset, 112 miles from London. It has some trade in making stockings, and much good stone is found near to it. The market is on Tuesday, but thinly attended. The inhabitants were, in 1801, 1254; in 1811, 1421; in 1821, 1571; and in 1831, 1773.

STALE, among sportsmen, a living fowl put in a place to allure and bring others where they may be taken. For want of these, a bird shot, his entrails taken out, and dried in an oven in his feathers, with a stick thrust through to keep it in a convenient posture, may serve as well as a live fowl.

STAMFORD, a town of Lincolnshire, in the hundreds of Ness and of Kesteven. It is eighty-five miles from London, on the river Willand, which divides Lincolnshire from Northamptonshire; and one of the parishes of the town, St. Martin's, is in the latter county, and called the out-parish. There are five parish churches, several of which have lofty spires. Two of them are so close together, as to resemble one building. St. Martin's church contains some curious ancient monuments. In that parish stands Burleigh Hall, the magnificent residence of the marquis of Exeter. This town was in former times a more extensive place than it is at present, and contained fourteen churches, besides many religious houses; but it suffered severely by the wars between the houses of York and Lancaster, and has never recovered from those ravages. It is by no means well built, though of late its appearance has been improved. Being in a rich district, it has good markets on Monday and Friday, and several fairs. The population was, in 1801, 4012; in 1811, 4582; in 1821, 5050; and in 1831, 5837.

STAMINA, in *Botany*, are those upright filaments which, on opening a flower, we find within the corolla surrounding the pistillum. According to Linnæus, they are the male organs of generation, whose office it is to prepare the pollen. Each stamen consists of two distinct parts, viz. the filamentum and the anthera.

STAMINA, in the animal body, are defined to be those simple original parts which existed first in the embryo or even in the seed; and by whose distinction, augmentation, and accretion by additional juices, the animal body at its utmost bulk is supposed to be formed.

STAMPHALIA, one of the islands of Greece, in the Archipelago, about twenty-seven square miles in extent. The surface consists of a single bare mountain, from which numerous springs issue, that render the lower parts capable of cultivation, and some spots are highly fertile. It contains about 800 inhabitants, who raise sufficient barley, wine, and fruit, for their consumption, and a large quantity of onions, which is the principal source of their trade. In a small island close to it are the remains of an ancient temple of Apollo. The number of partridges is so considerable, that to prevent their increase, from 10,000 to 12,000 of their eggs are taken every Easter. In the island there is a small town of the same name. Lat. 36.35. Long. 28.37. E.

STANCHIONS, a sort of small pillars of wood or iron, used for various purposes in a ship, as to support the decks, the quarter-rails, the nettings, the awnings, &c. The first of those are two ranges of small columns fixed under the beams, throughout the ship's length between decks; one range being on the starboard and the other on the larboard side of the hatchways. They are chiefly intended to support the weight of the artillery.

STANDON, a town in the hundred of Braughen and county of Hertford, twenty-seven miles from London. It is on the river Kib, on the ancient Roman road, called Ermine Street. The parish church has an ancient altar, raised nearly ten feet above the level of the floor. On Friday there is a market, tolerably well attended. The population was, in 1801, 1846; in 1811, 1889; in 1821, 2135; and in 1831, 2272.

STANDRA, a village of Asiatic Turkey, on the western coast of Anatolia. Long. 27. 18. E. Lat. 36. 54. W.

STANHOPE, PHILIP DORMER, the fourth EARL OF CHESTERFIELD, was born at London, on the 22d of September 1694. He was the son of Philip, the third earl, by his wife, Lady Elizabeth Savile, daughter of George, marquis of Halifax. At the age of eighteen he was sent to Trinity Hall, Cambridge, where he studied assiduously, and, according to his own account, became an absolute pedant. In 1714 he quitted the university, and travelled on the continent, where a familiarity with good company soon convinced him he was totally mistaken in almost all his notions; and an attentive study of the air, manner, and address of people of fashion, soon polished a man whose prominent desire was to please, and who, as it afterwards appeared, valued exterior accomplishments beyond any other human acquirement. While Lord Stanhope, he obtained an early seat in parliament; and in 1722, succeeded to his father's estate and titles. In 1728, and in 1745, he was appointed ambassador extraordinary and plenipotentiary to Holland. This high character he supported with the greatest dignity, serving his own country, and gaining the esteem of the States-General. Upon his return from Holland, he was sent as lord-lieutenant of Ireland; and during his administration there, gave general satisfaction to all parties. He left Dublin in 1746, and in October succeeded the earl of Harrington as secretary of state, in which post he officiated until February 6, 1748. In 1752, being seized with a deafness which incapacitated him for the pleasures of society, he from that time led a private and retired life, amusing himself with books and his pen; in particular, he engaged largely as a volunteer in a periodical miscellaneous paper called *The World*, in which his contributions have a distinguished degree of excellence. He died on the 24th of March 1773, leaving a character for wit and abilities that had few equals. He distinguished himself by his eloquence in parliament on many important occasions, of which we have a characteristic instance of his own relating. He was an active promoter of the bill for altering the style; and on this occasion, as he himself writes in one of his letters to his son, he made so eloquent a speech in the house, that every one was pleased, and said he had made the whole very clear to them, "when," says he, "God knows, I had not even attempted it. I could just as soon have talked Celtic or Sclavonian to them, as astronomy; and they would have understood me full as well." Lord Macclesfield, who was considered as a great mathematician, and who had a principal hand in framing the bill, spoke afterwards, with all the clearness that a thorough knowledge of the subject could dictate; but not having a flow of words equal to Lord Chesterfield, the latter gained the applause which was more justly due to the former. The high character which Lord Chesterfield supported during life, received no small injury soon after his death, from a fuller display of it by his own hand. He left no issue by his lady, Melosina de Schulenburg, countess of Walsingham; but he had a natural son, Philip Stanhope, Esq., whose education was for many years a close object of his attention, and who was afterward envoy extraordinary at the court of Dresden, but died before him. After Lord Chesterfield's death, Mr. Stanhope's widow published a series of letters, written by the father to the son, filled with instructions suitable to the different gradations of the young man's life to whom they were addressed. These letters contain many fine observations on mankind, and rules of conduct; but it is observable that he lays a greater stress on exterior accomplishments and address than on intellectual qualifications and sincerity; and allows a much greater latitude to fashionable pleasures than good morals will justify. These Letters to his Son, so discreditable to the memory of the writer, appeared in 1774, in 2 vols. 4to. This publication was followed by a collection of his Miscellaneous Works, 1777, 2 vols. 4to. A third volume was added in 1778; but his lordship's works do not appear to have attracted much attention.

Stanhope, Charles, Earl Stanhope, born in 1753, was the eldest son of Philip, the second earl, a man equally remarkable for his mathematical talents, and his liberal political opinions. The subject of this notice succeeded to the peerage in 1786, and died in 1816. By his first marriage he became the brother-in-law of Pitt; and on the mother's side he was closely allied to the Scotish earls of Haddington. This eccentric but public-spirited and most inventive man, while he divided his attention among a variety of inquiries, sufficient to have prevented excellence in any, had the rare merit of excelling in several most important pursuits, while in more than one he has bequeathed to the world discoveries that have proved most extensively useful. In politics he was a decided Whig, an assertor of religious toleration, and of non-intervention in the internal affairs of foreign states. Sometimes, however, he carried out the principles of his party with a boldness which other minds scrupled to follow; and in the latter years of his parliamentary life, Earl Stanhope used to be called "the minority of one." His political works were a refutation of Price's scheme of the sinking fund, an answer to one of Burke's invectives on the French Revolution, and an essay on juries. But his inventions in mechanical science are those by which he has secured the gratitude of posterity. They are too many to be here so much as completely enumerated. The principal of them, the Stanhope press, has been described in our article Printing, where notice has also been taken of his exertions for improving the process of stereotype. He was an early student of Franklin's theory of electricity, to which he contributed several valuable observations. Another of his most useful inventions was one for improving the locks of canals; and more curious ones were his two calculating machines, one of which performed addition and subtraction, the other multiplication and division.

Stanhope, *George*, an eminent divine, was born at Hertishorn in Derbyshire, in the year 1660. His father was rector of that parish, vicar of St. Margaret's at Leicester, and chaplain to the earls of Chesterfield and Clare. His grandfather, Dr. George Stanhope, was chaplain to James I. and Charles I.; had the chancellorship of York, where he was also a canon residentiary, held a prebend, and was rector of Weldrake in that county. For his loyalty he was driven from his home with eleven children, and died in 1664. The son was sent to school, first at Uppingham in Rutland, then at Leicester; he was afterwards removed to Eton, and thence chosen to King's College in Cambridge, in the place of W. Cleaver. He took the degree of A. B. in 1681, and of A. M. in 1685; was elected one of the syndics for the university of Cambridge, in the business of Alban Francis, 1687; minister of Quoi near Cambridge, and vice-proctor, 1688. He was that year preferred to the rectory of Tring in Hertfordshire, which after some time he quitted. In 1689 he was presented to the vicarage of Lewisham in Kent by Lord Dartmouth, to whom he had been chaplain, as well as tutor to his son. He was also appointed chaplain to King William and Queen Mary, and continued to enjoy that honour under Queen Anne. He commenced D. D. July 5, 1697, performing all the exercises required to that degree publicly and with great applause. He was made vicar of Deptford in 1703; succeeded Dr. Hooper as dean of Canterbury the same year; and was thrice chosen prolocutor of the lower house of convocation. His uncommon diligence and industry, assisted by his excellent parts, enriched him with a large stock of polite, solid, and useful learning. His discourses from the pulpit were equally pleasing and profitable; a beautiful intermixture of the clearest reasoning with the purest diction, attended with all the graces of a just elocution. In him were happily united the good Christian, the solid divine, and the fine gentleman. His conversation was polite and delicate, grave without preciseness, facetious without levity. His piety was real and rational, his charity great and universal, fruitful in acts of mercy and in all good works He died March 18, 1728, aged sixty-eight years; and was buried in the chancel of the church at Lewisham. The dean was twice married; first to Olivia Cotton, by whom he had one son and four daughters. His second lady, who was sister to Sir Charles Wager, survived him, dying October 1, 1738, aged about fifty-four. One of the dean's daughters was married to a son of Bishop Burnet. Dr. Moore, bishop of Ely, died the day before Queen Anne; who, it has been said, designed the dean for that see when it should become vacant. "The late Dean of Canterbury," says Dr. Felton, "is excellent in the whole. His thoughts and reasoning are bright and solid. His style is just, both for the purity of the language and for the strength and beauty of expression; but the periods are formed in so peculiar an order of the words, that it was an observation, nobody could pronounce them with the same grace and advantage as himself." His writings, which are considered as a treasure of piety and devotion, are, A Paraphrase and Comment upon the Epistles and Gospels. 1705, 4 vols. 8vo. Sermons at Boyle's Lectures. 1706, 4to. Fifteen Sermons. 1700, 8vo. Twelve Sermons on Several Occasions. 1727, 8vo. A Translation of Thomas à Kempis. 1696, 8vo. Epictetus's Morals, with Simplicius's Comment, and the Life of Epictetus. 1700, 8vo. Parson's Christian Directory. 1716, 8vo. Rochefoucault's Maxims. 1706, 8vo. A Funeral Sermon on Mr. Richard Sare, bookseller, 1724; two editions 4to. Twenty Sermons, published singly between the years 1692 and 1724. Private Prayers for every Day in the Week, and for the several Parts of each Day; translated from the Greek Devotions of Bishop Andrews, with Additions, 1730. In his translations, it is well known, Dr. Stanhope did not confine himself to a strict and literal version; he took the liberty of paraphrasing, explaining, and improving upon his author, as will evidently appear (not to mention any other work) by the slightest perusal of St. Augustin's Meditations, and the Devotions of Bishop Andrews.

STANISLAS Leckzinski, king of Poland, was born at

Stanislas.

Lemberg, the capital of Red Russia, on the 20th of October 1677. His father was a Polish nobleman, distinguished by his rank and the important offices which he held, but still more by his firmness and courage. In 1704 Stanislas was sent ambassador, by the Assembly of Warsaw, to Charles XII. of Sweden, who had conquered Poland. He was at that time twenty-seven years old, was general of Great Poland, and had been ambassador extraordinary to the Grand Signior in 1699. Charles was so delighted with the frankness and sincerity of his deportment, and with the firmness and sweetness which appeared in his countenance, that he offered him the crown of Poland, and ordered him to be crowned at Warsaw in 1705. He accompanied Charles into Saxony, where a treaty was concluded with King Augustus in 1705, by which that prince resigned the crown, and acknowledged Stanislas king of Poland. The new monarch remained in Saxony with Charles till 1707, when they returned into Poland and attacked the Russians, who were obliged to evacuate that kingdom in 1708. But Charles being defeated by Peter the Great in 1709, Augustus returned into Poland, and being assisted by a Russian army, obliged Stanislas to retire first into Sweden, and afterwards into Turkey. Soon after, he took up his residence at Weissenburg, a town in Alsace. Augustus dispatched Sum his envoy to France to complain of this; but the duke of Orleans, who was then regent, returned this answer: "Tell your king, that France has always been the asylum of unhappy princes." Stanislas lived in obscurity till 1725, when Louis XV. espoused the princess Mary his daughter. Upon the death of King Augustus in 1733, he returned to Poland, in hopes of remounting the throne of that kingdom. A large party declared for him; but his competitor, the young elector of Saxony, being supported by the emperor Charles VI. and the empress of Russia, was declared king, though the majority was against him. Dantzig, to which Stanislas had retired, was quickly taken, and with great difficulty the unfortunate prince made his escape in disguise, after hearing that the Russians had set a price upon his head. In 1736, when peace was concluded between the emperor and France, it was agreed that Stanislas should abdicate the throne, but that he should be acknowledged king of Poland and grand duke of Lithuania, and continue to bear these titles during life; that all his effects and those of the queen his spouse should be restored; that an amnesty should be declared in Poland for all that was past, and that every person should be restored to his possessions, rights, and privileges; that the elector of Saxony should be acknowledged king of Poland by all the powers who acceded to the treaty; that Stanislas should be put in peaceable possession of the duchies of Lorraine and Bar, but that immediately after his death those duchies should be united for ever to the crown of France. In Lorraine Stanislas succeeded a race of princes, who were beloved and regretted; and his subjects found their ancient sovereigns revived in him. He then tasted the pleasure which he had so long desired, the pleasure of making men happy. He assisted his new subjects; he embellished Nancy and Luneville; he formed useful establishments; he founded colleges, and built hospitals. He was engaged in these noble employments, when an accident occasioned his death. His nightgown caught fire, and burnt him so severely before it could be extinguished, that he was seized with a fever, and died the 23d of February 1766. He was a protector of the arts and sciences. He wrote several works of philosophy, politics, and morality, which were collected and published at Paris in 1763, in 4 vols. 8vo., under the title of "Œuvres du Philosophe bienfaisant." An octavo volume, ornamented with engravings, was published in 1825, under the title of "Œuvres choisies de Stanislas, Roi de Pologne, Duc de Lorraine et de Bar;" to which an historical notice was prefixed by Madame de Saint-Ouen.

STANISLAWOW, a circle of the Austrian principality of Gallicia, extending over 1495 square miles. It comprises five cities, thirteen market towns, and 264 villages, with 186,400 inhabitants. The capital is the city of the same name, between two branches of the river Wistrica. It is well built, and contains Catholic, Greek, and Armenian churches, with 370 houses, and 6880 inhabitants. The Jews and Armenians are the principal traders. Lat. 43. 56. Long. 24. 38. E.

STANLEY, Thomas, a very learned writer, was the son of Sir Thomas Stanley of Laytonstone in Essex, and Cumberlow in Hertfordshire, by his second wife Mary, the daughter of Sir William Hammond of St. Alban's-court. He was descended from a natural son of Edward earl of Derby. He was born in the year 1625, and received a domestic education under the tuition of William the son of Edward Fairfax, the well-known translator of Tasso. In 1639, he became a fellow-commoner of Pembroke Hall, Cambridge, where he distinguished himself by his progress in classical learning. After having travelled on the continent, he resided for some time in the Middle Temple. Here he lived on terms of particular intimacy with his cousin Edward, afterwards Sir Edward Sherburne, who cultivated similar studies, and who dedicated a volume of Poems to this learned kinsman. Stanley published Poems and Translations in 1649, 8vo. They were reprinted, with additions, in 1651. But his principal work was his "History of Philosophy, containing the Lives, Opinions, Actions, and Discourses of the Philosophers of every Sect." Of the original edition, printed in folio, the first part appeared in 1655, and the third in 1660. The work is dedicated to his uncle-in-law, Sir John Marsham, author of the *Canon Chronicus*, who first suggested the undertaking. There are four editions of the History, the last and best being that of 1743, 4to. The author has displayed solid as well as extensive erudition, but his valuable materials are not disposed to the best advantage. The reputation of his work extended to the continent; and a Latin translation of it by Olearius was published at Leipzig, in quarto, in the year 1711. The part relating to the history of oriental philosophy had been translated into the same language by Le Clerc, and published at Amsterdam in 1690, with a dedication to Bishop Burnet. This version he afterwards inserted in the second volume of his "Opera Philosophica." Stanley next prepared his elaborate and valuable edition of Æschylus. Lond. 1663, fol. Some copies of the same impression bear the date of 1664. This edition, which includes the fragments and the Greek scholia, and is accompanied with a commentary and a Latin version, was of great importance when it first appeared; but since the death of the learned editor, so much has been effected by Schütz, Wellauer, and other scholars, that it has lost a great portion of its original value. The best of all possible editions of Æschylus has for many years been expected from Hermann; but those who have sufficient means of ascertaining his present views and occupations, have at length begun to despair of its ever making its appearance. It was thought expedient to reprint Stanley's edition, with the commentary, corrected and enlarged from his papers preserved in the university library at Cambridge. The charge of this edition was committed to a very competent scholar, Samuel Butler, afterwards promoted to the bishopric of Lichfield; who, with the addition of his own annotations, published it at Cambridge in the year 1809, in 4 vols. 4to., and in 8 vols. 8vo. Some notes on Demosthenes, ascribed to Stanley, have recently been published in the ninth volume of Dobson's *Oratores Attici*. He died at his lodgings in Suffolk-street, in the parish of St. Martin's-in-the-Fields, on the 12th of April 1678. He had married Dorothy, the daughter and co-heiress of Sir James Enyon of Flower in Northamptonshire, Bart. He had a son, who bore his own name, and, like himself, was educated at Pembroke Hall. At a very early age, he published "Aelian's Various Histories, translated into English." Lond. 1665, 8vo.

STANNARIES, the mines and works where tin is dug and purified; as in Cornwall, Devonshire, &c.

STANNARY COURTS, in Devonshire and Cornwall, for the administration of justice among the tinners. They are held before the lord-warden and his substitutes, by virtue of a privilege granted to the workers in the tin-mines there, to sue and be sued only in their own courts, that they may not be drawn from their business, which is highly profitable to the public, by attending their law-suits in other courts.

STANOVOI, a chain of mountains in Asiatic Russia, forming a part of the great northern chain which crosses the breadth of that continent. It is of considerable height, and continues uninterrupted, though with some diminution of magnitude, to Cape Tchontchi, at the north-eastern extremity of Asia; and the Aleutian and Fox Islands may be considered as in some degree a continuation of it. This chain turns to the north near the source of the Aldane, whence it runs parallel to the eastern sea or gulf of Okhotsk, a narrow plain only intervening. Granite and porphyry are the chief materials of which these mountains consist, though there are some of green jasper.

STANSTEAD, a town in the hundred of Braughen, and county of Hertford, sixteen miles from London. It stands in a valley near the river Lea, two miles from Hoddesdon. In this parish is the Rye-house, remarkable for the supposed plot in the reign of Charles the Second, for the assassination of that monarch. The population was, in 1801, 861; in 1811, 832; in 1821, 950; and in 1831, 966.

STANSTEAD-MOUNTFITCHET, a small town in the county of Essex and hundred of Uttlesford, thirty-four miles from London. It derives its name from an ancient castle, built on an artificial mount about a quarter of a mile from the church, some relics of which are still visible. The hamlet of Bentfield is comprehended in the parish, and their united population was, in 1801, 1285; in 1811, 1334; in 1821, 1518; and in 1831, 1560.

STANZA, in *Poetry*, a number of lines regularly adjusted to each other; so much of a poem as contains every variation of measure or relation of rhyme used in that poem.

STAPLE primarily signifies a public place or market, whither merchants, &c. are obliged to bring their goods to be bought by the people. The merchants of England were formerly obliged to carry their wool, cloth, lead, and other like staple commodities of this realm, in order to expose them by wholesale; and these staples were appointed to be constantly kept at York, Lincoln, Newcastle upon-Tyne, Norwich, Westminster, Canterbury, Chichester, Winchester, Exeter, and Bristol; in each of which a public mart was appointed to be kept, and each of them had a court of the mayor of the staple, for deciding differences, held according to the law-merchant, in a summary way.

STAR, in *Astronomy*, a general name for all the heavenly bodies, which, like so many brilliant studs, are dispersed throughout the whole heavens. The stars are distinguished, from the phenomena of their motion, &c., into fixed, and erratic or wandering stars. These last are again distinguished into the greater luminaries, viz. the sun and moon; the planets, or wandering stars, properly so called, and the comets; which have been all fully considered and explained under the article ASTRONOMY. As to the fixed stars, they are so called, because they seem to be fixed, or perfectly at rest, and consequently appear always at the same distance from each other.

Falling STARS, in *Meteorology*, fiery meteors which dart through the sky in the form of a star.

STAR, in *Fortification*, denotes a small fort, having five or more points, or salient and re-entering angles, flanking one another, and their faces ninety or a hundred feet long.

STAR-CHAMBER, Court of, (Camera Stellata), a famous, or rather infamous, English tribunal, said to have been so called either from a Saxon word signifying to *steer* or govern; or from its punishing the *crimen stellionatus*, or cosenage; or because the room in which it sat, the old council-chamber of the palace of Westminster, was full of windows; or, (to which Sir Edward Coke, 4 Inst. 66. accedes), because *haply* the roof thereof was at the first garnished with gilded *stars*. This was a court of very ancient original; but new-modelled by statutes 3 Henry VII. c. 1, and 21 Henry VIII. c. 20, consisting of divers lords spiritual and temporal, being privy-councillors, together with two judges of the courts of common law, without the intervention of any jury. Their jurisdiction extended legally over riots, perjury, misbehaviour of sheriffs, and other notorious misdemeanours, contrary to the laws of the land. Yet this was afterwards, as Lord Clarendon informs us, stretched "to the asserting of all proclamations and orders of state; to the vindicating of illegal commissions and grants of monopolies; holding for honourable that which pleased, and for just that which profited; and becoming both a court of law to determine civil rights, and a court of revenue to enrich the treasury: the council-table by proclamations enjoining to the people that which was not enjoined by the laws, and prohibiting that which was not prohibited; and the star-chamber, which consisted of the same persons in different rooms, censuring the breach and disobedience to those proclamations by very great fines, imprisonments, and corporal severities: so that any disrespect to any acts of state, or to the persons of statesmen, was in no time more penal, and the foundations of right never more in danger to be destroyed." For these reasons, it was finally abolished by statute 16 Car. I. c. 10, to the general joy of the whole nation.

STAR-Board, the right side of the ship when the eye of the spectator is directed forward.

STAR-shot, a gelatinous substance frequently found in fields, and supposed by the vulgar to have been produced from the meteor called a *falling-star*; but, in reality, it is the half-digested food of herons, seamews, and the like birds; for these birds have been found, when newly shot, to disgorge a substance of the same kind.

STARAJA-RUSSA, a city of Russia in the province of Moscow and government of Novogorod, the capital of a circle of the same name. It is 206 miles from Petersburg, on the river Polesta. It is an ill-built place, containing 1048 houses, many of them of wood, and 6200 inhabitants. There is a copious brine spring, from which about 100,000 bushels of culinary salt are annually made, and this is the chief trade of the place. Lat. 57. 51. Long. 32. 54. 25. E.

STARCH, a fecula or sediment, found at the bottom of vessels in which wheat has been steeped in water. Of this fecula, after separating the bran from it, by passing it through sieves, they form a kind of loaves, which being dried in the sun or an oven, is afterwards cut into little pieces, and so sold. The best starch is white, soft, and friable, and easily broken into powder. Such as require fine starch, do not content themselves, like the starchmen, with refuse wheat, but use the finest grain. The process is as follows. The grain, being well cleaned, is left to ferment in vessels full of water, which they expose to the sun while in its greatest heat; changing the water twice a-day, for the space of eight or twelves days, according to the season. When the grain bursts easily under the finger, they judge it sufficiently fermented. The fermentation being perfected, and the grain thus softened, it is put, handful by handful, into a canvass-bag, to separate the flour from the husks; which is done by rubbing and beating it on a plank laid across the mouth of an empty vessel that is to receive the flour. As the vessels are filled with this liquid flour, there is seen swimming at top a reddish water, which is to be carefully skimmed off from time to time, and clean water is to be put in its place, which, after stirring the whole together, is also to be strained through a cloth or sieve, and what is left behind put into the vessel with new water, and exposed to the sun for some time. As the sediment thickens at the bottom, they drain off the water four or five times, by inclining the vessel, but without passing it through the sieve. What remains at bottom is the starch, which is cut in pieces to be taken out, and is left to dry in the sun. When dry, it is laid up for use.

STARGARD, a city of the Prussian province of Pomerania in the government of Stettin, the capital of the circle of Saalzig. It stands on the navigable river Ihna, in a fertile district, is surrounded with walls, and contains 1164 houses, with 9050 inhabitants, who are employed in making linen and woollen goods, hosiery, hats, leather, soap, and tobacco, and in brewing and distillation. It was formerly the capital of Pomerania. Lat. 52. 20. 42. Long. 15. 13. E.

STARITZA, a town of Russia, in the province of Moscow and government of Twer. It is the capital of a circle of the same name, containing seventy-seven parishes, with 83,800 inhabitants. It is 378 miles from Petersburg, and stands on the river Wolga, where the river Staritza joins that stream. It contains six churches, 650 houses, and 3860 inhabitants, whose chief trade is in hemp sent to Petersburg, and in making shoes and gloves. Lat. 56.48. Long. 35. 22. E.

STARK, WILLIAM, was born at Manchester in the month of July 1740; but the family from which he sprang was Scotish, and respectable for its antiquity. One of his uncles, John Stark, was minister of Lecropt in Perthshire; and it was under the care of this gentleman that he received the rudiments of his education, which, when we consider the character of the master, and reflect on the relation between him and his pupil, we may presume was calculated to store the mind of the latter with those virtuous prnciples which influenced his conduct through life. From Lecropt young Stark was sent to the university of Glasgow, where, under the tuition of Dr. Smith and Dr. Black, with other eminent masters, he learned the rudiments of science, and acquired that mathematical accuracy, that logical precision, and that contempt of hypotheses, with which he prosecuted all his future studies. Having chosen physic for his profession, he removed from the university of Glasgow to that of Edinburgh, where he was soon distinguished, and honoured with the friendship of the late Dr. Cullen; a man who was not more eminently conspicuous for the superiority of his own genius, than quick-sighted in perceiving, and liberal in encouraging, genius in his pupils. Having finished his studies at Edinburgh, though he took there no degree, Mr. Stark, in the year 1765, went to London, and devoted himself entirely to the study of physic and the elements of surgery; and looking upon anatomy as one of the principal pillars of both these arts, he endeavoured to complete with Dr. Hunter what he had begun with Dr. Monro; and under these two eminent teachers he appears to have acquired a high degree of anatomical knowledge. He likewise entered himself, about this time, a pupil at St. George's hospital; and with what industry he prosecuted this plan, with what success his labours were crowned, may be seen in a series of Clinical and Anatomical Observations, which were made by him during his attendance at the hospital, and were published after his death by his friend Dr. Carmichael Smyth.

In the year 1767 he went to Leyden, where he took the degree of M.D., publishing an inaugural dissertation on the dysentery. On his return to London, he recommenced his studies at the hospital; and when Dr. Black was called to the chemical chair in Edinburgh, which he long filled with so much honour to himself and credit to the university, Dr. Stark was solicited, by several members of the university of Glasgow, to stand as a candidate for their professorship of the theory and practice of physic, rendered vacant by Dr. Black's removal to Edinburgh. This, however, he declined, being influenced by the advice of his English friends, who wished to detain him in London, and having, likewise, some prospects of an appointment in the hospital. In 1769 he commenced a series of experiments on diet, which he was encouraged to undertake by Sir John Pringle and Dr. Franklin, whose friendship he enjoyed, and from whom he received many hints respecting both the plan and its execution. These experiments, or rather the imprudent zeal with which he prosecuted them, proved, in the opinion of his friends, fatal to himself; for he began them on the 12th of July 1769 in perfect health and vigour, and from that day, though his health varied, it was seldom if ever good, till the 23d of February 1770, when he died after suffering much uneasiness.

STARKENBURG, a province of the Grand Duchy of Hesse Darmstadt, in Germany. It is situated on the right bank of the Rhine, in contact with Nassau on the north, with Hesse Casel on the north-east, with Bavaria on the east, with Baden on the south, and on the west with the Darmstadt dominions to the west of the Rhine. It is 1102 square miles in extent, and contains thirty-six cities and towns, and 811 villages, with about 235,000 inhabitants, nearly one-half of whom are Lutherans, two-fifths Catholics, and the remainder Calvinists, Menonites, and Jews. The eastern part contains the mountainous forest country called the Odenwald; but the western part is a level and fertile country, well cultivated, and yielding good crops of corn, fruit, potatoes, flax, hemp, and tobacco. It also produces good wine and abundance of cider. The chief occupation, except agriculture, is spinning flax and hemp, and in converting the trees of the forests into woodware. The province is divided into thirty bailiwicks, and the capital is that of the principality, the city of Darmstadt.

STARLINGS, or STERLINGS, the name given to the strong pieces of timber which were driven into the bed of the river to protect the piles, on the top of which were laid the flat beams upon which were built the bases of the stone piers that support the arches of London bridge. In general, starlings are large piles placed on the outside of the foundation of the piers of bridges, to break the force of the water, and to protect the stone work from injury by floating ice. They are otherwise called *jettes*, and their place is often supplied by large stones thrown at random round the piers of bridges, as may be seen at Stirling bridge when the river is low; and as was done by Mr. Smeaton's direction round the piers of the centre arch of London bridge, when it was thought in danger of being undermined by the current.

STATES, or ESTATES, a term applied to several orders or classes of people assembled to consult of matters for the public good.

STATICS, a term which the modern improvements in knowledge have made it necessary to introduce into physico-mathematical science. It was found convenient to distribute the doctrines of universal mechanics into two classes, which required both a different mode of consideration and different principles of reasoning.

Till the time of Archimedes little science of this kind was possessed by the ancients, from whom we have received the first rudiments. His investigation of the centre of gravity, and his theory of the lever, are the foundations of our knowledge of common mechanics; and his theory of the equilibrium of floating bodies contains the greatest part of our hydrostatical knowledge. But it was as yet limited to the simplest cases; and there were some in which Archimedes was ignorant, or was mistaken. The marquis Guido Ubaldi, in 1578, published his theory of mechanics, in which the doctrines of Archimedes were well explained and considerably augmented. Stevinus, the celebrated Dutch engineer, published about twenty years after an excellent system of mechanics, containing the chief principles which now form the science of equilibrium among solid bodies. In particular, he gave the theory of inclined planes, which was unknown to the ancients, though it is of the very first importance in almost every machine. He even states in the most express terms the principle afterwards made the foundation of the whole of mechanics, and published as a valuable discovery by Varignon, viz. that three forces, whose directions and intensities are as the sides of a triangle, balance each other. His theory of the pressure of fluids, or hydrostatics, is no less estimable, including every thing that is now received as a leading principle in the science. When we consider the ignorance, even of the most learned of that age, in mechanical or physico-mathematical knowledge, we must consider these performances as the works of a great genius; and we regret that they are so little known, being lost in a crowd of good writings on those subjects which appeared soon after.

Hitherto the attention had been turned entirely to equilibrium, and the circumstances necessary for producing it. Mechanicians indeed saw, that the energy of a machine might be somehow measured by the force which could be opposed or overcome by its intervention: but they did not remark, that the force which prevented its motion, but did no more than prevent it, was an *exact* measure of its energy, because it was in immediate equilibrio with the pressure exerted by that part of the machine with which it was connected. If this opposed force was less, or the force acting at the other extremity of the machine was greater, the mechanicians knew that the machine would move, and that work would be performed; but what would be the rate of its motion or its performance, they hardly pretended to conjecture. They had not studied the action of moving forces, nor conceived what was done when motion was communicated.

The great Galileo opened a new field of speculation in his work on local motion. He there considers a change of motion as the indication and exact and adequate measure of a moving force; and he considers every kind of pressure as competent to the production of such changes. He contented himself with the application of this principle to the motion of bodies by the action of gravity, and gave the theory of projectiles, which remains to this day without change, and only improved by considering the changes which are produced in it by the resistance of the air.

Sir Isaac Newton took up this subject nearly as Galileo had left it. For, if we except the theory of the centrifugal forces arising from rotation, and the theory of pendulums, published by Huygens, hardly any thing had been added to the science of motion. Newton considered the subject in its utmost extent; and in his mathematical principles of natural philosophy he considers every conceivable variation of moving force, and determines the motion resulting from its action. His first application of these doctrines was to explain the celestial motions; and the magnificence of this subject caused it to occupy for a while the whole attention of the mathematicians. But the same work contained propositions equally conducive to the improvement of common mechanics, and to the complete understanding of the mechanical actions of bodies. Philosophers began to make these applications also. They saw that every kind of work which is to be performed by a machine may be considered abstractedly as a retarding force; that the impulse of water or wind, which are employed as moving powers, act by means of pressures which they exert on the impelled point of the machine; and that the machine itself may be considered as an assemblage of bodies moveable in certain limited circumstances, with determined directions and proportions of velocity. From all these considerations resulted a general abstract condition of a body acted on by known powers. And they found, that after all conditions of equilibrium were satisfied, there remains a surplus of moving force. They could now state the motion which will ensue, the new resistance which this will excite, the additional power which this will absorb; and they at last determined a new kind of equilibrium, not thought of by the ancient mechanicians, between the resistance to the machine performing work and the moving power, which exactly balance each other, and is indicated, not by the *rest*, but by the *uniform motion* of the machine. In like manner, the mathematician was enabled to calculate that precise motion of water which would completely absorb, or, in the new language, balance the superiority of pressure by which water is forced through a sluice, a pipe, or canal, with a constant velocity.

Thus the general doctrines of motion came to be considered in two points of view, according as they balanced each other in a state of rest or of uniform motion. These two ways of considering the same subject required both different principles and a different manner of reasoning. The first has been named *statics*, as expressing that rest which is the test of this kind of equilibrium. The second has been called DYNAMICS or UNIVERSAL MECHANICS, because the different kinds of motion are characteristic of the powers or forces which produce them. A knowledge of both is indispensably necessary for acquiring any useful practical knowledge of machines; and it was ignorance of the doctrines of accelerated and retarded motions which made the progress of practical mechanical knowledge so very slow and imperfect. The mechanics, even of the moderns, before Galileo, went no further than to state the proportion of the power and resistance which would be balanced by the intervention of a given machine, or the proportion of the parts of a machine by which two known forces may balance each other. This view of the matter introduced a principle, which even Galileo considered as a mechanical axiom, viz., that *what is gained in force by means of a machine is exactly compensated by the additional time which it obliges us to employ.* This is false in every instance, and not only prevents improvement in the construction of machines, but leads us into erroneous maxims of construction. The true principles of dynamics teach us, that there is a certain proportion of the machine, dependent on the kind and proportion of the power and resistance, which enables the machine to perform the greatest possible work.

It is highly proper therefore to keep separate these two ways of considering machines, that both may be improved to the utmost, and then to blend them together in every practical discussion.

Statics therefore are preparatory to the proper study of mechanics; but they do not hence derive all their importance. They are the sole foundation of many useful parts of knowledge. This will be best seen by a brief enumeration.

1. They comprehend all the doctrines of the excitement and propagation of pressure through the parts of solid bodies, by which the energies of machines are produced. A pressure is exerted on the impelled point of a machine, such as the float-boards or buckets of a mill-wheel. This excites a pressure at the pivots of its axle, which act on the points of support. This must be understood, both as to direction and intensity, that it may be effectually resisted. A pressure is also excited at the acting tooth of the cog-wheel on the same axle, by which it urges round another wheel, exciting similar pressures on its pivots, and on the acting tooth perhaps of a third wheel. Thus a pressure is ultimately excited in the working point of the machines, perhaps a wiper which lifts a heavy stamper, to let it fall again on some matter to be pounded. Now statics teach us the intensities and direction of all those pressures, and therefore how much remains at the working point of the machine unbalanced by resistance.

2. They comprehend every circumstance which influences the stability of heavy bodies; the investigation and properties of the centre of gravity; the theory of the construction of arches, vaults, and domes; the attitudes of animals.

3. The strength of materials, and the principles of construction, so as to make the proper adjustment of strength and strain in every part of a machine, edifice, or structure of any kind. Statics therefore furnish us with what may be called *a theory of carpentry*, and give us proper instructions for framing floors, roofs, centres, &c.

4. Statics comprehend the whole doctrine of the pressure of fluids, whether liquid or aeriform, whether arising from their weight or from any external action. Hence therefore we derive our knowledge of the stability of ships, or their power of maintaining themselves in a position nearly upright, in opposition to the action of the wind on the sails. We learn on what circumstances of figure and stowage this quality depends, and what will augment or diminish it.

STATIONARY, in *Astronomy*, the state of a planet when, to an observer on the earth, it appears for some time to stand still, or remain immoveable in the same place in the heavens. For as the planets, to such an observer, have sometimes a progressive motion, and sometimes a retrograde one, there must be some point between the two where they must appear stationary.

STATISTICS. The term statistics naturally suggests the object to which the science applies. It is derived from the word state, or, according to others, the German word *Staat*, signifying a body of men living together in social union; and it comprehends all the details connected with their condition. There cannot be a more interesting subject of speculation than the structure of society; and if we are anxious to trace, by laborious research, the laws of the material world, no less important is it to ascertain the moral laws by which society is upheld, and on which depend the character, condition, and happiness of man. But neither this nor any other branch of philosophy can be explained without a suitable collection of facts. In those sciences which regard merely the properties of matter, experiments can be made at pleasure, and facts abundantly obtained. But we cannot make experiments on society; and we must therefore rely on observation for the facts by which principles are to be illustrated. As the astronomer, in deducing the laws which regulate the solar system, patiently surveys the structure and movements of the heavens, in like manner the political philosopher must watch the progress of society, under all its various aspects of prosperity and decay, of happiness and misery, from the stagnation of trade, from famine, from disease, or any other of the long catalogue of evils to which man is subject. We cannot expound by *a priori* reasonings the wonderful economy of human society; we cannot find our way through those intricate speculations without the light of facts; and hence the importance of this science, which does not consist in reasoning, but in collecting materials for reasoning, which it is the business of the philosopher to arrange under general principles, and thus to place every fact in its just place in the great system of knowledge. Facts are the only true foundation of philosophy. This is the true mode of philosophising by experiment recommended by Bacon, or by observation, which, to the political inquirer, must supply the place of experiment. Those sketches of society which are merely speculative, however ingenious and amusing, carry no conviction to the mind, and may be supported by other theories equally plausible. But no sophistry can shake the solid array of facts, and their legitimate conclusions, of which all valuable knowledge may be said to consist. Hence the importance of statistics, which supply the raw material, to be afterwards fabricated by the delicate hand of science into those fine but not flimsy speculations, which give importance to the most trifling circumstances, by shewing how they bear on great principles; and hence, by the unexpected analogies which they often disclose in the practice and policy of nations, a new light is reflected on the history of mankind.

It is not, however, from a mere barren collection of facts that instruction can be derived. The statist must be so far trained in the school of philosophy, as to be able to cull out what is instructive, and cast aside what is useless. He must not be a mere collector of unconsidered trifles. There are many uninteresting facts from which no conclusion can ever spring. A collector of information is not in this view merely a pioneer to the philosopher. He must be qualified for his task by previous knowledge. He must know what questions to ask, into what useful channel to guide his researches, otherwise he would waste his labour in the vain accumulation of useless details, which would rather be an incumbrance than an aid to scientific inquiry. A brief enumeration of the chief facts connected with the different subjects of political science may serve more clearly to explain our views. Every subject to which the statist directs his attention has its appropriate facts. Thus, the ratio in which population and subsistence respectively increase, and the condition of the people in different countries, can only be illustrated by an accurate census at different periods, by the proportion of marriages to the whole population, and of births to deaths; and the same facts will indicate the healthiness or unhealthiness of the different countries; the population slowly increasing where the deaths are few, and being renewed more rapidly by frequent marriages, where there is a greater mortality.

In giving an account of the commerce of a country, the facts sought after must chiefly be, the amount of its exports and imports; the general rate of wages; a copious list of prices; the state of the currency; of what it consists, whether of gold, silver, or of paper; and if of the latter, the number of banks, the amount of the circulation, the price of gold and silver, and such other facts as may throw light on the difficult subject of those mercantile convulsions, and of other causes, with which we are now unfortunately so familiar.

In an investigation of the revenue, its amount for a series of years must be ascertained; the different taxes, with the annual products of each; the time when they were imposed; their increasing or decreasing amount; by which a judgment may be formed of their productiveness, and of the condition of the country in which they are imposed.

The state of a community in respect to crime is a subject of deep importance; and the facts naturally sought after must be the number of criminals tried, the nature of their offences, the number condemned, the punishment inflicted, the state of the prisons; whether there are any penitentiaries, and by what rules conducted; by which the inquirer, be he statesman or philosopher, will be able to appreciate the influence of the penal code on the morals of the country, and whether it tends to one of its great ends, namely, the reformation of the criminal, as well as his punishment.

The produce of the soil, in all its various departments, with the laws by which it is distributed among the other classes of the community, opens a wide field of inquiry; and the facts which throw light on these subjects are of great value, and must chiefly be, the amount of the produce in different years, whether scarce or abundant; the prices in these different years, and the amount of importation or exportation, with the fluctuations of price that may occur in different periods of the same season.

The mineral riches of a country, its fisheries, either on the shores or in the rivers, its climate, the diversity of its surface, and the variety of its vegetable produce on the mountains and in the plains, are all the legitimate subjects of statistics, which, it will be thus seen, has a wide range, and is connected with various sciences; 1st, with mineralogy, chemistry, and mechanics, because of the importance of those sciences in the extraction of metals from the earth, in refining the ore from the dross by the most economical modes, and in protecting those subterranean regions from the inundations of water, from the corruption of the air, or from the falling of the superincumbent masses under which the work is carried on; 2d, with meteorology, from the influence of the atmosphere on the soil; from the variation of the climate, according to the altitude, and the varieties of the vegetable tribes which are found at different heights, all which are important facts in the statistics of every country; and, 3d, with zoology, from the necessity of ascertaining the different breeds of the domestic animals, and their qualities, and how far they can be made subservient to the purposes of man. How curious it is to contemplate the varieties of these animals in different climates and countries: how in Asia the elephant, whose gigantic strength could crush its masters in the dust, is yet, by the ingenuity of man, reduced to one of the humblest of his drudges; the camel in like manner to be a pattern of patient service; and the swift dromedary, and the wild ass, with its indomitable spirit, broken to the yoke, though in the eastern countries still retaining its native fire; while in Europe man depends upon an entirely different class of animals, whose properties are of the highest importance in reference to the various duties to which they are appointed, and form, therefore, the proper subject of statistical inquiries, to which zoology contributes its aid.

The moral and religious condition of the people is a subject of still greater importance, which cannot be understood without knowing the nature and extent of the religious establishments and seminaries of education; the funds that are appropriated for these purposes, and their efficiency for their proposed ends; from what source they are derived; whether they are large or small; the number of churches and schools, as compared with the population; the nature of the different seminaries; what are the sciences taught; the pay of the teachers, civil as well as religious; the different sects; the number of each; the proportion of those teachers who are paid by the state to those who depend on the voluntary contributions of their flocks. All these facts are necessary to be known in order to decide on the great questions which will ever agitate the world on the subject of religion, namely, whether any particular form ought to be encouraged by the state; whether it is not the better policy to leave religion to its own native and divine strength; to give protection to all, but encouragement to none; a fair field and no favour; whether religion is more effectually promoted by a largely endowed ministry, or by one more humble and industrious, depending for their subsistence on the good will of their people; whether large pay may not be a source of corruption and a bribe to indolence; or whether such a class of luxurious priests may not be necessary to propagate religion among the rich. It is by inquiries into facts such as we have enumerated that these important questions can be best elucidated; and it is to these objects, therefore, of which we have given an imperfect enumeration, that the statistical inquirer ought to direct his attention, with a view of clearing away all obstructions from the paths of science.

The study of statistics has only been of late years systematically prosecuted. It makes no part of the early history of nations. The glare of battles, and of political commotions which fix the destiny of nations, alone attracts the notice of the historian; and for these, the more precious details of domestic history are thrown into the shade, and finally lost. It is only, therefore, that portion of human affairs, which, though more striking, is the least valuable, that history embalms, while it casts aside as useless those important facts which illustrate the progress of society, in arts, in literature, and in science; in wealth also, in population, and in commerce, by new and more ingenious modes of industry, which shew the changes of manners that follow increased wealth, the state of the public revenue, with various other topics equally interesting to the statesman as well as the philosopher. The ancient history of Greece and Rome is eminently deficient in those details. The writers of those times appear to be extremely loose in their facts; and they very seldom refer to the authority of any original document. In the ancient republics of Greece and Rome, every thing was subservient to war; and the accounts that were from time to time taken of the male population, were with a view to ascertain the military strength of the state. But little reliance can even be placed on these accounts. The ancient historians were rather intent on general description, often vigorous and eloquent, than in any accurate appeal to facts. There was no accurate census of the Roman empire after it had attained to the height of its power; and the Roman historian, admitting that the number of subjects cannot now be fixed "with such a degree of accuracy as the importance of the object would deserve," is reduced to little better than conjecture, when he estimates the number of persons under the imperial sway at 120 millions; "a degree of populousness," he adds, "which possibly exceeds that of modern Europe;' the vague manner of his expression truly intimating the imperfect data with which he was furnished. In other departments the statistics of Rome are still more deficient in facts. The relative proportions of births, deaths, and marriages, are never so much as pointed at in any historical work; and the accounts that remain of the state of commerce and manufactures are meagre in the extreme. A list is no doubt given of articles of luxury imported into Rome, and of the trade to India and Arabia; in which Pliny complains of the unfavourable exchange, a modern complaint, also, in this country, and of the drain of gold which it occasioned, there being no other equivalent with which the rare luxuries of those countries could be purchased. (See the article ARABIA.) But we have no account of the state of wages, of the value of the exports or imports, nor any very accurate account of the currency, or of the public revenue. The modern historians of Rome, gleaning a few scattered facts which shed an incidental light, from the works of the classical writers, are reduced, by the help of their own conjectures, to form them into a specious, but often doubtful hypothesis. What a meagre account, accordingly, does the illustrious Gibbon, not less noted for eloquence and fancy, than for accurate research, give of the revenues of Rome. He begins with lamenting the want of any authentic document. "History," he observes, "has never perhaps suffered a greater or more irreparable injury than in the loss of the curious register bequeathed by Augustus to the senate, in which that experienced prince so accurately balanced the revenues and expenses of the Roman empire." And when groping his way, by the imperfect light which history supplies, he estimates that 20,000 pounds weight of gold were annually received from the provinces of Austria, Gallicia, and Lusitania, he adds, "we want both leisure and materials to pursue this curious inquiry through the many potent states that were annihilated in the Roman empire." After stating the incidental circumstance of Augustus having once received a petition from the inhabitants of Gyarus, a solitary and desolate isle, for a remission of their annual duties, which only amounted in value to L.5 sterling, and naturally inferring, if such severe attention was directed to the abodes of sterility, that much larger contributions would be levied in the seats of population and of wealth, he adds, "from the faint glimmerings of such doubtful and scattered lights, we should be inclined to believe, that with every fair allowance of times and circumstances, the general income of the Roman provinces could seldom amount to less than L.15,000,000 or L.20,000,000 of our money." Such is all the information which the most diligent research could collect from any extant record concerning the revenues of Rome. What a contrast does this present to the enlightened science of modern times, and to the more accurate documents prepared by authority in the great states of Europe, and in America, in which their respective revenues and expenditure are detailed with arithmetical accuracy; not only the general result, but also the amount of the duty on such separate articles for a series of years, from which we are enabled to draw important conclusions as to the nature and policy of different taxes, as to the general effect of taxation, and the condition of the country, whether, as indicated by the state of its revenue, it is advancing or going back.

Under the imperial government of Rome the land was accurately measured by surveyors, who reported its produce, whether arable or pasture, vineyards or woods, what was the number of slaves or cattle; and an average estimate was made of its produce for five years, on which a fixed proportion was exacted by the state. But nothing remains of the records to point out the state of property in this great empire, the chief seat of wealth and civilization in the ancient world; and it is lamentable to reflect, that most of those inquiries by government were instituted, not with any view of promoting science, or of benefiting the people, but rather of plundering them: their rulers inquired into their means that they might know how heavily they might be burdened. This was probably the origin of that exact survey of the lands of England which took place by order of William the Conqueror, which was finished in six years, and was entered into the register called *Doomesday-Book;* not only a relic of antiquity, but a statistical document equally valuable and curious, more especially considering the rude age in which it was produced. Neither in that early age, however, nor in much later times, are there any materials for domestic history; and accordingly the English historian, in describing the progress of manners, is reduced, like the historian of Rome, to draw his imperfect conclusions from the few facts which are scattered through the pages of the early writers.

When the progress of political science became more rapid, the facts on which that science was founded, were investigated with redoubled assiduity. Towards the close of the seventeenth century, several treatises were published on the subjects of commerce, manufactures, circulation, and finance, by Reynolds, Child, and Petty. But they were deficient in comprehensive views, and attracted comparatively little attention. The more recent works of Price, Arthur Young, and Playfair, on population, commerce, and agriculture, though evincing laborious research, are liable to the same objection. Dr. Smith was the first writer who laid open the philosophy of commerce, and the publication of his work was an era in the science. It attracted universal attention; and carried conviction wherever it was studied, by the force and the extreme simplicity of its reasonings. The far-reaching views of the author into all the complicated relations of society, are not more striking than the perfect plainness with which he lays open its hidden structure. There is a peculiar force and propriety in his style, which, repudiating the use of ornament, possesses a weight and brevity which is quite remarkable. It is the pure ore of expression, refined from all those inconvenient accessaries of speech which encumber the modern languages. His argument often appears to consist of a series of insulated propositions, yet they are linked together into so fine a logical chain, that the mind is carried on step by step to the grand and striking conclusion. Since the publication of Dr. Smith's work, statistical knowledge has been more and more sought after, and many valuable works have been published on the subject. Among these may be mentioned the *Statistical Account of Scotland,* to which the clergymen throughout the country contributed each the account of his own parish. The design of the work, which was begun about the year 1791, and was suggested by Sir John Sinclair, to whom the accounts were sent, and who superintended the publication, is extremely judicious, and the execution is in general useful and accurate. In these volumes was accumulated, in respect to Scotland, a greater portion of correct information than had ever before appeared. The work is useful as a memorial of the condition of the country at that period, and as an illustration of domestic history. The great improvements which have taken place in the country, have now rendered obsolete most of the information which it contains; but a new work on the same plan is now in the course of publication at Edinburgh; and so far as it has proceeded, it appears to be executed with judgment and care, and to contain an ample store of statistical information.

But those publications, valuable as they are, fall short of the important documents which are now annually laid before the respective legislatures of different countries. Great Britain, France, and the United States, possess, in these public accounts and papers, a valuable mass of political information, and the most authentic details on all the important subjects of commerce, agriculture, finance, the moral instruction of the people, and on every other branch of domestic history. And the great advantage is, that we can appeal to these accounts with the most perfect confidence. They are the solid materials of philosophy, the original sources from which are drawn those unerring conclusions concerning the laws and structure of society which nothing can reverse; which equally survive the tempests of revolution, and the change of manners. On important subjects, the British Parliament often appoints a select committee of members to make inquiry, and to prepare a report. They have authority to summon witnesses, and to collect evidence from every quarter. The diligence and ability with which those committees have executed this task, is attested by the long and elaborate reports which are among the parliamentary papers on the revenue, on trade, on agriculture, on banks and paper currency, and on almost all the different manufactures which are carried on in the country; such as glass, soap, starch, paper, malt, the distillation of spirits, the brewing of beer, and others of less moment. It is of great importance that the accuracy of these, and the accounts which they contain, should be undisputed, or otherwise their effect would rather be to mislead than to inform.[1] The information that is now called for by Parliament, is much more extensive than in former times, and relates to matters that were formerly thought to be of the most private nature. Prior to the suspension of cash payments by the Bank of England in 1797, nothing was known of its circulation or of its operations; and Dr. Smith, however justly he expounds the nature of money and of paper currency, had no knowledge whatever of the amount that circulated in the country. No accounts of this nature were published at that time. These were official secrets, which were to be rigidly kept from the eyes of the profane. The catastrophe which befel the bank in 1797, broke the spell of secrecy; the various committees which have been appointed to inquire into the affairs of the bank, namely, the Lords' committee of secrecy in 1797, in 1810, and in 1819, and the committee of the Commons in 1832, have both laid open the transactions and policy of the bank; and a quarterly account is now ordered to be published in the Gazette of its circulation, its deposits, its liabilities, and the average amount of its stock of gold. Such information gives to the political inquiries of modern times an incalculable advantage. The progress of freedom in Europe also conduces to the extension of statistical knowledge. Where popular assemblies are established, with the right of free discussion, inquiries into all the branches of the public service will naturally follow. Papers and accounts will be called for; no longer will the transactions of statesmen be shrouded in darkness; they will be dragged into light; and the people formerly reprobated by the tyrant Henry VIII. as brutes, who were no more judges of these high matters than a blind man of colours, will insist, in their boldness and presumption, to know how their money is spent. Thus will be obtained the financial accounts of the kingdom, and those of commerce, and other public matters will follow in due course. Publicity is the true corrective of corruption; and in the pure administration of free states, the ruler will rather court than shun inquiry, being conscious of nothing that will not bear the light. Accordingly, in 1832, a statistical office was established in the department of the board of trade, for the purpose of collecting, arranging, and publishing statements relating to the condition and the various interests of the British empire. The volumes to which this arrangement has given birth, are annually printed and laid before Parliament, and contain an ample store of the most satisfactory details. Several societies have since been formed for prosecuting statistical inquiries. In 1833, a statistical section was formed in the British Association for the advancement of Science during the period of its meeting at Cambridge; and, before the close of the year, the Manchester Statistical Society was established. The Statistical Society of London, which had been projected at Cambridge, was established in 1834, and has published a monthly journal, which contains much useful information. Statistical societies have been formed in other populous towns, in Liverpool, in Bristol, and in several towns in Ireland, and promise, by their industry, to add largely to the existing stock of useful knowledge. Many important publications have of late years issued from the press, on the condition and resources of the country; on its commerce, its agriculture, its currency, as well as on the state of education, which tend to promote, and greatly to aid statistical inquiries. The most important of these is Macculloch's Dictionary of Commerce, a work which combines extensive research, and the most copious details, with the spirit of philosophy. Other statistical works are, the Statistical Account of the British Empire, by the same author; Statistical Accounts of part of Ireland, by the Officers of the Irish Ordnance Survey; Milburn's Oriental Commerce; Macgregor's Statistics of Nations; Porter's Progress of the Nation; Martin's Colonial Magazine, and his British Colonial Library, an elaborate account of the colonies. An instructive and useful work has lately been published by Mr. A. Trotter on the Commerce and Banking System of the United States, which is a compendium of important statistical information. With all these aids, political science will undoubtedly advance, and may be expected in time to attain to more certain results in all those important inquiries which relate to the actual condition and moral improvement of mankind.

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[1] We think it necessary to give this caution, as we entertain doubts of the accuracy of an important table inserted in the Seventh Report of the Commission of Excise Inquiry, in which is given the amount and progressive increase of the duties on spirits in Scotland; with the quantity, as far as can be ascertained, annually brought to account. It is stated in the report, that the mode of charging the duty per gallon of still-content was discontinued in Scotland in 1802; and, in the table, the highest amount of duty on the cubic contents of the still in the Lowland district, is stated to be L.64, 16s. 4d.; whereas the 46 Geo. III. c. 102, passed in 1806, raises the permanent duty on the cubic contents of the still to L.108, and adds the war-duty of L.54, to continue till six months after the definitive treaty of peace. It was not till the year 1814 that the duties were transferred from the cubic contents of the still to the wash and the spirit, at the rate of 1s. on the former, and 2s. 10d. on the latter. See 54 Geo. III. c. 172. The facts given in the table are at variance with the acts of Parliament which we have quoted.

STATIUS, Publius Papinius, a celebrated Latin poet, who was born at Naples, A.D. 61. His father was of a patrician family, but being poor, he maintained himself by teaching rhetoric, first at Naples, and afterwards at Rome. The emperor Domitian is said to have been one of his pupils. He was a master of the Greek as well as the Latin tongue, and was a poet as well as a rhetorician. If we could rely on the statements of his son, he was little inferior to Homer in poetical genius; but as his contemporaries have nowhere noticed him, it may fairly be presumed, that his affection for his father blinded the son's judgment.

Statius received his education at Rome, and married at an early age (A.D. 81) a widow named Claudia, whom he frequently mentions in his verses. He was distinguished by his powers as an improvvisatore, which seem to have been very considerable, and he often appeared before the public in the poetical contests of the age. In these he was not unfrequently victorious; yet though crowds flocked to hear the recitation of his Thebaïs, Juvenal, Sat. vii. 87, remarks, that he would have perished from hunger, if he had not been able to sell to the principal actor of the day his tragedy of Agave, which is now lost. His high reputation however excited against him many enemies, and among others Martial, who, it is observed, never took any notice of Statius. The principal poem of Statius is entitled Thebaïs; it is an epic poem in twelve cantos, and a work of considerable merit. It relates to the Theban war under the sons of Œdipus, and is in reality, like that of Silius Italicus, an historical poem, the materials for which have been drawn principally from Greek sources, more particularly from the Thebaïs of Antimachus. He has taken for his model Virgil's Æneid, but has not been very successful in his imitation. Another of his poems is entitled Achilleïs, being intended to exhibit a detailed account of the life and deeds of Achilles, from the moment of his birth; but the author did not live to complete his plan, and only two books remain, the last of which is imperfect. This portion contains only a small part of the life of Achilles. We have besides a collection of thirty-two poems, divided into five books, and bearing the title of Silvæ. They are mostly in hexameter, but some few in Alcaic, Sapphic, and Phaleucian verse. Having fallen into a feeble state of health, he retired to Naples in the hope of deriving some benefit from his native air. Here he laboured at his Achilleïs; but death arrested his progress before he had completed the thirty-sixth year of his age.

The poems of Statius exhibit nearly the same faults as are to be found in the works of Silius Italicus, and Valerius Flaccus. He possesses the rhetorical spirit of his age, which, disregarding the beauties of simplicity, aimed at effect by ingenious turns of expression, and a display of great learning. His language is sometimes bombastic. His works were at one period, not of the most refined taste, held in as great estimation as those of Virgil. The first collective edition of his poems appeared at Venice in 1483, folio. They had been separately printed at an earlier period. The subsequent editions are sufficiently numerous. Among the more elaborate of the early editions, we must mention that of Lindenbrog, Paris. 1600, 4to. It includes the scholia of Lactantius, or Lactatius, on the Thebaïs and Achilleïs. Nor must we omit the accurate edition of Gronovius, Amst. 1653, 12mo. The same able critic had previously published "In P. Papinii Statii Silvarum libros v. Diatribe." Hagæ Com. 1637, 8vo. An edition of Statius was not long afterwards published with the very elaborate and learned commentary of Barthius, Cygnæ, 1664, 2 tom. 4to. The commentator was then dead, and the edition was superintended by Daumius. Considerable additions were here made to the ancient scholia formerly printed. Another critic to whom this poet has many obligations, is Markland, who published, with notes and emendations, a separate edition of the "Silvarum libri quinque." Lond. 1728, 4to. Among the attempts at English translation, we may mention Lewis's version of "The Thebaid of Statius," Oxford, 1767, 2 vols. 8vo.

STATUARY, a branch of sculpture, employed in the making of statues. See Sculpture.

STATUE, is defined to be a piece of sculpture in full relievo, representing a human figure. See Sculpture.

STEAM.

Steam.

THE articles STEAM and STEAM-ENGINE in the third edition of the present work were originally written by DR ROBISON, and were long the standards of reference upon these subjects. The rapid progress of science and of the mechanical arts during the present century, has now rendered it necessary to substitute for these articles those maturer results of recent research, to the attainment of which the original papers were themselves the means of very materially conducing. The value of these original researches was further enhanced by passing through the hands of the man of all others the most capable of appreciating their value, and the best qualified to increase it by his contributions. It was the early friend and companion of Professor Robison, Mr WATT himself, who, towards the close of his life, and notwithstanding the laborious nature of the undertaking, agreed to revise those articles for republication, so as to present them to the public with somewhat of that greater completeness which it is to be presumed their author would himself have conferred upon them, had he lived to see the investigations which he had begun, carried forward and completed. Mr Watt was, however, prevented by the weakness of increasing years from doing more than adding notes to these articles, and they were accordingly printed in that form; but they contain a most interesting chapter of the history of inventive genius, for they give us, in Watt's own words, the history of the progress and consummation of his own noble inventions, and display the efforts of genius working its way through the obscurities of imperfect knowledge to the discovery of pure truth and the achievement of the most exquisite combinations.

While, therefore, it was impossible to retain the articles themselves, it was highly desirable that all that had rendered them valuable should be retained, and more especially such portions as serve to record the state of the mechanics and physics of steam at that time, and the progress of the invention; and these, together with the notes of Mr Watt, it has been thought better to give in the precise words of the original, than to transpose them into language which could neither be more clear nor more appropriate than that with which their authors had invested them. Such portions of the articles on steam and the steam-engine, as have been in this manner retained, are distinguished by an appropriate mark. Paragraphs from the pen of Dr Robison have a star * placed at their commencement; those of Mr Watt, in like manner, have a cross †. To all that was interesting and valuable in the original articles, an attempt has been made to superadd whatever subsequent labour and research may have brought to light. These remarks apply to the articles STEAM and STEAM-ENGINE. STEAM NAVIGATION is entirely new.

SECTION I.—CONSIDERATIONS OF A GENERAL NATURE REGARDING THE PROPERTIES, PHENOMENA AND APPLICATIONS OF STEAM.

Origin of Steam.

1. * STEAM is the name given in our language to the visible, moist vapour which arises from all bodies which contain juices easily expelled from them by heats not sufficient for their combustion. Thus we say, the steam of boiling water, of malt, of a tan-bed. It is distinguished from smoke by its not having been produced by combustion, by not containing any soot, and by its being condensible by cold into water, oil, inflammable spirits, or liquids composed of these.

2. * We see it rise in great abundance from bodies when they are heated, forming a white cloud, which diffuses itself and disappears at no very great distance from the body from which it was produced. In this case the surrounding air is found loaded with the water or moisture which seems to have produced it, and the steam seems to be completely soluble in air, composing, while thus united, a transparent elastic fluid.

3. * But, in order to its appearance in the form of an *opaque white* cloud, the mixture with or dissemination in air seems necessary. If a tea-kettle boils violently, so that the steam is formed at the spout in great abundance, it may be observed, that the visible cloud is not formed at the very mouth of the spout, but at a small distance before it, and that the vapour is perfectly invisible at its first emission. This is rendered still more evident by fitting to the spout of the tea-kettle a glass pipe of any length, and of as large a diameter as we please. The steam is produced as copiously as without this pipe, but the vapour is transparent and colourless throughout the whole of the pipe. Nay, if this pipe communicate with a glass vessel terminating in another pipe, and if the vessel be kept sufficiently hot, the steam will be as abundantly produced at the mouth of this second pipe as before, and the vessel will remain quite transparent. The visibility, therefore, of the matter which constitutes the steam is an accidental circumstance, and appears to require its dissemination in the air; and we know that one perfectly transparent body, when minutely divided and diffused among the parts of another transparent body, but not dissolved in it, makes a mass which is visible. Thus oil beaten up with water makes a *white opaque* mass.

4. If the column of steam which ascends from a boiler that is suddenly opened, be observed in a clear dry day, when the sun is shining, the column of vapour, gradually widening as it rises, will be observed to be of a very brilliant silvery white, and will cast a strong dark shadow upon the objects which it intercepts from the direct rays of the sun: but, if the observer be placed in this shadow, the sun will appear to him to be of a strong tawny, or fiery red colour, or, if the column be very dense, the sun will be invisible. These appearances closely resemble some phenomena of the clouds, which we know are composed of watery vapour, and which sometimes appear of a fleecy white, again of a fiery red or a burnished gold colour, or again of a dappled grey, down through every degree of darkness, until the vapour become so dense and opaque as altogether to obscure the light of the sun by a thick black cloud. These appearances have been satisfactorily accounted for. Steam, in its attenuated state, is a transparent, invisible, colourless gas. When disseminated through the air, in excessive quantities, small globules are formed, of a film of water, enclosing light vapour. These globules, floating thickly in the air, form an aggregation of minute films of fluid, capable of reflecting and transmitting light. When we are so placed that the light may be reflected to us, and when the cloud is so thick as to reflect it completely, we have the same brilliant white which results from the comminution of glass, rosin, ice, and other transparent media; and, at the same time, an observer, placed on the opposite side of the cloud, sees it as a dense black opaque mass, because the light being totally

reflected, none of it can be transmitted to him. The richer colours transmitted by thinner strata of vapour are thus noticed by M Leopold Nobili of Reggio. "The tints exhibited by the clouds in every variety of aspect are almost all comprised in Sir Isaac Newton's first ring (the white, yellow, orange, red; or the blood, tawny, copper, ochre, and fire red, and vialaceous red, or No. 1–12 of Mr Nobili's scale). Tints of this kind do not arise from refraction and diffraction, they are produced only *by means of thin plates.* Now the measurements of Sir Isaac Newton have shown what are the dimensions of the layers of air, of water, and of glass, which produce the colours of the several rings; and, as we know that the vesicular vapours are formed of water, and that they do not reflect or transmit any other tint, we may conclude that their external film is in no case thicker than ten millionth parts of an inch. This result appears to me to be so decidedly certain as to be entitled to a place in science." It was to the effect of thin plates on light that Newton referred the colours of all bodies; and the accounting for the rich golden hues of the clouds, and the fiery red colour of light passing through dispersed steam, by the effect of the thin plates of water enclosing the vapoury spheroids of pure steam, must be regarded as one of the most satisfactory applications of his theory. (See article OPTICS.)

Apparent nnil- ion Steam

5. A very singular phenomenon takes place, if the flame of a candle or lamp be held below a jet of steam, as it issues from the mouth of a small pipe; the steam instantly ceases to be visible. In this case, one of two changes may be conceived to take place, either or both of which account for the permanent invisibility of the vapour: the intense heat of the flame may disperse the particles to such a distance, that there does not remain in a given space a sufficient number to form a vesicle of vapour, and it therefore remains diffused in combination with the air, which always holds a large quantity of invisible vapour, especially at high temperatures; or the vapour may be decomposed by the flame into the permanent and invisible gases, of which it consists, which may again become combined, to a certain extent, with the burning substance, and support the flame.

The matter f Steam.

6. * When steam is produced, the water gradually wastes in the tea-kettle, and will soon be totally expended if we continue it on the fire. It is reasonable, therefore, to suppose that this steam is nothing but water, changed by heat into an aerial or elastic form. If so, we should expect that the privation of this heat would leave it in the form of water again. Accordingly, this is fully verified by experiment; for, if the pipe fitted to the tea-kettle be surrounded with ice, or any cold substance, no steam will issue, but water will continually trickle from it in drops: and if the process be conducted with the proper precautions, the water which we thus obtain from the pipe will be found equal in quantity to that which disappears from the tea-kettle. Steam is therefore the matter of water, converted by heat into an elastic vapour.

ondi s f the atter team.

7. Steam, water, and ice, are three conditions of the same substance, which it assumes under different circumstances of heat and of external pressure. In each condition it obeys different laws; as a solid, ice obeys the laws of the mechanics of solid bodies: in Russia it is quarried like rock, and is used for building houses and paving ways; it is cast into moulds for domestic purposes, like iron or lead; it is painted like alabaster, and chiselled like marble: as a liquid, water is the exemplar of the hydrostatical laws of all fluids: as a vapour, it obeys the laws of aerostatics; and we now know that steam is, in all respects, similar in its constitution and phenomena to all other elastic fluids or gases. If we apply heat to a bar of extremely cold ice, it expands like other solids with heat, gradually elongating with its increased temperature, its particles receding from one another by the repulsive action induced between the particles by the entrance of caloric between them, the cohesion of the particles becoming less and less, until at last, if the heat be continually thrown in, the cohesion of the particles is altogether overcome, they lose their aggregation, they become separable without effort, and, falling to pieces, the bar of ice loses its form and subsides into water. When thus melted, the water being placed in a vessel, and having heat applied to it, will, like other fluids, continue to expand from its point of greatest density, and will increase in bulk nearly one-twentieth by about 172°, but at last the entrance of so large a quantity of heat will produce a repulsive force between the particles so strong as to cause them suddenly to spring apart from one another, so as to recede to a distance twelve times as far asunder as in the state of water, and they have now assumed the aerial condition of gas or vapour, and constituting steam, occupy 1728 times their original space. The ice passing into the condition of water, is said to be *liquefied*, and the heat necessary to convert ice into water is called the *caloric of liquidity of ice*, or the *caloric of condition of water;* when water is converted into steam, the quantity of caloric necessary for this purpose is called the *caloric of vaporization of water*, or the *caloric of elasticity of steam*, and the water is then said to *boil* or *evaporate*. This process may be reversed. If the steam have been collected in a close receptacle, it may be squeezed by external compression into its original bulk, or by cooling the outside so as to withdraw the caloric of elasticity from between the particles, they may be allowed to come together by the attraction of cohesion, and resuming their original proximity to each other, appear once more in their former condition of water, and in this case the *vapour* is said to be *condensed;* and if the process of abstraction of caloric, with sufficient pressure, be continued, the liquid particles approaching each other, will gradually contract the bulk of the mass, and at a certain point will take again the original character of ice, and the *liquid* is then said to be *congealed* or *frozen*. The same particles of matter do "thus in turn play many parts."

Ice melts and becomes water by increment of heat.
Water evaporates into steam by increment of heat.
Steam is condensed into water by decrement of heat.
Water congeals into ice by decrement of heat.

Steam one of the Gases.

(8.) These phenomena are not confined to one substance: many substances, apparently the most refractory, have been melted and again congealed, while other substances which had never been observed in any other form than that of transparent air or invisible gas, have been condensed by the expedients of modern artifice into liquids heavier than water, and have even been congealed into hard and strong solids. To so great an extent has this taken place, that we are now almost warranted in deducing, from a wide induction of facts, the following generalization; that all bodies assume the solid, liquid, or gaseous condition, according to the accidents of temperature and pressure under which they happen to be placed; and that it is merely from the circumstance of their being more ordinarily found, at the present temperature of the earth and under the weight of our present atmosphere, in one of these states rather than another, that some substances have been characterised and distinguished, and classed as permanent solids, liquids, or airs. We now speak of ice only as frozen water; but had we lived under a temperature such as that which the inhabitants of the planet Jupiter, at their distance from the sun, may be conceived to endure, we should have spoken of swallowing *melted ice* as we now speak of molten lead, and a separate name for melted ice would have remained unknown; or, if we conceive, in like manner, our air to be withdrawn, and the temperature of the earth raised above 212°, we should then have moved under an atmosphere of steam of the same pressure as at present, transparent and colourless, and might only have heard of water as a curious substance obtained from the compression of the air. The phenomena of steam are much simplified and more perfectly explained when we take this enlarged view of its analogy with other kinds of matter.

Phenomena of Ebullition.

9. We are most familiar with steam when in the act of rising violently from heated water in the process of *ebullition*. The history of steam at this crisis is highly instructive, and its phenomena may be studied with advantage by examining it in a glass vessel placed over a strong lamp. When heat is first applied, a rapid circulation of the fluid ensues. The water on the bottom, being first heated and expanded, becoming lighter than the rest, rises to the top, and is replaced by the current of colder water descending to receive in its turn a further accession of heat. By and by, small globules of steam, formed on the bottom and surrounded by a film of water, are observed adhering to the glass; as the heat increases they enlarge, in a short time several of them unite, form a bubble larger than the others, and, detaching themselves from the glass, rise upwards in the fluid. But they never reach the surface; they encounter currents of water still comparatively cold, and descending to receive from the bottom their supply of heat; and encountering them, the bubbles are robbed of their heat, shrivel up into their original bulk, and are lost among the other particles of water. In a short time the mass of the water becomes more uniformly heated, the bubbles, becoming larger and more frequent, are condensed with a loud crackling noise, and at last, when the heat of the whole mass reaches 212°, the bubbles from the bottom rise without condensation through the water, swell and unite with others as they rise, and burst out upon the air in a copious volume of steam, of the same heat as the water from which they are formed, and pushing aside the air, make room for themselves. In this process, by continuing the application of heat, the whole of the water may be "boiled away" or converted into steam.

Sounds of Simmering and Ebullition.

10. The singular sounds produced from a vessel of water exposed to heat, previously to boiling, have attracted attention; the water is then vulgarly said to be simmering or singing; and, when this takes place, it is because the vessel is boiling at one place and comparatively cold at another. This noise is most distinctly heard when the fire or flame applied is small, and its heat intense, when the vessel is large and the water deep; for in that case the entrance of the caloric will take place more rapidly than the circulation can convey it to the remote particles of fluid, and so bubbles of steam will form rapidly at one place and be rapidly condensed at another; the degree of velocity with which such bubbles succeed will determine the pitch of the singing tone. We have observed this phenomenon in greatest perfection when we have attached a slender pipe to a close boiler producing steam, and carried its open mouth, of the diameter of $\frac{1}{8}$ or $\frac{3}{16}$ of an inch, down below the surface of cold water in a glass jar. When the mouth of the steam-pipe is held just below the surface of the water, the steam issues with great rapidity in small bubbles, producing an acute tone; and, on the other hand, when the pipe is held at a considerable depth, the concussions become more violent and louder, their intervals of succession greater, the tone is lowered, and finally, the shocks become detached, and so violent as to shake the glass and surrounding objects with much force. On this subject Professor Robison observes, *that a violent and remarkable phenomenon appears, if we suddenly plunge a lump of red-hot iron into a vessel of cold water, taking care that no red part be near the surface. If the hand be now applied to the side of the vessel, a most violent tremor is felt, and sometimes strong thumps; these arise from the collapsing of very large bubbles. If the upper part of the iron be too hot, it warms the surrounding water so much, that the bubbles from below come up through it uncondensed, and produce ebullition without concussion. The great resemblance of this tremor to the sensation which we experience during the shock of an earthquake, has led many to suppose that the latter is produced in the same way; and their hypothesis, notwithstanding the objections which we have elsewhere stated to it, is by no means unfeasible. Any obstruction on the bottom of a boiler, on the inside, as a piece of metal or stone introduced among the water, may produce a succession of smart concussions by the sudden condensation of gas collected under it.

11. The permanence of the boiling point is one of the most remarkable of the phenomena of ebullition. When water has once been brought to boil in an open vessel, it is not possible to make the water sensibly hotter, however strongly the fire may be urged or its intensity increased. This circumstance is very striking, because we know that heat continues to be thrown in exactly as fast as before the boiling point, and that in that case the heat rose rapidly, whereas now it has altogether ceased to increase. If a thermometer of mercury, air, oil, or metal be placed among the water, the temperature will constantly increase, and expand the matter of the thermometer, until the water boils, and then, whether it boil slowly or rapidly, with a strong fire or a gentle one, the thermometer will continue to stand at the same point. This point is so well defined, as to furnish our standard for the comparison of temperatures, and is the same on all thermometers, being called *the boiling point*, although it is differently numbered on each, being called 212° on our common thermometer or Fahrenheit's, 80° on Reaumur's, and 100° on the centigrade thermometer.

It is also to be remarked, that the temperature of the steam issuing from boiling water is the same with the temperature of the water itself, and remains equally invariable; so that all the steam produced from water boiling at 212° is itself at 212°. This remark will assist us in accounting for the disposal of the heat which the fire gives out during the time of ebullition; for it is manifest that the heat is all the while carried off by the large volumes of steam, at a temperature of 212°, that are diffused through the air; and so it happens that an increase of heat in the fire, instead of increasing the heat of the water, only increases the volumes of the steam thrown off, and the quantity of heat carried away. This view of the subject is confirmed by a simple experiment. Take a strong glass flask, place water in it and a thermometer among the water, and let it be held over a lamp until the water boil, and the thermometer will be observed rising till it reach 212°, when the steam will begin to escape rapidly from the neck of the flask. Let it now be corked tightly, and the heat continually applied; and it will be observed that the thermometer does not now stand at 212°, but rises rapidly from that point up to 220° and 230°, showing that the free escape of the steam into the open air is necessary to the permanence of the boiling point. If the heat be still applied, the experiment may be rendered still more instructive, by suddenly pulling out the cork of the flask, when the vapour will instantly rush out in a large volume, and the thermometer sink down to 212°, showing that all the excess of heat has been carried off by the steam into the air.

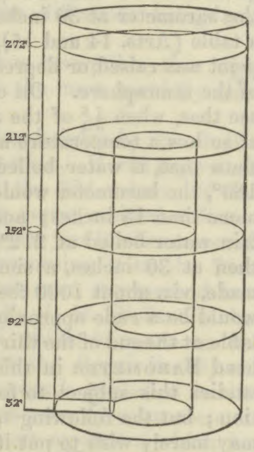
12. We have thus seen that a large quantity of heat may be given out to the particles of a certain quantity of water, converting them into steam, and yet that the thermometer shall afford no indication of this quantity. As soon as water boils, the whole mass is heated up to 212°;

and although the same heat that produced the ebullition be still continually applied, and although we know that this heat must be continually entering into the water, still it is not detected, or in any way exhibited by the thermometer. On this account, the heat given to water during ebullition is said to become *latent*, or lie hid from the thermometer; and, indeed, the thermometer merely indicates the intensity of heat, the calorimeter alone can measure its quantity. The quantity of heat given out to water after it has begun to boil, is more than five-fold that which is sufficient to bring it from the freezing up to the boiling point; for, if we continue the fire with the same intensity that was used in bringing it to boil, it will require more than five-fold that duration and quantity of fuel to boil all the water away, or convert it all into steam of 212° of heat. Thus the sensible heat, added from 32°, will be 180°, and that latent in the steam is more than five-fiold; or, in other words, the *insensible caloric* in steam is five-fold its *sensible* heat; or the same quantity of matter in the condition of steam at 212°, and of water at 212°, will hold different quantities of caloric, in the proportion of about 6 to 1. This is called the greater *capacity of steam for caloric* than of water for that substance; and it is in part accounted for, by the greater distances of the particles of the matter of steam and water from each other in the former than the latter condition; for when the distances of the particles are increased 12 times, the spheres of caloric around each atom may be much larger, without increased elasticity of the calorific fluid. Dr Black was the discoverer of the admirable doctrine of *latent heat*.

Ca ity of am for loric —I Dal- ton

13. Dr Dalton has thus illustrated the doctrine of latent heat, and of the increased capacity of a liquid for holding caloric, when it passes into the condition of vapour. The liquid and its vapour may be considered as two reservoirs of caloric, capable of holding different quantities of that fluid. Let figure 1. represent to us such an arrangement; the internal cylinder of smaller capacity, the external one of enlarged capacity surrounding and extending far above it, and a small open tube of glass, communicating freely at the bottom with the inside of the cylinders. Let us now conceive water to be poured into the internal cylinder, the water will manifestly flow into the slender tube till it stand on the same level in the tube as in the cylinder. If any additional quantity be now poured into the internal cylinder, the rise of water in the slender glass tube will serve as an index of the quantity of added fluid; and when it is filled to the top, the fluid will stand at the height marked 212°, and will still be a correct index of the addition of fluid. But if more water be now added to it, it will not make its appearance in the slender tube, but will simply overflow from the internal cylinder over into that of enlarged capacity, so that, while a large quantity is passing into the vessel and gradually filling it up to 212°, no additional rise takes place until the whole of the outer cylinder become filled to that point, after which any further addition will again become sensible, by a corresponding rise in the tube. This process is in precise analogy to the succession of circumstances in heating a liquid, and converting it into steam. The internal cylinder represents the liquid, the external one the vapour of greater capacity, and the slender glass tube at the side the thermometer placed in communication with them. When heat flows into the liquid, it passes equally into the thermometer; and each increment of the one produces an equal increment in the other, until the liquid reaches the limit of its capacity, when it suddenly begins to enlarge its bulk and take the form of steam; but the quantity of heat required to fill up this enlarged capacity is so great as to require about 5½ times as much to fill it as was contained in the whole liquid before, so that all this time the thermometer is standing still, and it is not until the whole of the steam is thus supplied with 212° of caloric, that the thermometer will begin to show any further elevation; after which, any increment of heat thrown into the steam will make its appearance on the thermometer, and proceed as formerly, by simultaneous increments.

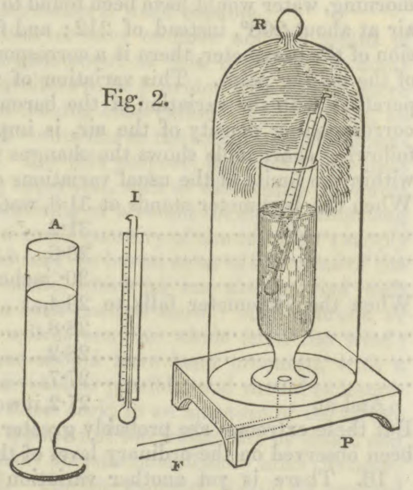
Fig. 1.



Ebullition in vacuo—Dr Dalton

14. It appears, therefore, that the cause why water boiling under the open air does not reach a higher temperature than 212°, is, that the steam which is raised by any additional heat, carries that additional quantity of heat along with it into the air. But here a question occurs at once to the enquirer into these phenomena, viz. Why does water require to be heated up to 212° before it will throw off its increments of heat and vapour into the air? Why does not steam rise equally strongly from water at 200° or 180°? The categorical reply is, that the elastic force of the heat is not sufficient to enable the steam to force its way against the pressure of the air until it reaches this point. In order to understand the means by which we arrive at this conclusion, it is necessary to know that, when the pressure of air on the surface of the water is artificially diminished, the steam does actually rise, and the water bubbles and boils with great violence, at temperatures far below 212°. It is only when the surface of the water is exposed to the full *pressure of the air* in a common vessel that it is prevented from rising in vapour, at temperatures lower than the usual boiling point. If the surface of the hot water be protected from the pressure of the air, by being placed under a glass shade, and the air removed from the inside of it by an air-pump, the water may be made to boil at all temperatures below 212°. The following table contains the results of a series of experiments made, with great care, by Dr Dalton, towards the end of last century, in order to ascertain how much of the whole pressure of the air it was necessary to remove, in order to make water boil at a given temperature. In order to understand the way in which this table was formed, the reader must conceive a vessel of water first of all boiling at 212° in the open air, as the vessel A in figure 2, the thermometer I being placed in it. After allowing the water to cool to 200°, let the vessel of water and the immerged thermometer be now placed on the plate stand P of an air-pump, and covered over with a strong glass receiver R; and let a portion of the enclosed air be now withdrawn by the pump from the inside of the receiver by the pipe F; and suppose that there are in all 30 cubical inches, or other volumes, of air in the receiver at first, then the water being at 200°, when about 7

Fig. 2.



out of the 30 parts of the air have been withdrawn, leaving only about 23 parts out of 30 pressing on the water, it will be observed instantly to commence giving off steam in rapid ebullition. If next the process be repeated, only allowing the water to cool to 190°, the ebullition will not commence in this lower temperature till about 12 out of the 30 volumes of air have been withdrawn; and if, in a third experiment, the water be cooled down to 180°, the elastic force communicated by this degree of heat will not be capable of overcoming the resistance arising from the pressure of the air, until one half of the original pressure of 30 has been removed. To this process there is no limit; for as we go on lowering the temperature, we can always find a point at whichthe water will boil, provided the counteracting pressure be sufficiently diminished. The following is Dr Dalton's table, containing the results of his experiments, as given in his *Meteorology*, in 1793:

Heat of the Water when boiling under diminished Pressure.	Quantity of Pressure of Air remaining on the Fluid.
212°	30·0
200	22·8
190	18·6
180	15·2
170	12·2
160	9·45
150	7·48
140	5·85
130	4·42
120	3·27
110	2·52
100	1·97
90	1·47
80	1·03

Effect of Barometric changes on Ebullition—Sir John Robison.

15. In vacuo, therefore, or under a rarified atmosphere, the boiling point of water is lower than 212°. Now, the barometer informs us, that the pressure of our atmosphere is not constantly the same; it has normal and abnormal variations, it has horary, and menstrual, and annual variations. It frequently stands at 30 inches, sometimes at 31 inches; and on the morning of the 7th of January, 1839, it was observed at Edinburgh, by Sir John Robison, to be as low as 27 inches and six-tenth parts. Now, on that morning, water would have been found to boil in the open air at about 208°, instead of 212; and for every depression of the barometer, there is a corresponding depression of the boiling point. This variation of the boiling temperature with the variation of the barometer, and of the corresponding density of the air, is important: and the following short table shows the changes which take place within the limits of the usual variations of the weather:

When the barometer stands at 31·8, water boils at 215°
.................................31·2,.....................214
.................................30·6,.....................213
.................................30· inches,.............212
When the barometer falls to 29·4,.....................211
.................................28·8,.....................210
.................................28·2,.....................209
.................................27·7,.....................208
And at 27·2, it would boil at 207

But these extremes are probably greater than have ever been observed on the ordinary level of this country.

Ebullition on mountains and in mines.

16. There is yet another variation of circumstance which affects the point of ebullition, and that is, distance from the centre of the earth and height above the level of the sea. It is well known, that, on the summit of a mountain, the pressure of the air is less than on a plain, and still less there than at the bottom of a pit or deep valley. It is now equally well known, that the cause of this is the very limited height to which air in a dense state covers the earth, the whole atmosphere being equivalent to not more than 5 miles in depth of such air as we breathe; and it is hence obvious, that after a vertical ascent of a mile to the top of a mountain, there would be only about $\frac{4}{5}$ of the atmosphere remaining above the person on its summit. One of the highest of the Andes has been ascended to such a height, that there remained only $\frac{13}{30}$ of the whole atmosphere above the observer. Now, in this case, the barometer, instead of being sustained at 30 inches, its usual height, had fallen to 13 inches, because, according to the constitution of the barometer (See Arts. BAROMETER and PNEUMATICS), the height of the column of mercury in it is proportional to the quantity of air resting above it. Hence, a barometer being carried up a mountain by an observer, falling as he ascends, enables him to ascertain the height of his ascent. This he does with perfect precision, so as to determine accurately the height of any point of the mountain to which he has ascended, and where he has noticed the fall of the barometer from the point where it stood when at the bottom, by means of an allowance of nearly 100 feet of height for every tenth part of an inch that the barometer has fallen, as explained more fully under the heads BAROMETER and ATMOSPHERE.

The steam of water may be rendered the means of determining the height of a mountain, on the principle of diminished atmospheric pressure, so as to act as a substitute for the barometer. We have just seen that water gives off steam by ebullition, above or below the temperature 212°, according as the pressure of the atmosphere is greater or less than the standard pressure which sustains the barometer at 30 inches. And we have already given a table (Arts. 14 and 15), showing how much the boiling point was raised or depressed by diminishing the pressure of the atmosphere. On consulting Dr Dalton's table, we see that, when $\frac{15}{30}$ of the air were removed, water boiled at so low a temperature as 180°. This, therefore, would show that, if water boiled on the top of any mountain at 180°, the barometer would stand there at a height of little more than 15 inches; and if at the bottom of the mountain water boiled at 212°, showing the barometer to be then at 30 inches, a similar allowance of height being made, viz. about 1000 feet for each inch, or 15,000 feet, would be a rude approximation to the true height. The table at the end of the third section, and the rules under the head BAROMETER in this work, will enable any one who studies this subject to form rules for closer approximation; but the following table will be of use to those who may merely wish to put it in practice.

To de mine t height mount by the ing po of wat

Rule for finding heights by boiling water.—Boil pure water in an open vessel at the bottom of the elevation, and observe on the thermometer the point at which it boils. Boil it again at the top of the mountain, and observe with the thermometer the height at which it now boils: the difference of temperature, multiplied by 530 feet, will give a close approximation to the height of the upper above the lower station.

This will give an approximation; but, if greater accuracy be required, it will further be necessary to correct for the difference of the temperature of the air at the two stations, in the following manner. Add the temperatures of the air at the stations, and subtract 64 from their sum, multiply the remainder by one-thousandth part of the height found; and this will be the correction to be added to the height formerly found. The result thus found will still require a slight correction for the figure of the earth and latitude of the place; but this does not amount to more in our latitude than an addition of about two feet in a thousand, which forms a second correction. This method is, however, to be regarded only as an approximation, for which all the corrections given under the head **Barometer** would be necessary, in order to render it equally perfect with observations by that instrument. In short, this method may be considered as a telltale on the barometer, showing where the barometer would stand if placed in its position. Thus, if water boil at 200° on the top of a mountain, that is merely to be considered as indicating that the barometer, if placed there, would stand at 22.8; after which, the process of deducing the height remains the same. To illustrate the mode of deducing heights from the boiling point, as we have given it, we take the following example.

Water boils on the top of Ben Nevis at 203·8°, while at the side of the Caledonian Canal it boils at 212°, the temperature being 30° on the summit of the mountain, and 35° below. In order to determine the height,

From 212°			
Take 203·8°		To	30°
		Add	35°
There remains 8·2°			
Multiply by 530		Sum	65°
		Subt.	64°
246·0			
410		Remain 1° mult. by 4·346	
4346	first approx.	Latitude 56° nearly	
4	first correct.	Mult. 4·350	
		by 2·	
4350	second approx.		
9.7	second correct.	9.700	

Calc. height, 4359·7 third approximation.
4358· true measured height—the difference being less than 2 feet.

This method, however, is seldom susceptible of so high a degree of accuracy, even with the most carefully conducted experiments.

Th ev. F. I. Wo- ton ppa-ratu

17. This method of determining heights by the ebullition of water is not a recent invention. It was suggested originally by Mr Fahrenheit, in the 33d volume of the *Philosophical Transactions*, in a paper entitled "*Barometri Novi Descriptio*." The subject was further matured by Cavallo, who has written concerning it in the 71st volume of the same Transactions; and the method has finally received from the Rev F. J. H. Wollaston the highest degree of perfection of which it seems to be capable. His paper, read before the Royal Society on the 6th of March, 1817, and afterwards published in the Philosophical Transactions of that year, gives an account of the very beautiful and ingenious apparatus which he has contrived for facilitating the procedure of taking the observations with the requisite precision. Fig. 4, is a view of the whole apparatus, consisting principally of a tripod stand, surrounded by a sort of tent cover, which is quite essential for the protection of the lamp from the strong winds generally encountered at considerable altitudes. The lamp acts on a small tin vessel, which is a cylinder $5\frac{1}{2}$ inches deep and $1\frac{1}{3}$ in diameter, the sides of which are double, leaving an interstitial space of confined air to prevent cooling. Above this vessel is a circular plate of metal G H K, to which the thermometer is to be fixed; and the scale and neck of the thermometer are seen projecting above the stand. A (fig. 3) represents the thermometer made use of, which it is desirable to have of as strong and as compact a construction as possible, while, at the same time, its degrees should range as extensively as possible. These desiderata are attained in his construction. The bulb A, one inch in diameter, is blown thick and strong, on the end of a tube about $\frac{1}{40}$ of an inch in diameter: close above the bulb, is a cavity B, swelled out to such a size as to contain whatever mercury will expand out of the bulb, between 32_o and the lowest temperature at which the mercury is likely to boil at such altitudes as it will be used to measure. It is this which renders the instrument compact; because, if it be not taken out of the British islands, it will never, in all probability, boil at less than 200°; and thus the whole length of the stalk is left for a range of 12° or 15° of the thermometer. In the instrument figured, the scale R is 5 inches long, $\frac{9}{10}$ of an inch wide, and a length 4·15 inches is divided into 100 parts, which, by a vernier reads off to 1000 parts, being 241 parts to an inch; so that 1° Fahr. corresponds to 233 parts on the scale, or to 530 feet. Each part of the scale, as read by the vernier, will therefore correspond to 2·275 feet, being about half the degree of minuteness of the mountain barometer divided into thousandths, each of which is nearly equivalent to one foot of height. The accuracy, however, of this scale is probably greater than the degree of accuracy of which the method of observation is itself capable.

Fig. 3.

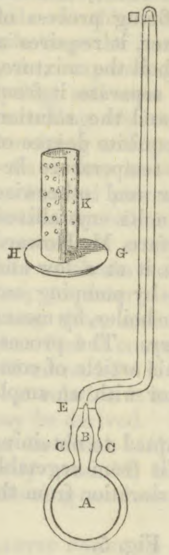
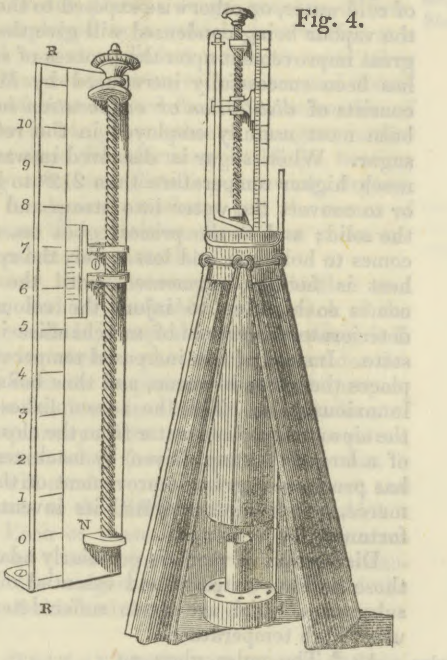


Fig. 4.



Directions to travellers.

Whether an observer have or have not the means of obtaining such an instrument as this, it will be, in many cases, useful to travellers to be provided with means, more or less accurate, of making observations of this nature, on the summit of such mountains as they may have the opportunity of visiting. For this purpose, the most convenient is a small cooking apparatus, such as will supply the wants of a traveller; consisting of a round tin stand, protecting a lamp, in which a small quantity of the traveller's supply of spirituous liquid may be burnt, so as to boil some of the water of a small bottle, which he has also carried with him, or perhaps a little melted snow. An umbrella or waterproof cloak will screen the whole from the wind; and a thermometer should have been procured, with a stem as minutely divided as possible, and should be inserted, by means of a small cork, in an aperture of the lid left on purpose. The quantity of the water may be small, and it will serve a culinary purpose immediately after the operation is completed. The thermometer should be inserted only among the steam. The traveller must take great precautions for striking a light, as he will find this much more troublesome in the cold rarified air of a mountain summit than below.

18. Distillation is a method of separating a liquid from extraneous matter, by first of all converting it into steam,

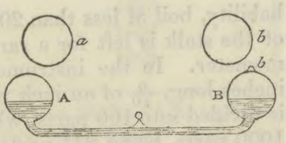
Distillation in vacuo.

and then condensing that steam so as to form the liquid. Different substances take the liquid form at various temperatures; and, therefore, the heat may be so regulated that only one substance of a mixture shall take the form of vapour, and being conveyed by a pipe through a vessel of cold water, or otherwise exposed to the cooling process, the vapour being condensed will give the pure liquid. A great improvement upon the process of separating liquids has been successfully introduced by Mr. Howard. It consists of *distillation or evaporation in vacuo*, and has been most usefully employed in the refining process of sugar. When sugar is dissolved in water, it requires a much higher temperature than 212° to boil the mixture, or to convert the water into steam and separate it from the solid; and as the process goes on, and the solution comes to hold less and less water, the requisite degree of heat is further augmented, until the temperature becomes so high as to injure the colour and otherwise deteriorate the article of merchandise in its crystallized state. Instead of this increased temperature, Mr Howard places the syrup in vacuo, and thus boils it at a low and innoxious heat. This he accomplishes by pumping out the air and vaporized water from the close boiler, by means of a large air-pump driven by machinery. The process has produced a great improvement on this article of commerce, and has remunerated its inventor with an ample fortune.

Distillation in vacuo is peculiarly adapted to obtaining those delicate extracts and essential oils from vegetable substances, which are apt to suffer deterioration from the usual high temperatures.

The Pulse Glass.

Fig. 5.



19.* The pulse glass, an invention attributed to Dr Franklin, is an apparatus illustrating beautifully the process of ebullition in vacuo at low temperatures. If two glass balls, A and B (fig. 5), be connected by a slender tube, and one of them, A, be filled with water, a small opening or pipe *b* being left at the top of the other, and this be made to boil, the vapour produced by it will drive all the air out of the other, and will at last come out itself, producing steam at the mouth of the pipe. When the ball B is observed to be occupied by transparent vapour, we may conclude that the air is completely expelled. Now, shut the pipe by sticking it into a piece of tallow or wax, the vapour in B will soon condense, and there will be a vacuum. The flame of a lamp and blow-pipe being directed to the little pipe *b*, will immediately cause it to close and seal hermetically. We have now a pulse glass. Grasp the ball A in the hollow of the hand; the heat of the hand will immediately expand the bubble of vapour which may be in it, and this vapour will drive the water into B, and then will blow up through it for a long while, keeping it in a state of violent ebullition, as long as there remains a drop or film of water in A. But care must be taken that B is all the while kept cold, that it may condense the vapour as fast as it rises through the water. Touching B with the hand, or breathing warm on it, will immediately stop the ebullition. When the water in A has thus been dissipated, grasp B in the hand; the water will be driven into A, and the ebullition will take place there as it did in B. Putting one of the balls into the mouth will make the ebullition more violent in the other, and the one in the mouth will feel very cold. This is a pretty illustration of the rapid absorption of the heat by the particles of water which are thus converted into elastic vapour. We have seen this little toy suspended by the middle of the tube like a balance, and thus placed in the inside of a window, having two holes, *a*, *b*, cut in the pane, in such a situation, that, when A is full of water and preponderates, B is opposite to the hole *b*. Whenever the room became sufficiently warm, the vapour was formed in A and immediately brought the water into B, which was kept cool by the air coming into the room through the hole *b*. By this means B was made to preponderate in its turn, and A was then opposite to the hole *a*, and the process was now repeated in the opposite direction. This amusement continued as long as the room was warm enough. Instead of water, alcohol or ether may be substituted, and will act more readily.

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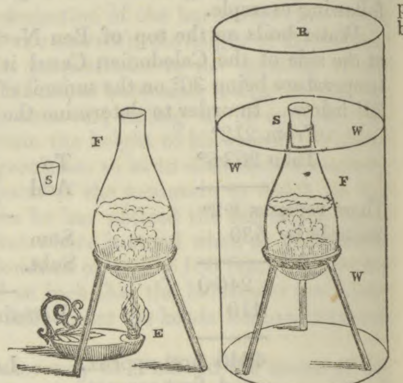
Fig. 6.



20. The following experiment, where ebullition is produced by the application of cold, is instructive. A Florence flask F, is about $\frac{1}{3}$ full of water, and is placed over a lamp E until the water boils; and when the steam has been rising for a short time violently from the neck of the vessel, the cork S is to be applied as a stopper, and must fit with great accuracy. The flask thus closed is to be set aside for a few minutes till it have cooled considerably, and is then to be suddenly placed on a stand in the cold water W, contained in the glass reservoir R. The ebullition in the flask will recommence with a degree of violence proportioned to the coldness of the water W.

The theory of this action is simple. When the flask is plunged in the cold water, $\frac{2}{3}$ of its contents are steam: the chill water condenses it into water, it shrinks up into 1-1728th part of its bulk, and would leave 1727 parts out of 1728 vacuous; but the warm water being now in vacuo, throws up in rapid ebullition (according to Art. 14) copious volumes of vapour of its own temperature, which is again, by coming into contact with the sides of the vessel, and by directly giving off its heat to the water, chilled into water, and so in succession all the vapour thus sent up is in turn reconverted into water, and the vacuum sustained, until at last, the equilibrium between the temperature of the water, within and around the flask, having been established, the interchange of caloric ceases; and even now, if the flask were plunged into freezing water, the ebullition would recommence as violently as before.

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21. We have already noticed (Art. 11.) the fact that, when water is confined in a close vessel, and heat is applied to it, the water will not boil even at a temperature of 212°. If heat be continually thrown into the water in this state, the particles will acquire a very high temperature; and, at the same time, the tendency of the enclosed fluid to burst the vessel will become very great. The following experiment upon this subject is one of the most interesting and the earliest of which we are in possession. It was published in 1663 by the Marquis of Worcester, and we give it in his own words. "I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end, as also the touch-hole, and making a constant fire under it; within twenty-four hours it burst, and made a great crack."

It is in virtue of the great elastic force by which water, when heated, tends to expand into 1728 times its bulk, in the form of steam, that this element has become a mechanical mover, subject to the control of man. There are two great principles upon which such machines are constructed; the one commonly called high-pressure steam-engines, and the other low-pressure steam-engines.

In a high-pressure steam-engine, the principal source of motion is the *elastic force* of steam, formed by water, raised to a high temperature in confined vessels, and tending to escape from them with such force, as to impart motion and movement to solids or fluids, ingeniously arranged to receive from it velocity or direction required for the accomplishment of some end.

In a low-pressure steam-engine, the principal source of power is derived from using steam merely for the purpose of forming a vacuum. For this purpose steam is admirably calculated. It is only necessary to allow the steam of a liquid to enter any vessel filled with air; and if there be left an aperture of escape, the steam, entering in abundance, will push the air out before it. When the air has wholly escaped, it only remains necessary to close all the openings of the vessel, and allow it gradually to cool down, when the steam will be condensed, will shrivel up in the form of water into the 1728th part of its bulk, leaving the other 1727 parts vacuous. The mechanical force of a vacuum on the earth's surface is well known: it will raise water to a height of more than 30 feet, and support 15 lbs. on every square inch of surface exposed to it. Whatever, therefore, the formation of a vacuum on the earth's surface can effect, of that is the force of steam capable at low pressure, scarcely exceeding the temperature of 212°. Hence the low-pressure engine is sometimes called the condensing engine, because it acts principally by condensation of steam to form a vacuum. The high pressure of steam, and its vacuum-forming power, are frequently used in combination.

Steam.

Warming, Boiling, Distilling, &c., by Steam.

22. There are other properties of steam, besides its mechanical force, that render its use of great practical value. Its great capacity for heat enables it to take up, at one time, and in one place, a large quantity of heat, which it may be employed as a vehicle to transfer, at a subsequent period and at a distant point, to some other substance. It is thus rendered an economizer and distributer, a reservoir of heat derived from the combustion of fuel. In this view it has great value as an agent in distributing the heat used for warming buildings, heating baths, evaporating solutions, distilling, brewing, drying, dyeing, and even for domestic cookery, and the means of extracting wholesome and nutritious food from most unpromising and unpalateable materials.

In order, however, to its successful application as a mechanical power, and its profitable use in each of the various functions which it is capable of performing, it is necessary to study its various phenomena in greater detail; to obtain an intimate acquaintance with its properties; to determine its laws in the various relations of space, time, and quantity; how much heat it requires, what fuel it consumes, what force it exerts, how fast it will move, how it will condense, expand, and contract, and what relation it bears to the different fluids from which it may be derived. Each of these enquiries, and the manner in which each of these objects may be most satisfactorily attained, is the subject of one or other of the following sections of this article.

SECT. II.—EXPERIMENTAL RESEARCHES CONCERNING THE ELASTIC FORCE OF STEAM AT DIFFERENT TEMPERATURES.

Fig. 7.

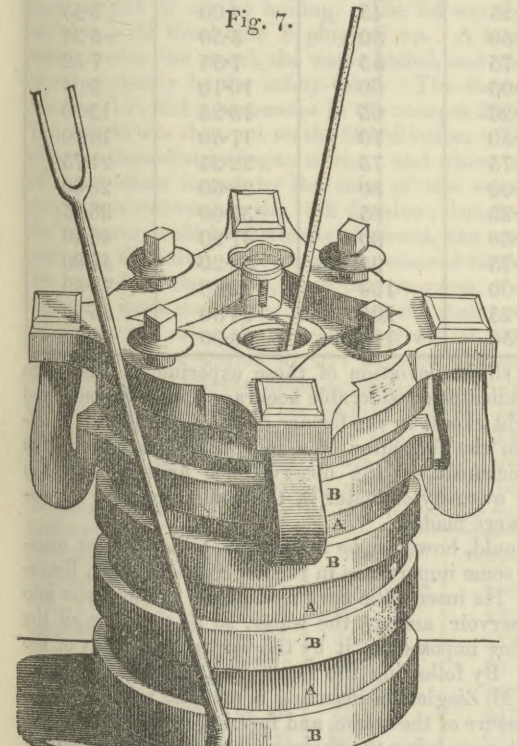
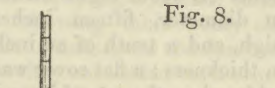


Fig. 8.



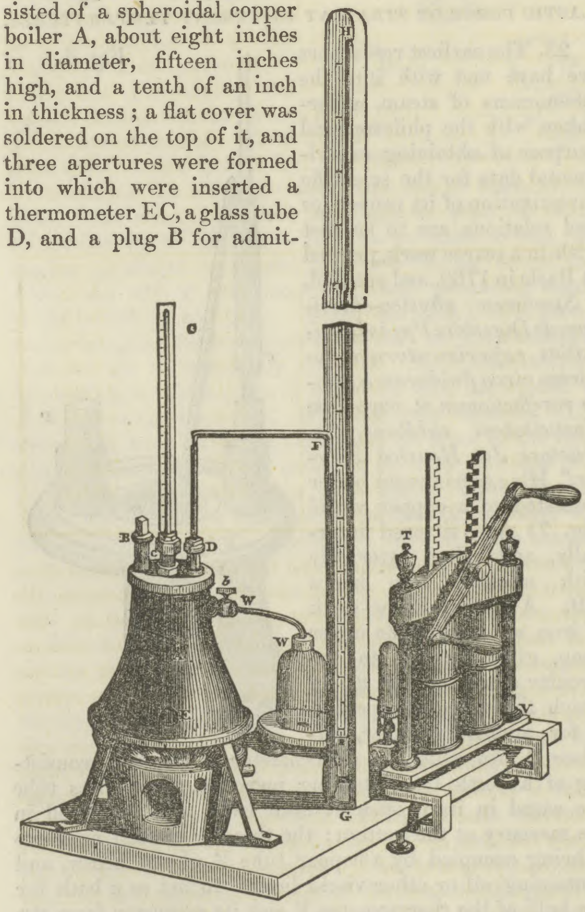
23. The earliest researches we have met with into the phenomena of steam, undertaken with the philosophical purpose of obtaining experimental data for the scientific investigation of its properties and relations, are to be met with in a scarce work, printed at Basle in 1769, and entitled, "*Specimen physico-chemicum de Digestore Papini; primitias experimentorum novorum circa fluidorum a calore rarefactionem et vapoream elasticitatem exhibens, &c. Auctore Jo. Henrico Ziegler.*" His experimental boiler consisted of a copper vessel (fig. 7) AA, silvered internally, and belted externally with massive iron hoops BB. A strong frame-work of iron, attached to the upper hoop, gives support to the circular cover B, (fig. 8,) in which there are an opening P for admitting water, another D into which an elaterometer is inserted, consisting of a bottle G, containing mercury, and a glass tube *c c* cased in iron, open at both ends, and immersed in the mercury at the bottom; the third or central aperture E being occupied by a copper tube F, closed below, and containing oil or other viscid liquid, to act as a bath for the bulb of the thermometer F and its protector from the pressure of the vapour. The method of using this apparatus was as follows. The digester being partly filled with water, closed and placed on the fire, the generation of the steam would raise the oil or mercury in the bath

(E) to the temperature of the water and steam within, so as to give to the thermometer F an indication of the temperature; and, at the same time, the elastic force of the steam flowing or moving by would raise it in C to a certain number of inches, so as to cause the corresponding pressure. This apparatus is both appropriate and ingenious, and indicates considerable mechanical knowledge in its inventor, a physician of Winterthour in Switzerland. Unhappily he lived too remote from the scene of the philosophical discoveries of that period, to adopt the precautions necessary to give value to his experiments. He allowed atmospheric air to mingle with the steam to such an extent as greatly to vitiate his results.

M. Betancourt's Experiments.

24. M. Betancourt visited England about the end of last century; and having been employed to select machines, models, and drawings for the Spanish government, made himself acquainted with the use of steam in Great Britain at that period. On his return, he immediately undertook a series of experiments on the force of the vapour of water, alcohol, and other liquids, at various temperatures. His apparatus is tolerably perfect; and the precautions which he adopted for the removal of atmospheric air from intermixture with the vapour, give his experiments considerable value and precision. Some of his experiments were made in vacuo; and he seems to have been one of the first philosophers who examined the production of steam at temperatures below the ordinary point of ebullition, under the pressure of the atmosphere His experiments extend from 32° up to 279°, being 67° above the ordinary boiling point.

Fig 9.



His apparatus (Fig. 9) consisted of a spheroidal copper boiler A, about eight inches in diameter, fifteen inches high, and a tenth of an inch in thickness; a flat cover was soldered on the top of it, and three apertures were formed into which were inserted a thermometer EC, a glass tube D, and a plug B for admitting water. The glass tube being bent downwards at F, was recurved upwards at G, leaving an upright stem, ten feet high, and hermetically scaled at the top, so as to leave a perfect vacuum in that end of the tube, over a column of mercury of about 30 inches in the two branches of the recurvation at the bottom. The boiler was provided with a stop-cock *b*, by which the air was extracted from the boiler previous to experiment, by means of an air-pump TV, communicating with W; and when this was accomplished so as to obtain a vacuum on both ends of the mercurial column, the mercury stood, as in the figure, on nearly the same level in both its branches. The fire was instantly applied, and the crackling noise which followed informed him that the ebullition had commenced, and the steam in the boiler pressing on that end of the mercurial column nearest to it, raised the other in the vacuum a certain quantity above its outer level, indicating its elastic force, which gradually increased until it became at the usual heat of boiling water, equal to twenty-eight French inches, the mean pressure of the atmosphere. The following table will enable us to estimate the value of these experiments; it is given in degrees of Reaumur's thermometer, of which 0° coincides with 32° of our common scale, and 80° with our boiling point 212° Fahrenheit, each degree of Reaumur being equal to 2¼ of our scale. The pressure is in French inches of mercury:—

Degrees of Fahrenheit.	Reaumur's Scale.	First Series of Observations.	Second Series of Observations
		Inches of Mercury.	Inches of Mercury.
32°	0°	0·0	0·0
43·25	5	0·05	0·02
54·50	10	0·17	0·15
65·75	15	0·35	0·35
77·00	20	0·62	0·65
88·25	25	1·00	1·05
99·50	30	1·50	1·52
110·75	35	2·12	2·15
122·00	40	2·90	2·92
133·25	45	4·00	3·95
144·50	50	5·50	5·35
155·75	55	7·55	7·32
167·00	60	10·10	9·95
178·25	65	13·25	13·20
189·50	70	17·50	16·90
200·75	75	22·35	21·75
212·00	80	28·60	28·00
223·25	85	37·00	36·45
234·50	90	47·20	46·40
245·75	95	58·20	57·80
257·00	100	72·40	71·80
268·25	105	84·90	86·80
279·50	110	98·00	98·00

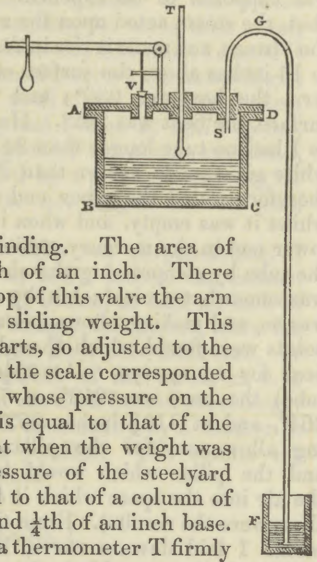
The slight deviation of these experiments from each other indicates considerable accuracy of experiment; and the slight excess in the former of the two series is attributed to the formation of a less perfect vacuum at the commencement of the observations, arising from the smaller quantity of water in the boiler when the experiments were made.

It should, however, be noticed, that there is one omission of some importance in the experiments of M. Betancourt. He inserts the *bare bulb* of his thermometer into the reservoir among the water, so as to suffer all the variations imposed on it by the varying elasticity of the steam. By following the method adopted by his predecessor, M. Ziegler, of inserting a metallic tube to sustain the pressure of the steam, and forming it into a mercurial bath for containing the thermometer, and so transmitting the heat of the steam to it without exposure to variable pressure, a source of considerable error might have been avoided. This precaution is essential to a good set of experiments on steam; for a very slight pressure, even of the finger, on the bulb of a thermometer will raise it several degrees.

25. Of British philosophers, Dr Robison was one of the first to make accurate and systematic experiments on the

phenomena of the temperature and elastic force of steam. They appear to have been made in 1778. His apparatus is represented in the accompanying figure.

Fig. 10.



* ABCD (Fig. 10.) is the section of a small digester made of copper. Its lid, which was fastened to the body with screws, was pierced with three holes, each of which had a small pipe soldered into it. The first hole was furnished with a brass safety-valve V, nicely fitted to it by grinding. The area of this valve was exactly $\frac{1}{4}$th of an inch. There rested on the stalk at the top of this valve the arm of a steel-yard carrying a sliding weight. This arm had a scale of equal parts, so adjusted to the weight, that the number on the scale corresponded to the inches of mercury, whose pressure on the under surface of the valve is equal to that of the steelyard on its top; so that when the weight was at the division 10, the pressure of the steelyard on the valve was just equal to that of a column of mercury 10 inches high, and $\frac{1}{4}$th of an inch base. The middle hole contained a thermometer T firmly fixed into it, so that no vapour could escape by its sides. The ball of this thermometer was but a little way below the lid. The third hole received occasionally the end of a glass pipe SGF, whose descending leg was about 36 inches long. When this syphon was not used, the hole was properly shut with a plug.

* The vessel was half filled with distilled water which had been purged of air by boiling. The lid was then fixed on, having the third hole S plugged up. A lamp being placed under the vessel, the water boiled, and the steam issued copiously by the safety-valve. The thermometer stood at 213°, and a barometer in the room at 29.9 inches. The weight was then put on the fifth division. The thermometer immediately began to rise; and when it was at 220, the steam issued by the sides of the valve. The weight was removed to the 10th division; but, before the thermometer could be distinctly observed, the steam was issuing at the valve. The lamp was removed further from the bottom of the vessel, that the progress of heating might be more moderate; and when the steam ceased to issue from the valve, the thermometer was at 227. The weight was now shifted to 15; and, by gradually approaching the lamp, the steam again issued, and the thermometer was at 232½. This mode of trial was continued all the way to the 75th division of the scale. The experiments were then repeated in the contrary order; that is, the weight being suspended at the 75th division, and the steam issuing strongly at the valve, the lamp was withdrawn, and the moment the steam ceased to come out, the thermometer was observed. The same was done at the 70th, 65th division, &c. These experiments were several times repeated both ways; and the means of all the results for each division are expressed in the subjoined table, where column 1st expresses the elasticity of the steam, being the sum of 29.9; and the division of the steelyard, column 2d, expresses the temperature of the steam corresponding to this elasticity.

Elasticity.	Temperature.
35 inches.	209 °
40	226
45	232
50	237
55	242
60	247
65	251
70	255
75	259
80	263
85	267
90	270½
95	274½
100	278
105	281

Dr Robison's Experiments.

* A very different process was necessary for ascertaining the elasticity of the steam in lower temperatures, and consequently under smaller pressures than that of the atmosphere. The glass syphon SGF was now fixed into its hole in the lid of the digester. The water was made to boil smartly for some time, and the steam issued copiously both at the valve and at the syphon. The lower end of the syphon was now immersed into a broad saucer of mercury, and the lamp instantly removed, and every thing was allowed to grow cold. By this the steam was gradually condensed, and the mercury rose in the syphon, without sensibly sinking in the saucer. The valve and all the joints were smeared with a thick clammy cement, composed of oil, tallow, and rosin, which effectually prevented all ingress of air. The weather was clear and frosty, and the barometer standing at 29.84, and the thermometer in the vessel at 42°. The mercury in the syphon stood at 29.7, or somewhat higher, thus showing a very complete condensation. The whole vessel was surrounded with pounded ice, of the temperature 32°. This made no sensible change in the height of the mercury. A mark was now made at the surface of the mercury. One observer was stationed at the thermometer, with instructions to call out as the thermometer reached the divisions 42, 47, 52, 57, and so on by every five degrees till it should attain the boiling heat. Another observer noted the corresponding descents of the mercury by a scale of inches, which had its beginning placed at 29.84 from the surface of the mercury in the saucer.

* The pounded ice was now removed, and the lamp placed at a considerable distance below the vessel, so as to warm its contents very slowly. These observations being very easily made, were several times repeated, and their mean results are set down in the following table: only observe, that it was found difficult to note down the descents for every fifth degree, because they succeeded each other so fast. Every 10th was judged sufficient for establishing the law of variation. The first column of the table contains the temperature, and the second the descent (in inches) of the mercury from the mark 29.84.

Temperature.	Elasticity.	Temperature.	Elasticity.
32 °	0.0	130 °	3.95
40	0.1	140	5.15
50	0.2	150	6.72
60	0.35	160	8.65
70	0.55	170	11.05
80	0.82	180	14.05
90	1.18	190	17.85
100	1.61	200	22.62
110	2.25	210	28.65
120	3.00		

Four or five numbers at the top of the column of elasticities, are not so accurate as the others, because the mercury passed pretty quickly through these points. But the progress was extremely regular through the remaining points; so that the elasticities corresponding to temperatures above 70° may be considered as very accurately ascertained.

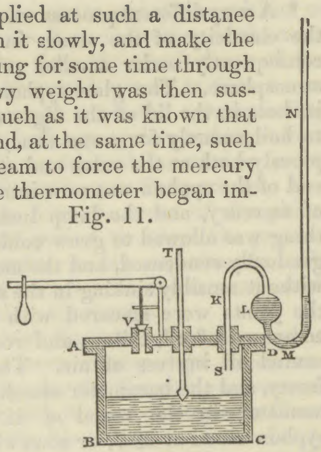
* Not being altogether satisfied with the method employed for measuring the elasticity in temperatures above that of boiling water, a better form of experiment was adopted. Indeed it was the want of other apparatus which made it necessary to employ the former. A glass tube was procured of the form represented in Fig. 11, having a little cistern L, from the top and bottom of which proceeded the syphons K and MN. The cistern contained mercury, and the tube MN was of a slender bore, and was about six feet two inches long. The end K was firmly fixed in the third hole of the lid, and the long leg of the syphon was furnished with a scale of inches, and firmly fastened to an upright post.

Steam.

Dr Robison's Experiments.

The lamp was now applied at such a distance from the vessel as to warm it slowly, and make the water boil, the steam escaping for some time through the safety-valve. A heavy weight was then suspended on the steelyard; such as it was known that the vessel would support, and, at the same time, such as would not allow the steam to force the mercury out of the long tube. The thermometer began immediately to rise, as also the mercury in the tube MN. Their correspondent stations are marked in the following table.

Fig. 11.



Temperature.	Elasticity.
212°	0.0
220	5.9
230	14.6
240	25.0
250	36.9
260	50.4
270	64.2
280	76.0

This form of the experiment is much more susceptible of accuracy than the other, and the measures of elasticity are more to be depended on. In repeating the experiment, they were found much more constant; whereas, in the former method, differences occurred of two inches and upwards.

* We may now connect the two sets of experiments into one table, by adding to the numbers in this last table the constant height 29.9, which was the height of the mercury in the barometer during the last set of observations.

Temperature.	Elasticity.	Temperature.	Elasticity.
32°	0.0	160	8.65
40	0.1	170	11.05
50	0.2	180	14.05
60	0.35	190	17.85
70	0.55	200	22.62
80	0.82	210	28.65
90	1.18	220	35.8
100	1.6	230	44.5
110	2.25	240	54.9
120	3.0	250	66.8
130	3.95	260	80.3
140	5.15	270	94.1
150	6.72	280	105.9

Mr Watt's Experiments.

26. In the mean time, however, Mr Watt had been led, in the course of his invention of the steam-engine, to make experiments on the elastic force of steam, of which he has given the following account, and which was annexed by himself to Dr Robison's original article in this work.

† In the winter of 1764–5, I made experiments at Glasgow on the subject, in the course of my endeavours to improve the steam-engine, and as I did not then think of any *simple* method of trying the elasticities of steam at temperatures less than that of boiling water, and had at hand a digester by which the elasticities at greater heats could be tried, I considered that, by establishing the ratios in which they proceeded, the elasticities at lower heats might be found nearly enough for my purpose. I therefore fitted a thermometer to the digester, with its bulb in the inside, placed a small cistern with mercury also within the digester, fixed a small barometer tube with its end in the mercury, and left the upper end open. I then made the digester boil for some time, the steam issuing at the safety-valve, until the air contained in the digester was supposed to be expelled. The safety-valve being shut, the steam acted upon the surface of the mercury in the cistern, and made it rise in the tube. When it reached to 15 inches above the surface of the mercury in the cistern, the heat was 236°; and at 30 inches above that surface, the heat was 252°. Here I was obliged to stop, as I had no tube longer than 34 inches, and there was no white glass made nearer than Newcastle-upon-Tyne. I therefore sealed the upper end of the tube hermetically, whilst it was empty, and when it was cool immersed the lower end in the mercury, which now could only rise in the tube by compressing the air it contained. The tube was somewhat conical; but, by ascertaining how much it was so, and making allowances accordingly, the following points were found, which, though not exact, were tolerably near for an *aperçu*. At 29½ inches (with the sealed tube) the heat was 252°, at 75½ inches the heat was 264°, and at 110½ inches 292°. (That is, after making allowances for the pillar of mercury supported, and the pillar which would be necessary to compress the air into the space which it occupied, these were the results). From these elements I laid down a curve, in which the abscissæ represented the temperatures, and the ordinates the pressures, and thereby found the law by which they were governed, sufficiently near for my then purpose. It was not till the years 1773–4, that I found leisure to make further experiments on this subject, of which, though I do not consider the results as accurate, I shall give an account here, as they were in point of date prior to any others that I was then acquainted with.

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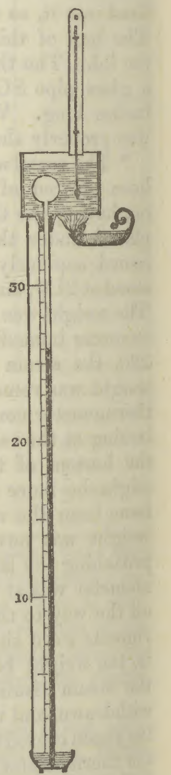
Mr W

Exper

ments.

Fig. 12.



† A tin pan, of about five inches in diameter and four inches deep, had a hole made in its bottom, near one side, and in this hole was soldered a socket somewhat conical, which nearly fitted a barometer tube with which the experiments were to be made. This tube was about 36 inches long, and had a ball at one end about 1½ inches diameter, the contents of which were nearly equal to those of the stem of the tube; some paper was lapped round the tube near the ball, and it was forced tight into the conical socket of the pan, so that the ball was within the latter, at such a height that it might be immersed in water. The tube and pan were then inverted, and the ball was filled with clean mercury, and the stem with distilled water fresh boiled. The tube was re-inverted, so that the ball and pan were uppermost; the lower end of the tube being shut by the finger, the water ascended into the ball, and the mercury occupied the tube. The lower end of the latter being then placed in a cistern of mercury, and released from the finger, the mercury and water descended, and the ball was left partly empty: being agitated in this position, and let stand some time, much air was extricated from the water; the tube was inclined as much as it could be, and again inverted, the air let out, and its place supplied with boiling water. It was again placed with the ball uppermost, the end of the tube stopped, the pan filled with hot water which was made to boil by means of a lamp, the lower end of the tube being

Mr Watt's Experiments.

placed in the cistern, and released from the finger, the mercury descended into the cistern, but upon the water in the pan being suffered to cool, partly rose again into the tube. Much air was thus liberated, and more was got rid of by agitation, in the manner of the water-hammer, and by leaving it standing for some time erect, until at last I got it so free from air, that when I raised it upright, it supported a column of mercury 34 inches high; and no vacuum was formed until it was violently shaken, when it fell down suddenly and settled at 28.75 inches, but upon being inclined, a speck of air always remained, though, when it was expanded by a pillar of mercury 27 inches high, this speck was not larger than a pin's head.

† In this state, when the tube was perpendicular, I found the mercury to stand at 28.75 inches, the column of water above it was about 6½ inches, = half an inch of mercury. The whole then being 29.25 inches, when the stationary barometer stood at 29.4, the difference, or pillar supported by the elasticity of the steam = 0.15 inch. The water in the pan was then heated exceedingly slowly by a lamp, and stirred continually by a feather to make the heat as equal as possible. The results are shown in the following table :—

Table No. I.

Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.
	Inches.		Inches.		Inches.		Inches.
55°	0.15	135°	4.53	167°	11.07	187°	17.51
74	0.65	142	5.46	172	11.95	189	18.45
81	0.80	148	6.40	175	12.88	191	19.38
95	1.30	153	7.325	177.5	13.81	193.5	20.34
104	1.75	157	8.25	180	14.73	196.5	21.26
118	2.68	161	9.18	182.5	15.66		
128	3.60	164	10.10	185	16.58		

At this time (1774) I tried a set of experiments in the same manner on a saturated solution of common salt. When this solution was perfectly saturated by boiling, and was put into the tube, it precipitated a quantity of salt which disturbed the experiment. I was therefore obliged to take it out, and filter it, during which process it attracted moisture from the air, and appeared, by its boiling point, not to be perfectly saturated. Though it was more free from air than water is, yet it parted from what it contained with great difficulty, and would part with none when shaken as a water-hammer, though it opened in all parts of the liquor. The result of this experiment is contained in the annexed table :—

Table No. II.—*Stationary Barometer*, 29.5.

Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.
	Inches.		Inches.		Inches.		Inches.
46°	0.01	154°	5.36	187°	12.67	208°	20.86
76	0.36	160	6.27	193.5	14.5	210	21.8
85	0.58	165	7.2	195.5	15.34	212	22.74
92	0.81	169	8.12	198.5	16.25	214	23.66
113	1.72	173	9.03	201.5	17.16	216	24.6
129	2.63	177	9.94	203.5	18.1	218	25.52
139	3 54	180	10.85	205.5	19.03	220	26.5
147	4.45	183	11.76	207	19.94		

In the same manner I tried a set of experiments upon spirit of wine, the results of which are contained in the annexed table :—

Table No. III.

Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.
	Inches.		Inches.		Inches.		Inches.
34°	0.22	120°	7.12	146.5°	15.03	164°	22.59
40	0.929	124.5	8.46	148.5	15.974	166	23.53
67	1.897	128	9.4	151	16.908	167	24.47
84	2.806	132	10.34	152.5	17.85	168	25.4
95	3.744	135	11.32	155	18.8	169	26.35
103	4.728	139	12.21	157	19.75	171	27.3
110	5.63	141.5	13.15	160	20.71	Stat. Bar. 29.4	
114	6.58	144	14.1	162.5	21.65		

Upon considering the probable cause of the difference, especially in the lower heats, between my experiments and those of Mr Southern, related in his letter annexed to this essay, I can only reconcile them by supposing that the stationary barometer, with which the comparison was made, had its scale placed 0.2 of an inch too low, and by adding that quantity to the elasticities in table 1st, they approach nearly to Mr Southern's experiments.

If that conjecture is adopted, the same addition will be necessary to tables 2d and 3d, as they were compared with the same stationary barometer.

To determine the heats at which water boils when pressed by columns of mercury above 30 inches, a tube of 55 inches long was employed; one end was put through a hole in the cover of a digester, and made tight by being lapped round with paper, and within the digester the end of the tube was immersed in a cistern of mercury. A thermometer was fixed in another opening, so that the bulb was in the inside of the digester, and the stem and scale without; and the bulb was kept half an inch from the cover of the digester by a wooden collar. The cover being fixed on tight, and the digester half filled with water, it was heated by means of a large lamp.

† The air in the upper part of the digester expanding by heat, the column of mercury in the tube was considerably raised by that expansion before the water boiled. The air was let out, and the water heated to boiling; still, however, some air remained, for the mercury stood at 213½°. That deduction being made, the following table shows the heats and corresponding elasticities.

Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.	Heats.	Elasticities.
213°	30	228°	39	240°	49	259°	66
215	31	229.5	40	242.5	50	261	68
217	32	231	41	244.5	52	262.5	70
219	33	232.5	42	247	54	264.5	72
220.5	34	234	43	248.5	56	266.5	74
222	35	235	44	250.5	58	268	76
223.5	36	236.5	45	252.5	60	269.5	78
225	37	237.5	46	255	62	271	80
226.5	38	238.5	47	257	64	272.5	82

In making these experiments, the digester was heated very slowly, and the heat was kept stationary as much as was possible at each observation, so that the whole series occupied some hours. The degrees of elasticity were observed by my friend Dr Irvine, whilst I observed those of the thermometer in all these experiments.

With the whole of the observations, I was, after all, by no means satisfied, as I perceived there were irregularities in the results which my more urgent avocations did not permit me to explore the causes of and to correct.

The matter remained in that state till 1796, when I requested Mr Southern to try them over again, in the

Mr Watt's Experiments.

performance of which he was assisted by Mr William Creighton. The results of these observations are contained in Mr Southern's letter to me, which follows this memoir; and, from the very great care with which the experiments were made, the known accuracy of both Mr Southern and Mr Creighton, and the agreement of the experiments with one another, I have reason to believe them as nearly perfect as the subject admits of. The method he adopted of trying the elasticities above the temperature of boiling water by a piston, accurately fitted to a cylinder, is much to be preferred to that adopted by Dr Robison, and is more manageable under great elasticities than that of a long pillar of mercury.

Mr Southern's Experiments.

27. The reference which is here made applies to the following letter from Mr *Southern** to Mr Watt :—

" Dear Sir,—The experiments of which the particular circumstances are hereafter related, were made in 1803, with the view of ascertaining chiefly the density of steam raised from water under different pressures above that of the atmosphere, an apparatus having then been made for a different purpose, which seemed pretty well adapted to this object.

" Besides the experiments now to be related, in which the temperature of steam raised under *high* pressures was observed in 1803, others had been made some years before, in 1797 and 98, for that purpose only; and, as they were made with the greatest circumspection, both the manner of making them and their results may be here described, as may also the results of other experiments, made with equal care, to ascertain the temperature of steam raised under *low* pressures.

" The instrument used in the former was a Papin's digester, similar to what you had used; the leading differences being in adapting a metallic tube to it to contain the thermometer, or rather as much of it as contained mercury, in the manner mentioned in the beginning of this letter, and instead of a valve, by the load on which to measure the elasticity of the contained steam, a nicely bored cylinder was applied, with a piston fitting it, so as to have very little friction, and to the rod of this was applied a lever, constructed to work on edges like those of a scale-beam, by which the resistance against the elastic force of the steam could be accurately determined; and at your suggestion, to be assured that no inaccuracy had crept into the calculation, by which this resistance, through the medium of the lever, was ascertained, an actual column of mercury of 30 inches high was substituted, and the correspondence was found to be within $\frac{1}{100}$ of an inch.

" The observations at each of the points of pressure noted were continued some minutes, the temperature at each being alternately raised and lowered, so as to make the pressure of the steam on the under side of the piston alternately too much and too little for the weight with which it was loaded; and thence a mean temperature was adopted, the extremes of which were, as well as I now recollect, not more than half a degree on each side of it. The load on the piston, including its own weight, &c., &c., was calculated to be successively just equal to 1, 2, 4, and 8 atmospheres of 29.8 inches of mercury each, and the temperature of the steam was varied as above till that of each point was determined; the results were thus :—

Atmospheres.	Pressure in inches of Mercury.	Temperatures.
1	29.8	212°
2	59.6	250 3
4	119.2	293.4
8	238.4	343.6

" The experiments for ascertaining the temperature of steam below the atmospheric pressure were made with an apparatus essentially similar to that which you originally used, and with scrupulous care and attention: and I met with the same incidents as you had done; such as, the production of a bubble of air whenever, after any experiment, the tube was inclined to refill the ball; and also the extraordinary suspension of a column of mercury of 35 inches vertical height, and of 7 inches of water above that, although the counterpoise was only that of the atmosphere, then under 30 inches. I found also that the tube required a considerable degree of tabouring or shaking to make the column subside and leave a space in the ball. This phenomenon was not produced till after much pains taken in inverting and re-inverting the tube again and again, nor till it had been suffered, after these operations, to stand for three or four days undisturbed in the exhausting position, and then discharging the air that had been accumulating in the interval.

" The results to be found in the table below, were deduced from the observations as you had done—viz., by adding to the height of the column of mercury in the tube (ascertained by a gauge floating on the surface of the mercury in the basin), that of the water above it, or rather of an equivalent column of mercury, and subtracting their sum from the height of the common barometer at the time. All these results were taken from observations made after the apparatus had been so perfectly exhausted of air as to produce the phenomenon just mentioned.

Temperature.	Elasticity.			
	1st Set.	2d Set.	3d Set.	Mean.
	Inches.	Inches.	Inches.	Inches.
52°	0.	0.42	0 40	0.41
62	0.53	0.52	0.52	0.52
72	0.73	0.73	0.73	0.73
82	1.03	1.02	1.02	1.02
92	1.42	1.41	1.42	1.42
102	1.98	1.92	1.95	1.95
112	2.67	2.63	2.66	2.65
122	3.58	3.54	3.58	3.57
132	4.68	4.65	4.72	4.68
142	6.05	6.00	6.14	6.06
152	7.86	7.80	7.89	7.85
162	9.98	9.96	10.04	9.99
172	12.54	12 72	12.67	12.64
182	16.01	15.84	15.88	15.91

" The following formula will be found to give the elasticity belonging to a given temperature, and *vice versa*, with a sufficient degree of accuracy for most purposes, within the range of the experiments, at least, from which they have been formed.

Let t = temperature, e = elasticity, in inches of mercury;

$$T = t + 52, \text{ and } E = e - \tfrac{1}{10},\ m = 94250{,}000000;$$

Then

$$\frac{T^{5.14}}{m} = E$$

$$\sqrt[5.14]{Em} = T$$

" But as the calculation is most easily performed by logarithms, let L signify the logarithm of the quantity to which it is prefixed :

$$\text{Then}\quad 5.14\,LT - 10.97427 = LE$$

$$\frac{LE + 10.97427}{5.14} = LT.$$

" The following table shows the observed elasticities, those derived from calculation by the formula, and the differences of the two, which appear to me to be as small as can be expected, taking a general view.

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* In all these experiments Mr Southern was assisted by Mr William Creighton.

Temperature.	Observed Elasticities.	Calculated Elasticities.	Differences.
	Inches.	Inches.	Inches.
32o		0.18	
42		0.25	
52		0.35	
62	0.52	0.50	—0.02
72	0.73	0.71	—0.02
82	1.02	1.01	—0.01
92	1.42	1.42	0.00
102	1.95	1.96	+0 01
112	2.65	2.67	+0.02
122	3.57	3 58	+0.01
132	4.68	4.74	+0.06
142	6.06	6.20	+0.14
152	7.85	7.99	+0.14
162	9.99	10.19	+0.20
172	12.64	12.86	+0.22
182	15.91	16.08	+0.17
192	. . .	19.91	. . .
202	. . .	24.45	. . .
212	29.80	29.80	0.00
250.3	59.60	59.69	+0.09
293.4	119.20	118.32	—0.88
343.6	238.40	237.60	—0.80

"I believe it is now generally considered that the temperature 212° is that of water boiling when the barometer is at 30 inches instead of 29.8; and if, in the above algebraic expressions, the following alterations be made, the results from the formulæ will correspond with the adjustment of that point, and fully as well with the experiments generally.

"Let $T=t+51.3$; the index of the power and of the root be 5.13, instead of 5.14; and $m=87344,000000$. So the two last equations will be: $5.13\,LT—10.94123=LE$; and $\frac{LE+10.94123}{5.13}=LT$.

"The table will stand as follows, supposing the thermometer had been graduated for 212° to correspond with 30 inches of the barometer:—

Temp.	Observd. Elasticities.	Calcul. Elasticities.	Differences.	Temp.	Observd. Elasticities.	Calcul Elasticities.	Differences.
	Inches	Inches.	Inches.		Inches.	Inches.	Inche
32	*0.16	0.18	+0.02	142°	6.10	6 22	+0.12
42	*0.23	0.25	+0.02	152	7.90	8 03	+0.13
52	*0.35	0.35	0.00	162	10 05	10.25	+0.20
62	0.52	0.50	—0.02	172	12.72	12.94	+0.22
72	0.73	0.71	—0.01	182	16.01	16.17	+0.16
82	1.02	1.01	—0 01	192	. . .	20.04	. . .
92	1.42	1.42	0.00	202	. . .	24.61	. . .
102	1.96	1.97	+0.01	212	30.00	30.00	
112	2.66	2 68	+0.02	250.3	60.00	60.11	+0.11
122	3.58	3.60	+0.02	293.4	120.00	119.17	—0.3
132	4.71	4.76	+0.05	343.6	240.00	239.28	—02

"I remain, with the greatest esteem and respect, Dear Sir, Your very obedient Servant,

"*Oakhill, 26th March*, 1814."

"JOHN SOUTHERN.

"To JAMES WATT, Esq., Heathfield."

Achard's Experiments.

28. In the *Memoirs of the Royal Academy of Berlin* for 1782, there is an account of some experiments made by M. Achard on the elastic force of steam, from the temperature 32° to 212°. They agree extremely well with those mentioned here, rarely differing more than two or three-tenths of an inch. He also examined the elasticity of the vapour produced from alcohol, and when the elasticity was equal to that of the vapour of water, he found that the temperature was about 35° lower. Thus, when the elasticity of both was measured by 28.1 inches of mercury, the temperature of the watery vapour was 209°, and that of the spirituous vapour was 173°. When the elasticity was 18.5, the temperature of the water was 189.5°, and that of the alcohol 154.6°. When the elasticity was 11.05, the water was 168°, and the alcohol 134.4° Observing the difference between the temperature of equally elastic vapours of water and alcohol not to be constant, but gradually to diminish, in M. Achard's experiments, along with the elasticity, it became interesting to discover whether, and at what temperature, this difference would vanish altogether. Experiments were accordingly made by the writer of this article, similar to those made with water. They were not made with the same scrupulous care, nor repeated as they deserved, but they furnished rather an unexpected result. The following table will give the reader a distinct notion of them.

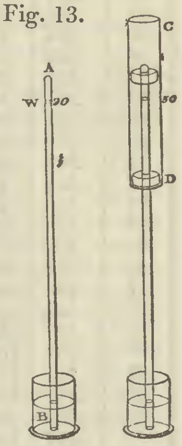
Temperature.	Elasticity.	Temperature.	Elasticity.
32°	0.0	140	12.2
40	0.1	160	21.3
60	0.8	180	34.
80	1.8	200	52.4
100	3.9	220	78.5
120	6 9	240	115.

Dr Dalton's Experiments.

29. Dr Dalton appears to have been the first to escape from the natural enough error of assuming that the vapour of water at 32° would be = 0. His apparatus is the most simple and refined of any that have been employed for temperatures below 212°, and his experiments are those which, to the present day, have the greatest authority. Dr Dalton's first experiments were published in 1793, in his *Meteorological Essays;* afterwards, when more extended, in the *Manchester Memoirs*, 1802; then in the first volume of his *System of Chemistry*, 1808; and finally in the second volume of the same work, 1827. The following is the account given by himself, of his early experiments, in the *Manchester Memoirs.*

"My method is this: I take a barometer tube AB, (Fig. 13,) perfectly dry, and fill it with mercury just boiled, marking the place (30) where it is stationary; then, having graduated the tube, I pour a little water, or any other liquid, the subject of experiment, into it, so as to moisten the whole inside: after this I again pour in mercury, and carefully inverting the tube, exclude all air; the barometer, by standing some time, exhibits a portion of water of $\frac{1}{8}$ or $\frac{1}{10}$th of an inch, W, on the top of the mercurial column; because, being lighter, it ascends by the side of the tube, which may now be inclined, and the mercury will rise to the top, manifesting a perfect vacuum from air. I next take a cylindrical glass tube CD, open at both ends, of two inches diameter and fourteen inches in length, to each end of which a cork is adapted, perforated in the middle, so as to admit a barometer tube to be put through, and to be held fast by them; the upper cork, C, is fixed two or three inches below the top of the tube, and is one-half cut away, so as to admit water, &c., to pass by, its service being merely to keep the tube steady. Things being thus circumstanced; water of any temperature may be poured into the wide tube, and thus made to surround the upper part or vacuum of the barometer, and the effect of temperature in the production of vapour within can be observed from the depression of the mercurial column at the top. In this way I have had water as high as 155° surrounding the vacuum; but as the higher temperatures might endanger a glass apparatus, instead of it I used the following:—

Fig. 13.



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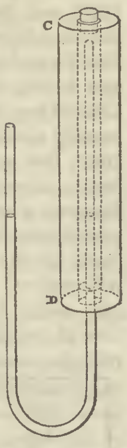
* These are inserted from numerous experiments made by Mr W. Creighton.

Steam.

Dr Dalton's Experiments.

Fig. 14.



Having procured a tin tube CD, four inches in diameter, and two feet long with a circular plate soldered to one end, having a round hole in the centre, like the tube of a reflecting telescope, I got another smaller tube of the same length soldered into the larger, so as to be in the axis or centre of it; the small tube was open at both ends, and on this construction water could be poured into the large vessel to fill it, while the central tube was exposed to its temperature. Into this central tube I could insert the upper half of a syphon barometer, and fix it by a cork, the top of the narrow tube, also, being corked—thus the effect of any temperature under 212° could be ascertained, the depression of the mercurial column being known by the ascent in the exterior leg of the syphon. The force of vapour from water between 80° and 212°, may also be determined by means of an air-pump, and the result exactly agrees with those determined as above."

"After repeated experiments by all those methods, and a careful comparison of the results, I was enabled to digest the following :—

Table of the Force of Steam from Water in the temperatures from 32° *to* 212° (1802.)

Temperature.	Force of Vapour in inches of Mercury.	Temperature.	Force of Vapour in inches of Mercury.	Temperature.	Force of Vapour in inches of Mercury.	Temperature.	Force of Vapour in inches of Mercury.
32°	.200	78°	.940	123°	3.59	168°	11.54
33	.207	79	.971	124	3.69	169	11.83
34	.214	80	1.00	125	3.79	170	12.13
35	.221	81	1.04	126	3.89	171	12.43
36	.229	82	1.07	127	4.00	172	12.73
37	.237	83	1.10	128	4.11	173	13.02
38	.245	84	1.14	129	4.22	174	13.32
39	.254	85	1.17	130	4.34	175	13.62
40	.263	86	1.21	131	4.47	176	13.92
41	.273	87	1.24	132	4.60	177	14.22
42	.283	88	1.28	133	4.73	178	14.52
43	.294	89	1.32	134	4.86	179	14.83
44	.305	90	1.36	135	5.00	180	15.15
45	.316	91	1.40	136	5.14	181	15.50
46	.328	92	1.44	137	5.29	182	15.86
47	.339	93	1.48	138	5.44	183	16.23
48	.351	94	1.53	139	5.59	184	16.61
49	.363	95	1.58	140	5.74	185	17.00
50	.375	96	1.63	141	5.90	186	17.40
51	.388	97	1.68	142	6.05	187	17.80
52	.401	98	1.74	143	6.21	188	18.20
53	.415	99	1.80	144	6.37	189	18.60
54	.429	100	1.86	145	6.53	190	19.00
55	.443	101	1.92	146	6.70	191	19.42
56	.458	102	1.98	147	6.87	192	19.86
57	.474	103	2.04	148	7.05	193	20.32
58	.490	104	2.11	149	7.23	194	20.77
59	.507	105	2.18	150	7.42	195	21.22
60	.524	106	2.25	151	7.61	196	21.68
61	.542	107	2.32	152	7.81	197	22.13
62	.560	108	2.39	153	8.01	198	22.69
63	.578	109	2.46	154	8.20	199	23.16
64	.597	110	2.53	155	8.40	200	23.64
65	.616	111	2.60	156	8.60	201	24.12
66	.635	112	2.68	157	8.81	202	24.51
67	.655	113	2.76	158	9.02	203	25.10
68	.676	114	2.84	159	9.24	204	25.61
69	.698	115	2.92	160	9.46	205	26.13
70	.721	116	3.00	161	9.68	206	26.66
71	.745	117	3.08	162	9.91	207	27.20
72	.770	118	3.16	163	10.15	208	27.74
73	.796	119	3.25	164	10.41	209	28.29
74	.823	120	3.33	165	10.68	210	28.84
75	.851	121	3.42	166	10.96	211	29.41
76	.880	122	3.50	167	11.25	212	30.00
77	.910						

Dr Dalton afterwards resumed the experimental examination of this subject, and was induced to modify these numbers slightly, as will be seen from our final table.

30. Passing over the experiments of Schmidt, Goldner, and others, as presenting no important differences from some of these we have already noticed, we come to those of Dr Ure, published in the *Philosophical Transactions* of 1818, and made at Glasgow during 1817. The adjoining figures represent his apparatus.

Fig. 15.

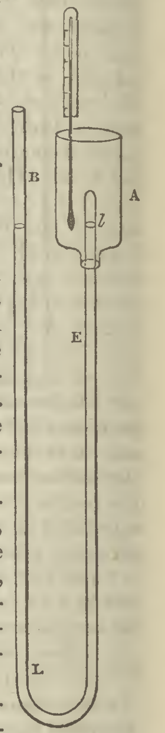


Fig. 15. represents the construction used for temperatures under and a little above the boiling point. Figs. 16. and 17. are those used for higher temperatures, the last being the more convenient of the two; each was suspended from a lofty window ceiling, and placed in a truly vertical position, by means of a plumb line. Dr Ure gives the following account of his mode of experimenting. "One simple principle pervades the whole train of experiments —which is, that the progressive increase of elastic force developed by heat from the liquid, incumbent on the mercury at L *l'*, is measured by the length of column which must be *added* over L, the primitive level below, in order to restore the quicksilver to its primitive level above, at *l*. These two stations or points of departure are nicely defined by a ring of fine platina wire, twisted firmly round the tube.

"At the commencement of the experiment, after the liquid, well freed from air, has been let up, the quicksilver is made a tangent to the edge of the upper ring, by cautiously pouring mercury, in a slender stream, into the open leg of the syphon B, the level ring below is then carefully adjusted.

"From the mode of conducting my experiments, there remained always a quantity of liquid in contact with the vapour, a circumstance essential to accuracy in this research.

"Suppose the temperature of the water or the oil in A to be 32° Fahrenheit, as denoted by a delicate thermometer, or by the liquefaction of ice; communicate heat to the cylinder A, by means of two argand flames, playing gently on its shoulder at each side. When the thermometer indicates 42°, modify the flames, or remove them so as to maintain a uniform temperature for a few minutes. A film or line of light will now be perceived between the mercury and the ring at *l*, as is seen under the vernier of a mountain barometer, when it is raised a few feet off the ground; were the tube at *l* and L, of equal area, or were the relation of the areas experimentally determined, then the rise of the quicksilver above L would be one-half, or a known submultiple of the total depression, equivalent to the additional elasticity of the vapour at 42° above that at 32°. Since the depressions, however, for 30 or 40° in this part of the scale are exceedingly small, one-half of the quantity can scarcely be ascertained with suitable precision, even after taking the above precautions; and besides, the other sources of error, or at least embarrassment, from the inequalities of the tube, and from the lengthening space occupied by the vapour, as the temperature ascends, render this method of reduction very ineligible.

"By the other plan we avoid all these evils; for whatever additional elasticity be communicated to the vapour above *l*, it will be faithfully represented and measured by the mercurial column, which we must add over L, in order to overcome it and restore the quicksilver under *l*, to its zero or initial level, when the platina ring becomes once more a tangent to the mercury. At E, a piece of

Steam.

Dr Ure's Experiments.

cork is fixed between the parallel legs of the syphon to sustain it, and to serve as a point by which the whole is steadily suspended. For temperatures above the boiling point, the part of the syphon under E is evidently superfluous, merely containing in its two legs a useless weight of equipoised mercury. Accordingly, for high heats, the apparatus, Figs. 16 or 17, is employed, and the same method of procedure is adopted; the aperture at O, Fig. 17, admits the bulb of the thermometer, which rests as usual on *l'*. The recurved part of the tube is filled with mercury, and then a little liquid is passed through it to the sealed end. Heat is now applied by an argand flame to the bottom of C, which is filled with oil or water, and the temperature is kept steadily at 212° for some minutes. Then a few drops of quicksilver may be required to be added to D', till L and *l'* be in the same horizontal plane. The further conduct of the experiment differs in no respect from what has been already described—the liquid in C is progressively heated, and at each stage mercury is progressively added over L to restore the initial level or volume at *l'*, by equipoising the progressive elasticity. The column above L being measured, represents the succession of elastic forces: when this column is wished to extend very high, the vertical tube requires to be placed for support in the groove of a long wooden prism.

Fig. 16.

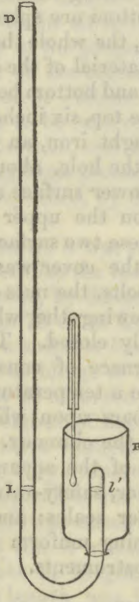
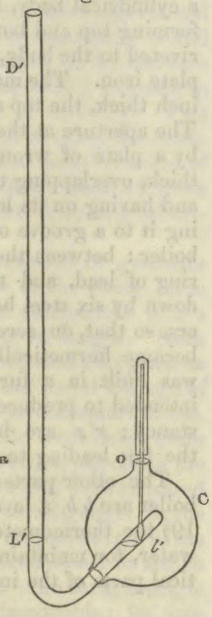


Fig. 17.



“ The height of the column in some of my experiments being nearly twelve feet, it became necessary to employ a ladder to reach its top. I found it to be convenient, in this case, after observing that the column of vapour had attained its primitive magnitude, to note down the temperature with the altitude of the column, then immediately to pour in a measured quantity of mercury nearly equal to three vertical inches, and to wait till the slow progress of the heating again brought the vapour in equilibrio with this new pressure, which at first had pushed the mercury within the platina ring at *l*. When the lower surface of the mercury was again a tangent to this ring, the temperature and altitude were both instantly observed.

“ This mode of conducting the process will account for the experimental temperatures being very often odd and fractional numbers. I present them to the public, as they were recorded on the instant in that particular repetition of the experiment which I consider most entitled to confidence. To trim and fashion the results into an orderly looking series, would have been an easy task; but, in my opinion, this is a species of deception very injurious to the cause of science, and a deviation from the rigid truth of observation, which ought never to be made for any hypothesis: we shall afterwards have ample opportunities of exposing the fallacy of such premature geometrical refinements.

The thermometers were constructed by Creighton with his well-known nicety, and the divisions were read off with a lens, so that $\frac{1}{10}$th of a degree could be distinguished. After bestowing the utmost pains in repeating the experiments, during a period of nearly two months, I found that the only way of removing the little discrepancies which crept in between contiguous measures, was to adopt the astronomical plan of multiplying observations, and deducing truth from the mean. It is essential to heat with extreme slowness and circumspection the vessels A, B, C. One repetition of the experiment occupies on an average seven hours.

“ The apparatus employed in obtaining these results, has the peculiar advantage, over all others, that the mercurial column is never heated. It is the concurrent opinion of all chemical philosophers, that caloric travels downwards in liquids with extreme slowness and difficulty. Indeed, Count Rumford's experiments led him to infer, that heat could not descend in fluids at all.

“ It is evident that, in my constructions, figures 15, 16, and 17, only that small portion of quicksilver within the vessels A, B, and C, will be affected by the heat, but the measuring column is beyond the reach of its influence.”

The Elastic Force of the Vapour of Water in inches of Mercury, obtained from Experiments by Dr Ure.

Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.	Temp.	Force.
24	0·170	115°	2·820	195°	21·100	242°	53·600	270°	86·300	295·6°	130·400
32	0·200	120	3·300	200	23·600	245	56·340	271·2	88·000	295	129·000
40	0·250	125	3·830	205	25·900	245·8	57·100	273·7	91·200	297·1	133·900
50	0·360	130	4·366	210	28·880	248·5	60·400	275	93·480	298·8	137·400
55	0·416	135	5·070	212	30·000	250	61·900	275·7	94·600	300	139·700
60	0·516	140	5·770	216·6	33·400	251·6	63·500	277·9	97·800	300·6	140·900
65	0·630	145	6·600	220	35·540	254·5	66·700	279.5	101·600	302	144·300
70	0·726	150	7·530	221·6	36·700	255	67.250	280	101·900	303·8	147·700
75	0·860	155	8·500	225	39·110	257·5	69·800	281·8	104·400	305	150·560
80	1·010	160	9·600	226·3	40·100	260	72·300	283·8	107·700	306·8	154·400
85	1·170	165	10·800	230	43·100	260·4	72·800	285·2	112·200	308	157·700
90	1·360	170	12·050	230·5	43·500	262·8	75·900	287·2	114·800	310	161·300
95	1·640	175	13·550	234·5	46·800	264·9	77·900	289	118·200	311·4	164·800
100	1·860	180	15·160	235	47·220	265	78·040	290	120·150	312	167·000
105	2·100	185	16·900	238·5	50·300	267	81·900	292·3	123·100		
110	2·456	190	19·000	240	51·700	269	84·900	294	126·700	312	165·5

Taylor and Arsberger's Experiments.

31. A series of experiments on high-pressure steam was subsequently made by Mr Philip Taylor, but he has not described his apparatus. A similar series was also made by Professor Arsberger of Vienna. As their results may be useful for comparison, we have united them in the following table:—

Taylor's and Arsberger's Experiments.

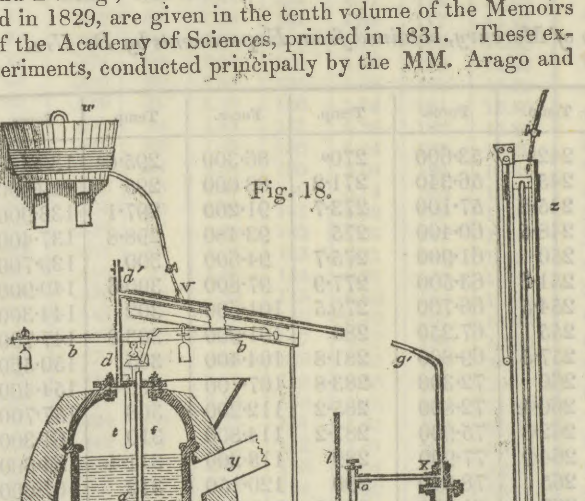
Taylor's and Arsberger's Experiments on High-Pressure Steam.

Temperature	Taylor.	Arsberger.
212°	30·0	,,
220	34·9	,,
230	41·5	,,
232	,,	44·4
240	50·0	,,
249	,,	59·1
250	59·1	,,
260	70·1	,,
270	82·5	,,
274	,,	88·9
280	97·7	,,
290	114·5	,,
293·4	120·4	,,
300	133·7	,,
320	179·4	,,
322	,,	176·0
372	,,	325·0
432	,,	620·0

Experiments of the French Academy.

32. We now come to the most imposing series of experiments hitherto conducted. In 1823, the government of France having resolved to legislate on the means for obtaining security in the use of steam-engines, consulted the Academy of Sciences, upon the mode of most effectually promoting the public safety, without placing useless restraints on commercial enterprise and manufacturing industry. The examination into the state of knowledge concerning the phenomena of vapour at elevated temperatures, which resulted from this application, having brought the imperfections of this part of science prominently into notice, the Academy were induced to undertake a long and laborious enquiry, not entirely free from personal danger, into the law connecting temperature with the pressure of steam. The commission consisted of the illustrious members of the Academy, Baron de Prony, Arago, Girard, and Dulong; and the results of their investigation, finished in 1829, are given in the tenth volume of the Memoirs of the Academy of Sciences, printed in 1831. These experiments, conducted principally by the MM. Arago and Dulong, were on a scale of magnitude and expense suited to the munificence of the French government and the resources of the Academy. The precautions adopted to ensure minute accuracy, entitle them to confidence, no less than the names of two philosophers, so well versed in experiments of a similar nature. They were carried as high as to the twenty-fourth atmosphere of pressure.

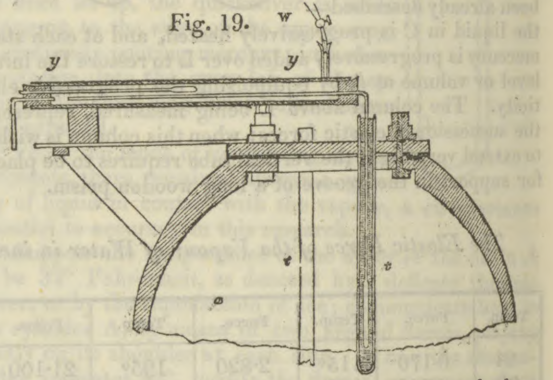
Fig. 18.



The experiments were made in one of the courts of the Observatory. Fig. 18 represents a section of the principal portions of the apparatus. The boiler *a* consists of a cylindrical body, having its axis vertical; the two ends forming top and bottom are spherical segments, strongly riveted to the body, the whole being made of the finest plate iron. The material of the cylindrical part is half an inch thick, the top and bottom being considerably thicker. The aperture at the top, six inches in diameter, was closed by a plate of wrought iron, an inch and three-quarters thick, overlapping the hole, about two inches all round, and having on its lower surface a projecting ring, adapting it to a groove on the upper side of the top of the boiler: between these two surfaces was interposed a thick ring of lead, and the cover was then strongly screwed down by six steel bolts, the nuts of which had head-washers, so that, on screwing the whole together, the cover became hermetically closed. This experimental boiler was built in a furnace of considerable size and mass, intended to produce a temperature of the requisite constancy; *x x* are bars upon which the fire rests; *y* is the flue leading to the chimney.

The other parts of the apparatus connected with the boiler are *b b*, a lever, safety-valve, and weights; *y y* (fig. 19) the thermometer scales; and *w w* reservoirs of cold water, for maintaining uniform temperatures on the vertical parts of the instruments.

Fig. 19.



During the process of proving the boiler by a hydraulic pump, the common safety-valve, when used as an instrument for measuring with precision the pressure of the fluid in the boiler, was observed to give very erroneous indications, and the necessity of a more delicate apparatus was demonstrated. The improved index of pressure, made use of in the experiments, is shown in fig. 18. For measuring the great pressures to be used, a tube of mercury, 80 feet high, would have been requisite; but there was used, as a substitute for it, a glass tube *z z*, closed at the upper end, filled with dry atmospheric air, and having a length of only five feet seven inches, and an internal diameter of $\frac{1}{5}$ of an inch, and of a thickness nearly equal to its diameter. It was so arranged as to furnish a convenient manometer, capable of giving the same indications, by the contraction of the contained air, as would have been given in similar circumstances, by a column of mercury of the height due to the diminished volume of the air. The graduation of this manometer, however, presented new difficulties.

These difficulties were successfully encountered by the skill and ardour of the academicians. Every one knows that it is impossible to obtain a glass tube of considerable length and magnitude which shall have a tolerably cylindrical interior; and that there are a number of practical

Experiments of the French Academy.

difficulties, which render it impossible to obtain even such a tube as that of a common thermometer, which shall possess the uniformity necessary to a good instrument. To make the proper allowance for this inevitable imperfection, the academicians easily might have adopted the same method as that used in the case of thermometer tubes, by determining the volume of successive small portions of its interior; but even this would have furnished a very partial remedy for the evil, because it had not been ascertained that the space occupied by the air in the manometer would diminish in bulk exactly in the proportion of the increase of compressing force, or of the corresponding increase in the height of the equivalent column of mercury. Two problems were therefore to be resolved at once, the elimination of the error of the tube, and the determination of the elasticity of air under high pressures. Both of them were satisfactorily accomplished, by the following laborious research.

As a preliminary measure, it was resolved to graduate the manometer, and determine the law of the elastic force of air under high pressures, by direct comparison with a column of mercury, from 75 to 80 feet in height. Such an experiment required a suitable *locale* and a stupendous apparatus. Among the buildings of the Royal College of Henri Quatre, there may be observed an old square tower, sole relic of the ancient church of Sainte Genevieve: there exist still in the interior three vaulted floors, pierced in the centre, and affording the very supports that were required for the erection of this stupendous mercurial gauge. In the centre of this opening there was raised a squared tree of the required height, and to this it was determined to attach the glass tube of 80 feet in height. To form a single glass tube of so great length was impossible; its own weight, when constructed, under the pressure of the mercury, would have endangered its existence. The glass column was built of separate portions, united in mastic, with great care, in viroles of steel. Each portion of tube was suspended in the air by an exact counterpoise, acting over pulleys fixed to the tree; and the whole of the parts were so united in equilibrio, that each sustained only its own weight, and the pressure of the mercury due to the height of the superior portion of the column. A homogeneous metallic scale was attached, and its divisions read by a vernier, as in the common barometer.

The manometer to be graduated, and this column of mercury, were both connected by tubes with a strong cylindrical vase *f*, holding about 100 lbs. of mercury. When thus placed in communication, a column of water was forced into the vase above the mercury by a hydraulic pump, and the pressure thus produced raised the metal with equal force up into the glass tube column on the one hand, and into the manometric tube on the other. The point to which the air was compressed was read off by a vernier, and the corresponding height of the mercury having been determined, it was manifest that the same degree of compression of the less instrument would ever after serve as the index of an equivalent column of mercury. In this manner the whole tube was graduated by careful experiment. The result of this graduation was satisfactory and very instructive. In forming the scale of the manometer, no room was left for errors of practical execution; and the comparison of the volume of the air with the height of the mercurial column demonstrated the diminution of the volume of the air to be precisely in the ratio of the pressure, so that the law of Marriotte is rigidly correct, even when extended to the extreme case, where the air is reduced to less than $\frac{1}{23}$ part of its usual volume.

This preliminary process having been successfully terminated, the enormous column of glass was now laid aside, and the manometer, with its reservoir of mercury, transported to the court of the Observatory, for the purpose of being attached to the experimental boiler. Figure 18 shows the manometer *in situ*. An iron tube *d d'*, *g'*, composed of gun barrels welded together, connects the cover of the boiler *a*, with the reservoir of the manometer *f*, so as to conduct the pressure of the steam to the surface, which formerly had sustained the mercurial column. The vacant space above the mercury was filled with water, which, by condensation from a stream of water on the outside, was kept full to the constant height v. A column of water contained in the glass tube *z z*, and constantly replenished, preserved the column of air, and other parts of the apparatus, at a constant temperature, indicated by a thermometer. A tube *o p*, of glass, communicating with the reservoir of mercury above and below, indicates, on the scale *l*, *m*, the variation of level arising from the recession of the mercury into the manometer tube.

To ascertain the temperature of the water and steam of the boiler, it had been considered sufficient in the ruder experiments of earlier observers to insert thermometers directly into the boiler itself. Every one who has an acquaintance with these instruments knows, that any difference of pressure on the glass produces a false indication of the instruments, so that even the few inches of mercury in the instrument itself, when inverted, alter its indications, and a slight pressure of the finger would raise it a degree; the inaccuracy of the old method, when used under a pressure of 70 or 80 feet of mercury, or 450 pounds on every inch of the immersed surface of the instrument would have been great. The French academicians avoided this error, by immersing strong iron tubes *t t*, (figs. 18 and 19,) in the water and steam, in which the thermometers, surrounded by liquid metal, were kept in close communication with the heat of the fluids, without exposure to their force. By adopting only very slow variations of temperature, the error arising from the motion of heat was rendered insensible.

The following Table contains the results of Thirty of the most unexceptionable Experiments:—

	1. Smaller Centigrade Thermometer.	2. Larger Centigrade Thermometer.	3. Elastic Forcemeters, in feet of Mercury at 32 degrees.	4. In Atmospheres of 76 degrees.	5. Condition in which the Observations were made.	
1	122·97	123·7	1·62916	2·14	max.	1
2	132·58	132·82	2.1767	2·87	a	2
3	132·64	133·3	2·1816	2·88	p. max.	3
4	137·70	138·3	2·5386	3·348	a	4
5	149·54	149·7	3·4759	4·584	max.	5
6	151·87	151·9	3·6868	4·86	a	6
7	153·64	153·7	3·881	5·12	a	7
8	163·00	163·4	4·9383	6·51	max.	8
9	168·40	168·5	5·6054	7·391	max.	9
10	169·57	169·4	5·7737	7·613	a. s.	10
11	171·88	172·34	6·151	8·114	a	11
12	180·71	180·7	7·5001	9·893	p. max.	12
13	183·70	183·7	8·0352	10·6	a	13
14	186·80	187·1	8·6995	11·48	a. s.	14
15	188·30	188·5	8·840	11·66	max.	15
16	193·70	193·7	9·9989	13·19	a	16
17	198·55	198·5	11·019	14·53	a. s.	17
18	202·00	201·75	11·862	15·65	a	18
19	203·40	204·17	12·2903	16·21	a. s.	19
20	206·17	206·10	12·9872	17·13	a	20
21	206·40	206·8	13·061	17.23	max.	21
22	207·09	207·4	13·1276	17.3	p. max.	22
23	208·45	208·9	13·6843	18.05	a	23
24	209·10	209·13	13·769	18.16	a	24
25	210·47	210·5	14·0634	18.55	p. max.	25
26	215·07	215·3	15·4995	20·44	a	26
27	217·23	217·5	16·1528	21·31	a	27
28	218·3	218·4	16·3816	21·6	p. max.	28
29	220·4	220·8	17·1826	22·66	a	29
30	223·88	224·15	18·1894	23.994	max.	30

Steam.

A table of temperatures, from 1 to 50 atmospheres, calculated in coincidence with the experiments of the French academicians, and adapted to English measures, is given by us in Article 57, for the purpose of convenient practical reference.

Experiments of the American Committee.

33. The latest series of experiments on the elastic force of high-pressure steam, we owe to America. At the request of the Hon. S. D. Ingham, Secretary of the Treasury of the United States, a committee of the Franklin Institute, of the State of Pennsylvania, was appointed "to examine into the causes of the explosions of the boilers used on board of steam-boats, and to devise the most effectual means of preventing the accidents, or of diminishing the extent of their injurious effects." Among other subjects, such as the strength of boilers, the construction of safety-valves, to which we shall refer in another place, this committee took into consideration the elastic force of high-pressure steam at different temperatures. Funds were placed at their disposal by the House of Representatives, and the committee consisted of such a combination of scientific and practical men, as to give high authority to their results. On the 1st day of November, 1830, the subject was placed in the hands of the following gentlemen:—Professor Alex. Dallas Bache, Mr Benjamin Reeves, Mr W. H. Keating, Mr M. W. Balwin, Mr S. V. Berrick, and Isaiah Sukens.

We shall enter more fully on the description of their apparatus of experiment than we should otherwise have done, because we shall have frequent reference to make to the whole of their experiments, not only in this article, but in our article on the Steam-Engine, where we treat of explosions of boilers and their causes.

The boiler used by the committee is represented in figs. 20, 21, 22. It is a cylinder, twelve inches in internal diameter, two feet ten inches and a quarter in length within, and a quarter of an inch thick, of rolled iron, with the ends rivetted in the usual manner. Fig. 21 is a side view. Figs. 20 and 22 are end views of the boiler, and of the apparatus connected with it. The boiler was placed horizontally in a furnace, the fire surface extending about halfway round the cylinder. The furnace was arranged for a charcoal fire, the grate bars extending the whole length of the boiler, and the fire being applied nearly the whole length. The draught entered by an opening, closed in the usual manner, and left the furnace through a flue placed at one end and side of the boiler. In fig. 20, A is the ash-pit door, B the furnace door, and in 21 and 22, C is the furnace chimney.

Fig. 20.

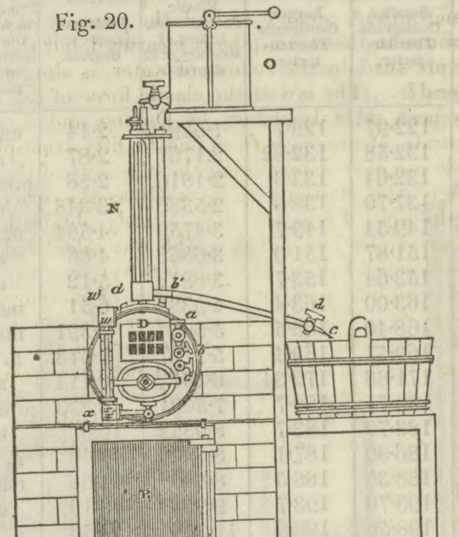
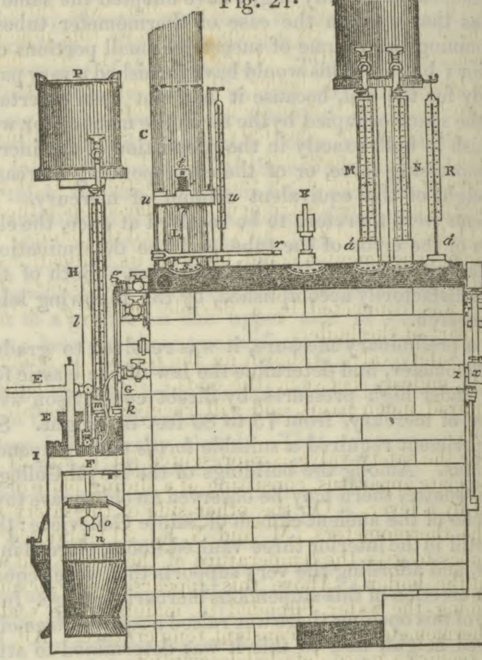


Fig. 21·



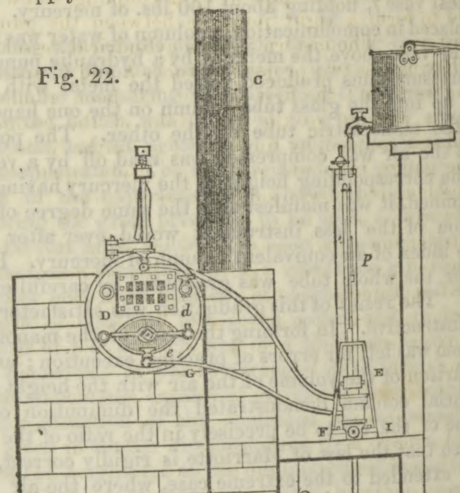
In order to examine, readily, the interior of the boiler during the progress of the experiments, each end was provided with a glass window (D, figs. 20 and 22). The glass used was three-eighths of an inch thick. The openings in the ends, which were rectangular, were two and a half by one and three quarters inches wide.

Three gauge cocks were placed in the front end of the boiler; their positions will be particularly stated hereafter; they are shown in figs. 20 and 21, at *a*, *b*, and *c*.

To the same end and by the side of the gauge cocks, a glass water gauge (*w*, *x*, figs. 20 and 21) was attached, a particular description of which will be given in the detail of experiments made to compare its performance with that of the gauge cocks.

To supply the boiler with water, a forcing pump EE'

Fig. 22.



Steam.

Experiments of the American Committee.

FG, figs. 21 and 22, was placed near the back end. This pump was of the ordinary construction, with a solid plunger and conical valves; the diameter of the pump was one inch, and the play of the piston one inch and three-quarters. The diameter of the pipe F G, by which the water was conveyed from the pump to the boiler, was three-hundredths of an inch. By a coupling screw, this pipe could be connected with either of the stop cocks *d e*, fig. 22, in the back end of the boiler: the opening of these cocks was two-hundredths of an inch in diameter.

To ascertain the elasticity of the steam within the boiler, a closed steam gauge (H, figs. 21 and 22), was used, a particular description of the construction, &c. of which will be given. This instrument was placed upon the same stand (I, figs. 21 and 22) which supported the pump, so that the same experimenter could observe its indications and attend to the working of the pump. The cistern of the gauge was connected by a flexible pipe *f g*, with the upper part of the boiler.

The safety-valve is shown on the top of the boiler (K, fig. 21), midway between the ends. The graduation of it required much pains, and will receive a separate discussion.

Near the safety-valve is represented (at L, fig. 21,) the fusible plate apparatus, consisting of a sliding plate of iron, moved by a lever. On the other side of the safety-valve are the thermometers (M and N, fig. 21) plunged into iron tubes to give the temperature of the steam and water within the boiler. Above this appears the reservoir O, containing the water intended to maintain the scales of the thermometers at a constant temperature. All these parts require a more detailed description.

The steam gauge consisted of a glass tube closed at the upper, and open at the lower end, which passed steam-tight into a reservoir for mercury: when this reservoir was connected with the boiler the pressure of the steam raised the mercury into the gauge tube, compressing the air which the tube contained. The first mercurial gauge which was made, was broken by a sudden access of surcharged steam, in the experiments upon that subject, and was replaced by a second one. The method of graduation, and in general the description of the second gauge, will serve also for the first; the details, only varied slightly.

The glass gauge tube was 26.43 inches in length. To the lower end was connected an iron ferule, terminated above by a projecting ring. This ring was pressed upon the upper end of the pipe *h*, by a coupling screw, which served to form a tight juncture between the gauge and the cistern. The cistern *i* was a cylindrical vessel of cast iron, having the two projecting tubes *h* and *k*, upon which screws were cut: the first of them has been alluded to as giving a passage to the glass tube of the gauge; the second was coupled, by the pipe *f g*, to the boiler.

The gauge tube was not of precisely equal diameter throughout, and it was judged more accurate to graduate small portions of it into equal volumes. This was done by introducing equal measures of air from the point of a sliding-rod gas measure (Hare's); this operation was performed repeatedly, and by multiple measures, to verify the results, until the marks made for the equal volumes, on a paper scale attached to the tube, coincided, in the various trials. The lengths of the spaces occupied by the equal volumes were then carefully measured upon the brass scale to be used with the gauge. The slight differences between the lengths given by adjacent parts of the tube, showed that it might be considered as divided into so many small portions of uniform diameter. The mercury rising into the gauge tube from the cistern when pressure is applied, the level of the cistern is necessarily depressed; the amount of the correction for this depends upon the relation between the areas of the cistern and tube, supposed uniform. The areas of the cistern were found to be, within the limits of its use, sensibly the same; those of the tube might be so assumed for such a purpose: the ratio was therefore found by filling the gauge tube with mercury, and pouring this into the cistern, noting the rise produced; comparing this with the mean length of of the tube, the ratio of depression in the gauge for elevation in the tube was found to be as .01 to 1. The air within the tube was next carefully dried by the introduction of a receptacle of chloride of calcium, of the same length with the tube; the air having been in contact with this substance for a sufficient time, the receptacle was withdrawn through the mercury over which the drying had been effected; the tube was next placed over a dish of mercury, in the receiver of an air-pump, and the air withdrawn, until, on re-admitting air to the receiver, the mercury rose in the tube above the iron ferule.

The gauge tube was next introduced into the cistern, the level of which, corresponding to the zero of the brass scale was then arranged, and the point of the scale at which the mercury stood was ascertained, the barometer and thermometer being noted.

It was intended in the experiments to keep the pipe from the gauge to the boiler cool, so that it might contain water, and thus give a nearly constant pressure upon the mercury of the cistern, besides preventing the exposure of the apparatus to heat; the height of this column, above the level of the cistern, was therefore ascertained, after the gauge was put in its place by screwing the cistern *i* to the stand.

All the elements for calculating the elasticity of the steam within the boiler, from the height of the mercury of the gauge, were thus known; the temperature of the apparatus being supposed constant.

The elastic force of the steam within the boiler, together with the column of water in the steam-pipe, balances the elasticity of the compressed air within the guage, together with the column of mercury above the level of that in the cistern. This level is not the original zero, but lower than that, by the depression produced by the rise of mercury in the gauge tube. The depression of the mercury changes the level above which the pressure of the column of water in the steam-pipe is measured, but the change in the pressure, by the column of water, is altogether inconsiderable. The law of the elastic force of dry air, which has been recently shown, by Dulong and Arago, to be accurate, at pressures from one to fifty atmospheres, was made use of in determining the elasticity of the air in the gauge: this elasticity is inversely as the space occupied by the air. From the data already obtained, and upon the principles just stated, a table was calculated, by which the observed heights of the gauge were converted into the corresponding pressures in inches of mercury or in atmospheres. The calculations were rendered rather tedious by the unequal diameter of the bore of the tube, on account of which equal lengths did not correspond to equal volumes. The usual method of calculation was resorted to, namely, to determine, by rigid calculation, the pressures, for points sufficiently near each other, and then to interpolate for intermediate heights.

The foregoing remarks take for granted that the temperature of the air in the gauge, as well as that of the mercury, remains constant; to secure this, an arrangement was adopted similar to that employed by Dulong and Arago for the same purpose. The gauge and scale were surrounded by a glass tube *l*, cemented below into a brass cap *m*, which had an opening in the side, communicating with a discharge pipe *n*, fig. 21. The tube was attached above, by an air-tight juncture, to a tin vessel P, of considerable capacity, compared with the tube. Water being introduced into the glass tube surrounding the gauge, the flow through this tube was regulated by a stop-cock *o*, placed at the end of the discharge pipe, the cistern above being filled with water.

To ascertain the temperature of the column of water

Experiments of the American Committee.

surrounding the gauge, a thermometer (*p*, fig. 22) with a very small bulb, was attached to the scale at the middle of its height: by this instrument, the flow of water through the casing of the gauge was regulated so as to keep the temperature nearly constant, and any deviations from a constant temperature were ascertained and noted, that the proper correction might be applied. The correction for the expansion of the air in the gauge, by a rise in its temperature during the progress of the experiments, was made according to the rules furnished by the rate of expansion of the gases, as determined by Gay Lussac, extended to compressed air by the experiments of Davy. The correction for the changes of height of the mercurial column, within the range to which the temperature was suffered to increase, could not have been appreciable if acting entirely, and the counteracting effect of the expansion of the glass further justified its being neglected. For similar reasons no reference was made to the effects of heat on the mercury in the cistern *i*, on the cistern itself, and on the water within the pipe communicating with the boiler.

In most of the researches of the committee, refinements in the mode of using the common thermometer would have been out of place. Results which might be obtained with little additional labour, and which would be interesting in both a practical and scientific point of view, were not to be neglected, and to some of them great accuracy was essential. In the questions of the first class, the thermometers were provided with wooden scales, and were graduated by immersion up to the point at which the scale commenced, the scale and upper part of the tube being exposed to the air: this was proper, as they were intended to be immersed in mercury nearly up to the scale. These instruments were examined after coming from the maker's hands, and the instrumental error ascertained. The tubes in which the thermometers were placed, and which contained mercury, were at first placed horizontally in one of the ends of the boiler; this had the advantage of rendering the tube for indicating the temperature of the water entirely independent of the steam, and thus any difference between the temperature of one and the other might be more effectually ascertained, than when the tube giving the temperature of the water passed through the steam. The position of these instruments interfered so much with other parts of the apparatus, and so much inconvenience and danger of error was experienced from the separation of the column of mercury in the thermometer, that these tubes were not used after the first weeks of experiment, and two vertical tubes, placed as already shown, were substituted for them.

The thermometers used, when the relation between the temperature of the steam and water, and the elasticity of the steam were to be observed in conjunction with some of the subjects more directly under the cognizance of the committee, had much pains bestowed upon them.

The scales (M and N,) were metallic, and surrounded by glass tubes, fitting into a cup *a'*, through the bottom of which the stem of the thermometer passed water tight; a pipe *b' c*, fig. 20, from the side of each cup, and provided with a stop-cock *d*, regulated the flow of water through the enveloping tubes: a tight connexion above with a reservoir (O) served, as in the case of the gauge, to supply the tubes with water. Small thermometers on the back of the scale of the large ones, showed the temperature of the water which surrounded them. The enveloping tubes being filled with water at 60°, the position of the boiling point of water and of the fusing point of tin, were used to verify the accuracy of graduation. The latter point, which is high upon the scale of the thermometer, having been very accurately determined, and being easily and with certainty ascertainable, serves as an excellent check upon the graduation. The greatest error within the limits just stated, was in one instrument, three-fourths of a degree, and in the other one degree of Fahrenheit. The scales were graduated from two to two degrees, one quarter of a degree being readily estimated upon them. The corrections required by this examination were made through the medium of a table prepared for the purpose. In order to call the attention to the temperature of the water surrounding the scales, this temperature was recorded from time to time, when the height of the thermometers was observed, At no time did the rise of temperature, permitted in the water, make it necessary to apply a correction for the expansion of the scale. None was required for the cooling effect of the water around the stem upon the mercury, owing to the method of verifying the scale.

The other parts of the apparatus, less general in their use, as the water-gauge, safety-valve, fusible plate apparatus, &c., will be more conveniently described in connexion with the experiments for which they were devised."

34. With this apparatus, and these precautions, a series of experiments were made, the results of which are contained in the following tables:—

The Table, No. 1, contains the temperature observed by the thermometer in the water, corrected for the error of the graduation; the temperature of the scale of the thermometer, with a view to show that it was not allowed to vary too considerably; the observed height of the mercury in the gauge, reduced to its mean height; the temperature

TABLE, No. I.—*Of the Elastic Force of Steam at different Temperatures.*

Temperature of steam.	Temp. of scale of thermometer.	Height of mercury in air gauge.	Temperature of air in gauge.	Volume of air at observed temperature.	Volume of air at 48 ° Fahrenheit.	Elasticity of air in inches of mercury.	.01 Height of gauge.	Height + .01 height.	Height + .01 height —1.29 inches.	Total elasticity in inches of mercury.	Elastic force in atmospheres of 30 inches.
Fah. °	Fah. °	Inches.	Fah. °	Vols.	Vols.	Inches.	Inches.	Inches.	Inches.	Inches.	Atmos.
		3.99*	62	8.33	8.101	27.26	.04	4.03	2.74	30.00	1.00
262¼	63	15.04	74	3.93	3.737	59.09	.15	15.19	13.90	72.99	2.43
268½	71	16 34	„	3.43	3.259	67.76	.16	16.50	15.21	82.97	2.76
275½	„	17.34	„	3.05	2.898	76.20	.17	17.51	16.22	92.42	3.08
286½	„	18.94	„	2.44	2.319	95.23	.19	19.13	17.84	113.07	3.77
296½	„	19.94	„	2.05	1.948	113.36	.20	20.14	18.85	132.21	4.41
298½	73	20.11	„	1.99	1.891	116.76	.20	20.31	19 02	135.80	4.53†
302	„	20.44	„	1.86	1.767	124.98	.20	20.64	19.35	144.33	4.81‡
305½	76	20.79	75	1.73	1.641	134.57	.21	21.00	19.71	154.28	5.14
313¼	79	21.39	„	1.50	1.422	155.30	.21	21.60	20.31	175.61	5.85§
317¾	80	21.64	„	1.405	1.332	165.79	.22	21.86	20.57	186.36	6.21
320¾	„	21.79	76	1.347	1.275	173.20	.22	22.01	20.72	193.92	6.46
327¾	„	22.24	„	1.176	1.113	198.41	.22	22.02	20.73	219.14	7.30
333¾	„	22.69	„	1.004	0.950	232.46	.23	22.92	21.63	254.09	8.47

* This observation shows the height of the gauge before the experiment, corrected for the height of the barometer.

† Mean of four observations. ‡ Mean of two observations. § Mean of two observations.

Experiments of the American Committee.

of the air in the gauge; its volume at the observed temperature; the volume reduced to 48°, the temperature of graduation of the gauge at which the column of mercury, equivalent to an atmosphere, is very nearly 30 inches; the elasticity of the compressed air, in inches of mercury; the correction in the height of the column of mercury, for the depression produced in the cistern below; the height thus corrected: the height, after subtracting the sensibly constant number for the column of water between the level of the steam-pipe from the boiler and the cistern of the gauge; the total elasticity in inches of mercury; the elasticity in atmospheres. The first line of numbers in the table is merely introduced for the convenience of presenting certain data required for subsequent calculation; it gives the height of the mercury in the gauge before beginning the observations, after correcting for the height of the barometer.

A curve traced to represent these observations, the ordinates representing the pressures, and the abscissæ the temperatures, is quite regular, until the temperature corresponding to eight atmospheres is attained, when it rises abruptly. This fact was explained, by examining the gauge; it was found that the cement used in attaching the glass tube to its ferule had become softened, and had permitted the tube to rise. This defect was remedied and its recurrence prevented. It was then determined to repeat the entire series of observations, and to carry them as high as could be done, with reasonable convenience, aiming particularly, to embrace the range of working, pressures of the American engines.

The results are contained in the following table in which the observed data, and calculated numbers, are arranged as in the last table. This table extends to 9.91 atmospheres, and to the temperature of 352° Fahrenheit.

Care was taken that the elasticities were increased not too rapidly, and the last numbers obtained, were verified by keeping the temperature sensibly constant for a considerable time.

TABLE No. II.—*Of the Elastic Force of Steam at Different Temperatures.*

Temperature of Steam.	Temperature of thermometer scale.	Height of mercury in air gauge.	Temperature of air in gauge.	Volume of air at observed temperature.	Volume of air at 48° Fah.	Elasticity of air in inches of mercury	.01 Height of gauge.	Height + .01 height.	Height + .01 height —1.29 inches.	Total elasticity in inches of mercury.	Elastic force in atmospheres of 30 inches.
Fah. °	Fah. °	Inches.	Fah. °	Vols.	Vols.	Inches.	Inches.	Inches.	Inches.	Inches.	Atmos.
		5.56*	48	7.695	7.695	25.67	.06	5.84	4.55	30.00	1.00
248¼	54	14.04	53	4.32	4.277	46.19	.14	14.18	12.89	59.08	1.97
269½	—	17.34	52	3.05	3.026	65.29	.17	17.51	16.22	81.51	2.72
284½	—	19.64	„	2.17	2.152	91.76	.19	19.83	18.54	110.30	3.68
289½	—	20.06	„	1.99	1.974	100.05	.20	20.26	18.97	119.02	3.97
294½	—	20.56	53	1.82	1.802	109.63	.21	20.77	19.48	129.11	4.30
299½	—	21.04	54	1.63	1.611	122.66	.21	21.25	19.96	142.62	4.75
304½	—	21.34	54½	1.52	1.500	131.66	.21	21.55	20.26	151.92	5.06
310¼	—	21.64	„	1.405	1.382	142.94	.22	21.86	20.57	163.51	5.45
314¾	58	22.04	55	1.25	1.233	160.26	.22	22.26	20.97	181.23	6.04
319¾	—	22.34	55½	1.14	1.124	175.86	.22	22.56	21.27	197.13	6.57
329¾	—	22.84	56	0.95	0.937	210.84	.23	23.07	21.78	232.62	7.75
334½	66	22.94	57	0.92	0.904	218.60	.23	23.17	21.88	240.48	8.02
338¾	—	23 04	57½	0.887	0.870	226.92	.23	23.29	22.00	248.92	8.30
345	—	23.24	„	0.82	0.805	245.44	.23	23.47	32.18	267.62	8.92
348	—	23.34	58	0.787	0.771	256.05	.33	23.57	22.28	278.33	9.28
350	—	23.44	„	0.752	0.737	267.97	.23	23.67	22.38	290.35	9.68
352	—	23.50	„	0.733	0.719	274.92	.23	23.73	22.44	297.36	9.91
346	—	23.28	62	0.807	0.785	251.78	.23	23.51	22.22	274.00	9.13

* This observation shows the corrected height of the gauge before the experiments.

There is one observation, namely, that at 329¾°, which is certainly recorded erroneously; but omitting this one, the rest which are given, present a very tolerable regularity in the curve traced to represent them. For the sake of adding to the force of these results, the scattered observations of temperatures and pressures incidentally made during the other experiments of the committee, are brought together in the annexed table.

A column is added to the table, to show the number of observations employed in obtaining the results.

TABLE No. III.—*Of the Elastic Force of Steam at Different Temperatures.*

Temperature of Steam.	Temperature of thermometer scale.	Height of mercury in air gauge.	Temperature of air in gauge.	Volume of air at observed temperatures.	Volume of air at 48° Fah.	Elasticity of air in inches of mercury.	+ .01 Height of gauge.	Height of gauge + .01 height.	Height + .01 height—1.29 inches.	Elasticity of steam in inches of mercury.	Elastic force in atmospheres.	No. of observations.
Fah. °	Fah. °	Inches.	Fah. °	Vols.	Vols.	Inches.	Inches.	Inches.	Inches.	Inches.	Atmos.	—
		3.91*	59	8.35	8.169	27.34	.04	3.95	2.66	30.00	1.00	—
234	54	8.80	55	6.39	6.301	35.45	.09	8.89	7.60	43.05	1.43	1
239¼	62	9.94	61	5.94	5.788	38.59	.10	10.04	8.75	47.34	1.58	„
245¼	68	11.16	63	5.46	5.300	42.14	.11	11.27	9.98	52.12	1.74	5
250¼	70	12.54	63	4.92	4.776	46.77	.12	12.66	11.37	58.14	1.94	4
256¼	73	13.88	64	4.38	4.243	52.64	.14	14.02	12.73	65.37	2.18	5
262¾	77	15.14	64	3.89	3.768	59.27	.15	15.99	14.00	73.27	2.44	2
271	70	16.34	65	3.43	3.316	67.35	.16	16.50	15.21	82.56	2.75	4
278	75	17.44	70	3.01	2.882	77.49	.17	17.61	16.32	93.81	3.13	3
288¼	75	18.74	68	2.50	2.403	92.94	.19	18.93	17.64	110.58	3.69	3
291	76	19.14	65	2.36	2.282	97.88	.19	19.33	18.04	115.92	3.86	2
292½	65	19.44	63	2.25	2.184	102.26	.19	19.63	18.34	120.60	4.02	3
300	73	20.12	65	1.98	1.494	117.33	.20	20.32	19.03	136.36	4.55	4
303½	74	20.54	66	1.82	1.756	127.27	.20	20.74	19.45	146.72	4.89	1

* This observation shows the corrected height of the gauge before the experiments.

Experiments of the American Committee.

This table enables us to go as low as 1.43 atmospheres, and is strikingly accordant with the two others as far as they extend in common.

A curve which would be traced by the following table, which may be considered to represent the mean of the foregoing, would differ little more than one-tenth of an atmosphere in any part of the range, from the observations, omitting one noticed in the first, and another noticed in the second table; the pressures in general differing less than one-tenth of an atmosphere from the observed pressures.

Table of the Elastic Force of Steam from One to Ten Atmospheres.

Pressure.	Observed Temp.	Pressure.	Observed Temp.	Pressure.	Observed Temp.	Pressure.	Observed Temp.	Pressure.	Observed Temp.
Atmo.	Fah. °	Atmo.	Fah. °	Atmo.	Fah. °	Atmo	Fah. °	Atmo.	Fah. °
1	212	3	275	5	$304\frac{1}{2}$	7	326	9	345
$1\frac{1}{2}$	235	$3\frac{1}{2}$	284	$5\frac{1}{2}$	310	$7\frac{1}{2}$	331	$9\frac{1}{2}$	349
2	250	4	$291\frac{1}{2}$	6	$315\frac{1}{2}$	8	336	10	$352\frac{1}{2}$
$2\frac{1}{2}$	264	$4\frac{1}{2}$	$298\frac{1}{2}$	$6\frac{1}{2}$	321	$8\frac{1}{2}$	$340\frac{1}{2}$		

To compare our results with those given by the committee of the French Academy, we have traced a curve, from the above table, and another from those of the thirty observations, selected by the committee of the Academy, from their experiments which are below ten atmospheres. The curve of our observations, passes at low pressures nearer to the line AB than that of the French experimenters, and after coinciding at the medium pressures of the table, crosses the latter, differing at 10 atmospheres 5 degrees, or at $352\frac{1}{2}$ degrees .65 of an atmosphere.

The difference here noticed is too considerable to be admitted as within the limits of errors in the apparatus or in observation. Having an authority of so much weight against them, the committee have been driven to examine their results very closely. The care employed in the graduation of the gauge seems to exclude the idea of error from it; the upper portion of the scale was divided to .05 of an inch, and could easily be read to half of that distance, making about .1 of an atmosphere at the highest pressure attained. A specific correction for capillarity was ascertained and employed. In one point of manipulation, namely, the method employed to dry the air, the committee differed from what was usual, and though they think there is reason to confide in that method, they have examined what effect would be produced if air were saturated with moisture. Recent experiments on the passage of gases, out and into vessels placed over mercury, and observations connected with them, warrant, moreover, a suspicion, that dry air standing in a glass vessel over mercury, the surface of which is covered by water, may become impregnated with vapour. The effect of such a source of error they have calculated in the highest and lowest results of table No. II. and find it to be as follows:—

For $248\frac{1}{4}$° the tension of the vapour is 1.96 instead of 1.97,
and 352 „ 9.78 „ 9.91.

Differing from the numbers given in table No. II. by .01 and .13 of an atmosphere.

This supposition is thus shown to be inadequate to explain the discordance, and must, in fact, be deemed, to a certain extent, gratuitous.

The committee have next compared the results furnished by the safety-valves graduated independently of the gauge, and these, as has already been shown, gave calculated pressures four per cent and ten per cent higher than the pressures indicated by the gauge. From these independent experimental data we have then an evidence that our results are, probably, not too high."

SECT. III.—ON THE MATHEMATICAL LAW WHICH CONNECTS THE ELASTIC FORCE OF VAPOUR WITH ITS TEMPERATURE.

Dr son's vesti tion

* 35. An inference which may be drawn from all these experiments is, that Nature seems to affect a certain law in the dilatation of aeriform fluids by heat. They seem to be dilatable nearly in the proportion of their present dilatation. For, if we suppose the vapours to resemble air in having their elasticity in any given temperature proportional to their density, we must suppose that if steam of the elasticity 60, that is, under a pressure of 60 inches of mercury, were subjected to a pressure of 30 inches, it would expand into twice its present bulk. The augmentation of elasticity, therefore, is the measure of the bulk into which it would expand, in order to acquire its former elasticity. Taking the increase of elasticity, as a measure of the bulk into which it would expand under one constant pressure, we see that equal increments of temperature produce nearly equal multiplications of bulk. Thus, if a certain diminution of temperature, diminishes the bulk of steam $\frac{1}{4}$, another equal diminution will very nearly diminish this new bulk $\frac{1}{4}$. Thus, in our experiments (Art. 25), *the temperatures being in arithmetical progression, having equal differences, we see that the corresponding elasticities are very nearly in the continued proportion of* 1 to 2, *thus:*

Temperatures	110°	140°	170°	200°	230°
Corresponding Elasticities,	2.25	5.15	11.05	22.62	44.7.

Now, although extreme temperatures differ considerably from this law, still we see that there is a considerable approximation to it; and it will frequently assist us, to recollect that within these limits an increase of 30° of temperature nearly doubles the elasticity and bulk of watery vapour.

This law obtains exactly in air and other gases, all of which are subject to the Boylean law, or law of Marriotte, as it is called, and have their elasticity proportional to their bulk inversely. If the bulk were always augmented in the same proportion by equal augmentations of temperature, the elasticities would be accurately represented by the ordinates of a logarithmic curve, of which the temperatures are the corresponding abscissæ; and we might contrive such a scale for our thermometer, that the temperatures would be the common logarithms of the elasticities, or of the bulks having equal elasticity; or, with our present scale, we may find such a multiplier m, for the number t degrees of our thermometer (above the temperature where the elasticity is equal to unity), that this multiple shall be the common logarithm of the elasticity F; so that

$$\text{Log. } F = m\,t \text{ .... A.}$$

Dr ton ves tion

36. As Dr Dalton was one of the earliest to investigate the properties of steam by well-contrived experiment, he has likewise been the most successful in obtaining profound and accurate views of those general relations which connect this with co-ordinate branches of physical knowledge. His experimental researches have been the model of imitation to all subsequent investigators. His apparatus was simple, his artifices were highly refined, and his processes elegant and precise; and, consequently, the results of his labour were immediately transferred to the works of highest philosophical character on the Continent and at home, and became part of the staple of accurate science. But his philosophical views were not so readily and widely received, and the fault lay, in part, with their author himself. He had overreached the ex-

isting condition of the other branches of contemporaneous science; and in taking for granted the accuracy of the existing state of knowledge, he proceeded to raise a theoretical structure on ground not yet sufficiently ascertained and determined. The result has been, as might have been anticipated, that now, when the progress of accurate knowledge has altered the conditions on which his system was based, his theory, becoming inapplicable to the facts, has been thrown aside, and, instead of having been modified, as it ought to have been, in conformity with the advancement of science, it has been hastily abandoned or undeservedly neglected.

From an extensive and laborious review of all that has since been added to the stores of our experimental facts on the properties of vapour, we have been conducted to this conclusion, that of all the views that have been taken of the constitution and laws of vapour, Dr Dalton's are those from which we may gain the clearest and most adequate conceptions; and therefore we have undertaken the task of reviewing the subject, and of making those changes and modifications which are now required to represent with fidelity and precision the advanced state of our knowledge.

If we examine any series of even the earlier experiments on the vapour of water (such as those in Art. 27), we cannot fail to recognise a certain degree of regularity in the progress of the increasing force of the vapour as the temperature is successively augmented. At the temperature of freezing water, the force of its vapour being taken at two-tenths of an inch, we see that it becomes more than *doubled* by raising the temperature 22½°: this again is rather more than *doubled* at 22½° of additional heat; and this is again exactly *doubled* by a third addition of 22½°. But another addition of 22½° of heat scarcely doubles the pressure; and 22½° more fall still further short of producing that effect; so that, while the increase of the force of the steam takes place rapidly, with equal additions of heat, the rapidity of the increase does not maintain a constant proportion, but slowly diminishes as the temperature ascends. This will be plainer in the following table:—

Temperature of the Vapour.	Pressure on Mercury.	Proportion of Increase.	Decrease of Proportion.
32°	0·200		8·
54½	0·445	$2 + \frac{17}{100}$	
77	0·910	$2 + \frac{9}{100}$	8·
99½	1·820	$2 + \frac{0}{0}$	9·
122	3·500	$2 - \frac{8}{100}$	8·
144½	6·450	$2 - \frac{16}{100}$	8·
167	11·250	$2 - \frac{25}{100}$	9·
189½	18·800	$2 - \frac{33}{100}$	8·
212	30·000	$2 - \frac{41}{100}$	8·

From this simple collocation of results, a principle of progression is manifested. The number of degrees in the first column increases at each step by 22½ degrees, and the number in the second column on the same line is nearly doubled every step. At first, as the third column shows, it is more than doubled by $\frac{17}{100}$, next time it is more than doubled by $\frac{9}{100}$, and next it is doubled exactly; after this, however, it falls $\frac{8}{100}$ short of being doubled, next time by twice that quantity, and so on, till we find at last that it falls short of doubling every time by about 8 or 9 hundredths for every 11½ degrees. Although, therefore, we may at first be disappointed in finding that the reduplication does not proceed with the regularity of a law of nature, still it is satisfactory to know that the deviation from this progression is itself the subject of a tolerably simple law, so as to enable us to predict, with some measure of accuracy, what would take place if we were to add another increment of 22½ degrees. We should then diminish the number in the third column by $\frac{9}{100}$, and by doubling the pressure, and having regard to this diminution from the preceding numbers, $2 - \frac{41}{100}$ we should have at

234½° 45.00 $2. - \frac{50}{200}$ —9

And again at

257 63.90 $2. - \frac{58}{100}$ —8

Dr Dalton's Investigation.

It was in this way that Dr Dalton examined his experiments, and proceeded to form his tables, so as to include not only those points which he had already examined by experiment, but to fill up the vacancies, and extend them beyond the range which his actual observation had reached. He thus completed the table which we have already given. This was much more accurate than any previous table, and, being more extensive, formed a valuable addition to our knowledge.

This simple method of interpolation by which Dr Dalton constructed his table, although it suited perfectly, the limited object which he at that time had in view, and coincided with the limited range of his observations, was not of a sufficiently general description to stretch far beyond that sphere. It is obvious, that if his progression were continued much further, it would come to an end of itself; because the constant diminution of the proportion in the third column would bring it down to nothing, and so the march of the method would close and retrograde, and would thus bring the method of the formation into opposition with the march of the fact, for the force of the vapour continues to increase. Dr Dalton was himself the first to recognise the limited applicability of his method of interpolation to wide ranges of temperature; and, accordingly, in his lectures on heat, delivered at Edinburgh and Glasgow in 1807, and in his *New System of Chemistry*, published 1808, he developed those larger and more matured views which had grown up in his mind during a longer and more thorough investigation of the subject.

It does not belong to this article to consider the nature, and decide on the merits of Dr Dalton's theory of temperature; nor is a perfect acquaintance with that theory of any further use in understanding his views of the constitution of vapour, than to enable us to perceive how he was led from the former to the latter. For the validity of his views regarding steam, it is indeed of no consequence whether the theory of temperature from which it was originally deduced, be true or erroneous. The general laws which he has determined for elastic vapours, form the well-settled foundation on which any theory of temperature, true or false, must in some measure ultimately rest.

The only circumstances in regard to temperature which it is proper to keep in view, are these: that the present thermometer used to indicate temperature is not to be regarded as an exact measure of the *quantity* of heat producing that temperature. This is shown from the circumstance, that the same quantity of fuel which heats water 10° from 180° to 190°, will not heat it from 80° to 90°, an equal interval. From considerations of this nature it was evident that the divisions of the common scale were too large near the bottom, and too small in the higher portions; and Dr Dalton evinced this difference to be so great, that 72° of the common scale below the freezing point of water down to the freezing point of mercury, were to be reckoned as equivalent to as many as 207° of Dalton's scale. Proceeding on this view, it was necessary to find the ratio of these two series of indications, the indications of Dalton's and of Fahrenheit's scale; and he accordingly found that the progression of Fahrenheit's scale was in a high geometrical proportion to the increments of true temperature of the new one. On this principle he proceeded to construct his new scale of temperature—of which the following is a specimen.

Dr Dalton's Investigation.

Fahrenheit's Scale.	Dalton's Scale.
—40° (Freezing point of Mercury),	—175°
32 (Freezing point of water),	+ 32
110 (Middle of scale),	122
212 (Boiling point of water),	212
296	272
342.7	302
409.8	342
520.3	402
600.7	422

By this new scale of temperature it was found that many of the apparent anomalies in the effects of heat were resolved, and the complex relations of its phenomena rendered very simple. Amongst others, the most important were the phenomena of vapours, as it was found that, on the new scale of temperature, the elastic force of different vapours increased almost exactly in a uniform ratio to equal increments of heat.

But the further progress of experimental science soon raised up serious grounds of objection to this view. It was found that Dr Dalton had rated the inaccuracies of the present scale somewhat too high. His results were thus rendered inapplicable to the advanced state of some branches of thermal science; and his theory, instead of being modified and improved, was first hastily discredited and then summarily dismissed. Unable to follow the theory to its whole extent, it was abandoned even when it had furnished a safe guide thoroughly to explicate the intricacies of obscure truth.

It is now, therefore, necessary to examine the views of those who have endeavoured to form adequate representations of the mathematical law which connects the elastic force of vapour with its temperature. We shall first of all examine the methods and views which they have adopted, and then consider whether there may not be deduced from the clear theoretical views of Dr Dalton, tested and modified by the results of modern experiment, mathematical expressions of a character, at once less empirical, and more closely in accordance with observed phenomena.

M. de Prony's Formulæ.

37. M. de Prony was the first to represent, by a purely empirical formula, the law which governs the relation between the temperature and the elasticity of aqueous vapour. It was derived by him, in 1796, from the experiments of M. de Betancourt, and constructed according to a method of interpolation, which he afterwards presented to the Academy of Sciences, and which they have placed among the *Mémoires des Savans Etrangers.*

The Formula which he has thus obtained is

$$y = e^{\mu + \lambda x} - e^{\mu' + \lambda' x} - e^{\sigma x - \rho} + e^{\sigma' x - \rho'};$$

y being the height of the mercurial column of pressure.
x the temperature.
e the base of the common log. . . $=10.$
μ an empirical co-efficient, . . . $= 0.068831$
λ . . . . $= 0.019438$
λ' . . . . $= 0.013490$
σ . . . . $= 0.058576$
σ' . . . . $= 0.049157$
ρ . . . . $= 4.686080$
ρ' . . . . $= 3.932560$

The same formula holds in the case of alcoholic vapour, the numerical co-efficients being changed, and a constant quantity $A = 1.126447$ subtracted from the result.

$\mu = -0.04853$, $\lambda = 0.02393$, $\sigma = 0.0467$, $\rho = 2.60249$
$\mu' = -0.63414$, $\lambda' = 0.09653$, $\sigma' = 0.0294$, $\rho' = 1.64909$

This formula was afterwards improved by its author, and presented in the following more elegant and convenient shape.

$$z = \mu_{\prime}\rho_{\prime}^{x} + \mu_{\prime\prime}\rho_{\prime\prime}^{x} + \mu_{\prime\prime\prime}\rho_{\prime\prime\prime}^{x} \text{ ....B.}$$

Where z is the mercurial column of pressure, x the temperature centigrade, and $\mu_{\prime}$ $\mu_{\prime\prime}$ $\mu_{\prime\prime\prime}$ $\rho_{\prime}$ $\rho_{\prime\prime}$ $\rho_{\prime\prime\prime}$ equidistant constants derived from experiment.—For water, these values are:—

$\mu_{\prime} = -0.0000000196$ $\rho_{\prime} = 1.136006$

$\mu_{\prime\prime} = +0.023403$ $\rho_{\prime\prime} = 1.038037$

$\mu_{\prime\prime\prime} = -0.023403$ $\rho_{\prime\prime\prime} = 1.022490$

and hence he has formed the numbers which we have united in a subsequent table.

M. de Prony's formula for the vapour of alcohol is—

$$z = \mu_{\prime}\rho_{\prime}^{x} + \mu_{\prime\prime}\rho_{\prime\prime}^{x} + \mu_{\prime\prime\prime}\rho_{\prime\prime\prime}^{x} + \mu_{\prime\prime\prime\prime};$$

the constants being

$\mu_{\prime} = -0.000058$ $\rho_{\prime} = 1.090391$

$\mu_{\prime\prime} = +0.024669$ $\rho_{\prime\prime} = 1.045453$

$\mu_{\prime\prime\prime} = +0.005677$ $\rho_{\prime\prime\prime} = 0.836030$

$$\mu_{\prime\prime\prime\prime} = -\left(\mu_{\prime} + \mu_{\prime\prime} + \mu_{\prime\prime\prime}\right)$$
$$= -0.030288$$

These numbers refer to the centigrade thermometer, and to an atmosphere of 0.7577 metres in height.

These formulæ indicate some singular phenomena at high temperatures, which have not been observed in recent experiments, and may therefore be deemed anomalies of the formulæ themselves rather than the legitimate results of the experiments they were intended to represent. The formulæ are, besides, much too operose to be useful.

38. The experiments of Dr Dalton are adopted by Laplace in the fourth volume of the *Méchanique Céleste*, where we find him applying them to the calculation of the influence of the aqueous vapour of the atmosphere upon astronomical refractions. As an empirical formula agreeing sufficiently with Dr Dalton's experiments, he adopted the following approximation:—

$$f_n = p.\,(10)^{n.0\,0154547 - n^2.0.0000625826} \text{ ....C.}$$

f being the force at any temperature n of the centesimal scale, reckoned from the point of ebullition, and p the pressure of the atmosphere $=0.76$ metres; or that we have only to add to the log. of 0.76 the quantity $n.0.0154547 - n^2.0.0000625826$ and we have the log. of the common tabular logarithm of the corresponding elasticity at n centisimal degrees of temperature.—*Méch. Cel.* iv. 273.

These numbers agree very well with the observations they were intended to represent, from 0° to 100° centigrade, but are found inaccurate above and below these points.

39. M. Biot, adopting still the methods and experiments of Dr Dalton, found it necessary to modify the formula in order to obtain a closer approximation to truth. Using the notation in which we have expressed Dr Dalton's method of calculation, Biot considers

$$f_n = p.\,a_n$$

as a first approximation; of which the logarithmic form is

$$\text{Log.} f = \text{log. } 30. + n \text{ log. } a;$$

which would always give the logarithm of the elastic force, provided the ratio were accurately constant; but, as it is variable in Dr Dalton's observed numbers, it would be convenient to represent the variation of the logarithm of the elastic force thus:—

$$\text{Log.} f_n = \text{log. } 30. + \alpha n + \beta n^2 + \gamma n^3, \text{ \&c.}$$

α, β, γ, being constants derived from experiments thus—and setting out from 100° cent. as the zero—

If $n = 0°$ the number given by exp. is $F_0 = 30.$ in.
$n = 25$ ....$F_{25} = 11.250$
$n = 50$ ....$F_{50} = 3.500$
$n = 75$ ....$F_{75} = 0.910$

By substituting successively these values in the formula we get

$$-0.4259687 = 25\alpha + 625\beta + 15625.\gamma.$$
$$-0.9330519 = 50\alpha + 2500\beta + 125000.\gamma.$$
$$-10.5180799 = 75\alpha + .5625\beta + 4{\cdot}21875.\gamma.$$

From these three equations we can readily obtain the three values wanted of α, β, and γ, and which we find to be

$$\alpha = -\,0.01537419550$$
$$\beta = -\,0.00006742735$$
$$\gamma = +\,0.00000003381$$

and hence the whole equation

$$\text{Log. } 30.f_n = \text{log. } 30. + \alpha n + \beta n^2 + \gamma n^3$$

is now determined in English inches for the centigrade thermometer; and in order to compare it with the French observations, it is only necessary to remember that 30. in. = 0.7679 French metres, and to transform it thus:

$$\text{Log. } F_N = \text{log. } 0^{m}.76199 - 0.00112919957 - 0{,}01537278757 \ldots N, \\ - 0.00006731995N^2 + 0.00000003374N^3$$

and in the common table of logarithms

$$F_N = 0^{m}{\cdot}76.10^{\,AN + BN^2 + CN^4}$$

or,

$$\text{Log. } F_N = \bar{1}.8808201 + AN + BN^2 + CN^3$$

which are almost identical with Laplace's formula (C), the degrees being reckoned positively from 100° cent. downwards, and negatively upwards.

In degrees Fahrenheit and English inches, the formula in this shape becomes—

$$\text{Log. } F_f = 1.4771213\bar{1}\ 0.00854121972f \\ -0.00002081091f^2 + 0.00000000580f^3 \ldots \text{D.}$$

These formulæ are far from representing the results of late experiments at high temperatures, although, within the limits of one atmosphere, they accord pretty closely with Dr Dalton's early observations.

40. In the first volume of the new series of the *Philosophical Magazine*, Mr Ivory has given a formula constructed to represent empirically the experiments of Dr Ure. It is—

$$\text{Log.}\frac{e}{30} = .0087466t - 000015178t^2 + 000000024825t^3 \text{ E.}$$

The application of this formula is laborious. It is of exactly the same nature with that of Laplace and Biot, and only represents the observations of Dr Ure within their narrow limits; extended to higher temperatures, it seems to deviate considerably from the truth, as may be seen from our table (Art. 57.)

41. Schmidt and Soldner, reviewing Dr Dalton's experiments, have each constructed a formula to represent them:

$$\text{Schmidt's is—} F = t^{1.363 + .0021t} \ldots\ldots\ldots\ldots\ldots\ldots \text{F.}$$

Soldner's formula is—

$$F = \text{Log. } 30.13 - \frac{(662-t)\ (212-t)}{52042} \ldots\ldots\ldots \text{G.}$$

42. In the *Edinburgh Journal of Science* for 1829, Mr Tregaskis has given a theorem, which furnishes a rough approximation to experiment. It is this: that $\frac{1}{5}$ of the temperature above 32°, added to vapour, will double its elasticity.

43. M. Roche, Professor of Mathematics at Toulon, sent to the Academy of Sciences, in 1828, a memoir on this subject, in which he proposes a formula, deduced from general principles. This formula is—

$$F = 760 + 10\frac{mt}{11 + 0.03t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{H.}$$

This formula agrees closely with the French experiments.

44. Dr Thomas Young invented a species of formula entirely new. Abandoning altogether the formula in which one of the variables is involved as an exponent, and abandoning altogether the views from which formulæ of this kind had been derived, he assumed an expression which is apparently perfectly arbitrary, and which has been adapted empirically to the experiments of Dr Dalton. It is this:

$$F = (1 + 0.0029.t)^7 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{I.}$$

Dr Young's Formula.

t being reckoned above 212 Fahr. and F being the force in inches of mercury. Hence we get inversely:

$$t = \frac{F^{\frac{1}{7}} - 1}{.0029}$$

For very small changes of temperature, Dr Young's formula becomes

$$t = 1.642e$$

e being the corresponding slight variation of pressure from 30 inches, which corresponds, within three-thousandth parts, with the mean between Deluc's correction 1.598, and Shuckburg's 1.70, or 1.645e.

Notwithstanding the simplicity of the form of this expression, and the facilities which it presents for ready calculation, it is impossible to adopt it, as it deviates widely and rapidly from the results of observation when extended to high temperatures. Induced, however, by the simplicity of the expression, and not a little influenced, it may be, by the high authority of a name that will ever be distinguished among the most distinguished of those who have contributed immortal truths to the treasures of physical science, the example of Dr Young has drawn after it many followers. Southern, Creighton, Coriolis, Tredgold, Arago, and Dulong, have successively attempted to modify the formula of Young, so as to twist it into some measure of conformity with observed phenomena—we shall see with how little success.

Creighton's Formula.

45. Mr Creighton adopted a similar formula to represent Ure's experiments, only changing the constant exponent from 7 to 6; so that, making F the force of steam in inches of mercury — 0.09, and the temperature of Fahrenheit + 85° = t, we have

$$F = \left(\frac{t}{168.878}\right)^6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{K.}$$

$$\text{Log. } F = (\text{Log. } t - 2.22679)^6$$

Southern's Formula.

46. Mr Southern represented his experiments by the formula

$$F = \frac{(t + 51.3)^{5.13}}{87344.000000.} + 0.1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{L.}$$

Or,

$$\text{Log. } (1.1F) = 5.13 \text{ Log. } (t + 51.3) - 10.94123$$

And,

$$\text{Log. } (t + 51.3) = \frac{\text{Log. } (F + 0.1) + 10.94123}{5.13}$$

Tredgold's Formula.

47. Mr Tredgold simply reinstated Creighton's exponent, altering the co-efficient to bring it nearer to those experiments with which he was acquainted when his work was written; but it is inaccurate at high temperatures, and like that of Creighton.

$$F = \left(\frac{t + 100}{177}\right)^6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{M.}$$

Coriolis's Formula.

48. To adapt the formula to more recent experiments, M. Coriolis (in his work *Du Calcul de l'Effet des Machines*, 4to, 1829) changed the exponent to 5.355, making it in French measures,

$$F = \left(\frac{1 + 0.01878t}{2.878}\right)^{5.355} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{N.}$$

reckoning from 0° cent. in atmospheres of 0.76 metres of mercury.

Formula of the French Academy.

49. The French Academy of Sciences have finally reduced the index to 5.; finding that number represent their experiments at high temperatures, they adopted the following expression:

$$F = (1 + 0.7153t)^5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{O.}$$

to give the elasticity in atmospheres of 0.76 metres, the temperature being in centesimal degrees, of course

$$t = \frac{F^{\frac{1}{5}} - 1}{0.7153}$$

50. In conclusion, the committee of the Franklin Insti-

Formula of the Franklin Institute.

tute have found it necessary to reinstate the index 6, of Creighton, only modifying Dr Young's constant multiplier, so as to obtain

$$F = (0.00333t+1)^6 \text{ ....P.}$$

51. It may be uscful to collate these formulæ, and for this purpose they are assimilated in notation as follows—F being the elastic force due to a certain temperaturc t.

Robison's Formula.

$$\text{Log. } F_t = m\,t \text{ ....A.}$$

Prony's Formula.

$$F_t = \mu_{\prime}\,\rho_{\prime}^{t} + \mu_{\prime\prime}\,\rho_{\prime\prime}^{t} + \mu_{\prime\prime\prime}\,\rho_{\prime\prime\prime}^{t} + \text{\&c..........B.}$$

Laplace's Formula.

$$F_t = 0.^m76.\,(10)^{t.0{,}0154547 - t^2.0{,}0000625826} \text{...C.}$$

Biot's Formula.

$$F_t = 0^m.76.\,(10)^{At + Bt^2 + Ct^3} \text{ ....D.}$$

Ivory's Formula.

$$F_t = 30.\,(0.0087466t - 0.000015178t^2 + 0.0000002483t^3) \text{ ....E.}$$

Schmidt's Formula.

$$F_t = t^{1.163 + 0021t} \text{ ....F.}$$

Soldner's Formula.

$$F_t = \text{log. } 30.13 - \frac{(662-t)\,(212-t)}{52042.} \text{...G.}$$

Roche's Formula.

$$F_t = 760.\ 10\,\frac{m\,t}{11+0.03t} \text{ ....H.}$$

Dr Thomas Young's Formula.

$$F_t = (0.0029t + 1)^7 \text{ ....I.}$$

Creighton's Formula.

$$F_t = \left(\frac{t}{16.57}\right)^6 \text{ .... K.}$$

Southern's Formula.

$$F_t = \frac{(t+51.3)^{5.13}}{87344{,}000{,}000} + 0.1 \text{ ....L.}$$

Tredgold's Formula.

$$F_t = \left(\frac{t+100}{177}\right)^6 \text{ ....M.}$$

Coriolis' Formula.

$$F_t = \left(\frac{0.01878t+1}{2.878}\right)^{5.355} \text{ ....N.}$$

Commission of the French Academy.

$$F_t = (0.7153t+1)^5 \text{ ....O.}$$

Committee of the Franklin Institute.

$$F_t = (0.00333t+1)^6 \text{ ....P.}$$

Examination of the Law of the Elastic Force of Steam.

52. From his earlier expcriments Dr Dalton constructed a scale of true temperature, in which the point of freczing mercury is placed at 175°, and in the method he there adopts, the increments of the scale of true temperature are as the square roots of the corresponding expansions of the mercury from its point of maximum density. This scale was soon made the subject of a close experimental scrutiny by Messrs Dulong and Petit, and afterwards of less accurate, though more acrimonious, strictures by Dr Ure.

This scale was, in fact, slightly inaccurate, because it was founded on the comparatively incorrect data of the experimental physics of that date. It is, however, scarcely fair to institute a comparison between the results of a theory based on certain phenomena and the results of experiments which the improvement of our knowledge has entirely altered. It were less unjust to the theory, and more wise as regards thc interest of philosophy, first to examine how far it would have been modified by recent discoveries and then to compare its results with the legitimate consequences of the data on which it rests. It ought also to be recorded, that Dr Dalton published, in the third part of his *Chemical Philosophy* in 1827, the corrected experimental results to which he had been conducted by the improved methods of observation, and the increased experience of thirty years which had elapsed from his first experiments, while modern writers continue to use the old numbers which should have been altogcther discarded.

Adopting, then, Dr Dalton's recent experiments below the point of ebullition of water, and the experiments of the French and American Institutes above that point to 24. atmospheres, let us see what theory the views of Dr Dalton would conduct us to, setting out from these improved data.

Now, Dr Dalton found that, in his experiments, a certain progression of temperatures was accompanied by a certain progression of elastic force; but his range of experiment being too small, he adopted an erroneous progression, by which, reckoning this progression as rising from the freezing point of mercury, and proceeding as the square roots of the equal expansions of mercury above that point, gave 175° as the point corresponding to the zero of the scale and the origin of his progression.

53. In examining this subject again, I have found that this gradation of temperatures, though not exact in truth, is analogous to one which may be deduced from the best experiments—and equally from Dr Dalton's and those of the French Academy. The law at which I have arrived is this—that if we reckon the temperatures from the point of congelation of mercury in a logarithmic series, the elastic force of steam forms a similar geometric series to these intervals of temperature. This would indicate that equal intervals of temperature are those which expand thc substance of the thermometer through equal fractional parts of its bulk, instead of equi-differential parts as at present, so that, instead of the common arithmetical scries as at present, viz.,

$$C + d + 2\,d + 3\,d + 4\,d + \text{..............}n\,d, \text{............}\alpha$$

we should have the temperatures represented by the geometrical series

$$(C+d)\,.\,(1+d^2+d^3+d^4+\text{......}d^n) \text{..........}\beta$$

and then the corresponding elasticities would be the geometrical series

$$(F+h)\,.\,(1+h^2+h^3+h^4+\text{......}h^n) \text{...........}\gamma$$

54. Let us, therefore, endeavour to obtain the values of two such series, so as to coincide with the best experiments. For this purpose we put the series γ into the form

$$a\,m^n = f \text{..........................}\delta$$

and the series representing the progression of temperatures into the form

$$\frac{t}{r} = p^q \text{...........................}\varepsilon$$

then since (δ)

$$\text{Log. } a + \text{log. } m.n = \text{log.} f$$

or making a the unit of pressure, for simplicity, we get

$$n = \frac{\text{log.} f}{\text{log. } m}$$

whence by substitution in ε when $q=n$, that is, when the elastic force is that which corresponds to the temperature q, we get

$$\frac{t}{r} = p^{\frac{\text{log.} f}{\text{log. } m}} \text{......................}\zeta$$

thercfore

$$\text{Log. } t = \frac{\text{log. } p}{\text{log. } m}\,.\,\text{log.} f + \text{log. } v \text{...............}\eta$$

and

$$\text{Log.}\, f = (\text{log.}\ t — \text{log.}\ v)\ \frac{\text{log.}\ m}{\text{log.}\ p} \ldots\ldots\ldots\ldots \theta$$

When, therefore, p and r are determined for a given value of m, the relative is obtained. If we take the value $m = 2$, and if we take from the experiments of the French Academy and Franklin Institute, values of t and f above and below 30 inches, or unity, which is the value of m, and let these values be t', t'', f', f''; then from (ζ) we have

$$\left(\frac{t'}{r}\right)^{\frac{1}{\text{log.}\, f'}} - \left(\frac{t''}{r}\right)^{\frac{1}{\text{log.}\, f''}} = 0$$

and

$$\text{log.}\ \left(\frac{t'}{r}\right)\ \text{log.}\, f' — \text{log.}\ \left(\frac{t''}{r}\right)\ \text{log.}\, f'' = 0 \ldots\ldots i$$

We have only, therefore, to assume r so as to satisfy these conditions. Now,

$$\frac{t}{r} = \frac{t^{\text{Fahr.}} + c}{212 + c}$$

that is to say, if we reckon temperature from some given point c above or below the usual zero, viz. at the freezing point of mercury, like Dr Dalton's scale of temperature, and use the elastic force at 212° as our unit of pressure, we have then only to take f' and f'' from the tables of experiment, and give such a value to c as will satisfy the conditions. But as Dr Dalton places that zero at 175° we get

$$\frac{t}{r} = \frac{t^{\text{Fahr.}} + 175°}{387}$$

We have still to find p the index of progression, corresponding to the values of f' and f'' in the experiments.

If we take the value of $m = 2$, then since by ζ

$$\left(\frac{t}{r}\right)^{\frac{\text{log.}\ m}{\text{log.}\, f}} = p$$

From the French experiments we get $p = 1.103$, whence by substitution, r being $= 387°$, $p = 1.102$, $m = 2$, we have

$$\frac{t + 175°}{387°} = (1.103)^{\frac{\text{log F.}}{\text{log 2.}}} \ldots\ldots\ldots\ldots\ldots\ldots \text{R.}$$

From Dr Dalton's experiments we get

$r = 387°$, $p = 1.1320$, $m = 2.602$,

whence

$$\frac{t + 175°}{387°} = (1.1320)^{\frac{\text{log. F.}}{\text{log. 2.602}}} \ldots\ldots\ldots\ldots\ldots\ldots \text{S.}$$

From the combination of Dr Dalton's experiments below 30 inches, with the mean between those of the French Academy and the Franklin Institute, we get

$r = 330°$, $p = 1.11401$, $m = 2.0$,

whence

$$\frac{t + 121°}{333°} = (1.11401)^{\frac{\text{log F.}}{\text{log. 2}}} \ldots\ldots\ldots\ldots\ldots\ldots \text{T.}$$

It is from equation S and equation T that we have constructed the large table (Art. 56) in which the results of these formulæ are compared with experiment; the formula for high-pressure steam being compared with the mean of the French and American experiments; but, as they do not extend below 212°, that part is compared with Dr Dalton's table. The coincidence of these formulæ with experiment turns out to be much closer than could possibly have been expected where the discrepancies of experiments from each other are so great. The experiments of Dr Ure deviate from those of Dr Dalton, below the pressure of the atmosphere, as much as .33, and the greatest deviation of the formulæ is .08. At pressures above the atmosphere the maximum deviation in the first ten atmospheres between the French and American experiments amounts to 6.4°, while the maximum deviation of the formulæ is only 1.1°.—

New Formulæ.

It is, however, remarkable, that in all the experiments hitherto made, the law of elasticity below the atmospheric pressure appears to deviate considerably from that above the atmosphere—perhaps it may arise from the circumstance that the experiments below atmospheric pressure have been made with different apparatus, having errors of a different kind from those made at high pressures above the atmosphere.

From these equations we easily deduce the following formulæ in a shape convenient for calculation.

$$\text{Below 212° or one atmosphere.}\left\{\begin{array}{l} \text{Log. F} = 7.71307\ (\text{log.} — 2.587711) \\ \text{Log.}\ t = 0.12965.\ \text{log. F} + 2.587711 \\ \text{when}\ \ t = t^{\text{Fahr.}} + 175.° \end{array}\right\} S^2$$

Finally

$$\text{Above 212° or one atmosphere.}\left\{\begin{array}{l} \text{Log. F} = 6.42\ (\text{log.}\ t — 2.5224442) \\ \text{Log.}\ t = 0.1557634.\ \text{log. F} + 52\,244422. \\ \text{when}\ t = t^{\text{Fahr.}} + 121.° \end{array}\right\} T^2$$

These formulæ converted into rules are as follows:—

To find the pressure corresponding to any given temperature of steam above 212°—

New Rules.

Rule. To the temperature add 121°, find the logarithm of that sum, subtract from this logarithm the number 2.5224442, and multiply the remaining number by 6.42, the product is the logarithm of the pressure in atmospheres of 30 inches of mercury.

To find the temperature of steam, having any given pressure greater than that of the atmosphere—

Rule. Find the logarithm of the pressure in atmospheres, multiply it by 0.1557634, add to the product 2.5224442; the sum is the logarithm of the temperature, from which, if 121° be subtracted, the remainder will be the temperature on the common scale.

Example. To find the temperature at which high pressure steam will exert a force greater than the atmosphere by 195 lbs. on the inch—

195. lbs. = 390. inches of mercury,
390. inches of mercury = 13. atmospheres,
∴ 14 atmospheres = total elastic force of the steam.

$$\begin{array}{lr} \text{Logarithm of 14......} & 1.1461280 \\ & .1557634 \\ \hline & 11461280 \\ & 5730640 \\ & 573064 \\ & 80227 \\ & 6876 \\ & 342 \\ & 44 \\ \hline & .17852473 \\ \text{Add} & 2.5224442 \\ \hline \end{array}$$

502.306 is the number of which 2.7009689 is the log.
121. being subtracted
381.306° is the temperature on Fahrenheit's scale at which the elastic force of steam has a pressure of 14 atmospheres; an elastic force of 13. × 15. lb. excess of pressure above the atmosphere on each square inch, = 195. lbs.

To find the pressure corresponding to any given temperature of steam below 212°—

Rule. To the temperature add 175°, find the logarithm of that sum, subtract from this logarithm the number

Steam.
New Rules.

2.587711, and multiply the remainder by 7.71307; the product is the logarithm of the pressure in decimal parts of an atmosphere; which, if multiplied by 15. will give pounds on the square inch, and by 30. inches of mercury.

To find the temperature at which steam will have a given elastic force less than that of the atmosphere—

Rule. Find the logarithm of the pressure in decimal parts of an atmosphere, multiply it by 0.12965, add to the product 2.5877110; the sum is the logarithm of the temperature which will be expressed in degrees of Fahrenheit's scale, if 175. be subtracted from it.

Example. To find the pressure of steam at 175°.
To 170°
Add 175°
The sum is 345°, of which the log. 2.5378191
subtract 2.5877110
the remainder 1.9501081
multiplied by 7.71307
6.6507567
6650756
95010
28503
6650
—(7.71307)
The next No. is 0.412837, its log. 1.6157786
30
12.384 inches of mercury is the pressure;
being 17.616 inches of mer. below the atmos.
30.000

By these rules the following table is calculated.

Table of the Elastic Force of Vapour in inches of Mercury, at different temperatures, according to our Formulæ S^2 *below* 212° *and* T^2 *above it.*

0°	0.07
10	0.10
20	0.15
30	0.22
*32	0.24
33	0.25
34	0.26
35	0.27
36	0.28
37	0.29
38	0.30
39	0.31
40	0.32
41	0.33
42	0.34
43	0.35
44	0.37
45	0.38
46	0.39
47	0.40
48	0.42
49	0.43
50	0.45
51	0.47
52	0 49
53	0.51
54	0.53
55	0.55
56	0.57
57	0.59
58	0.61
59	0.62
60	0.64
61	0.66
62°	0.68
63	0.70
64	0.72
65	0.74
66	0.77
67	0.80
68	0.82
69	0.85
70	0.88
71	0.91
72	0.94
73	0.97
74	1.00
75	1.03
76	1.06
77	1.09
78	1.12
79	1.16
80	1.20
81	1.24
82	1.28
83	1.31
84	1.36
85	1.39
86	1.44
87	1.47
88	1.51
89	1.56
90	1.61
91	1.65
92	1.69
93	1.74
94	1.79
95	1.84
96°	1.89
97	1.96
98	2.01
99	2.08
100	2.15
101	2.21
102	2.28
103	2.34
104	2.41
105	2.48
106	2.55
107	2.62
108	2.69
109	2.76
110	2.83
111	2.91
112	2.98
113	3.08
114	3.16
115	3.25
116	3.33
117	3.42
118	3.51
119	3.60
120	3.69
121	3.79
122	3.88
123	3.98
124	4.08
125	4.19
126	4.30
127	4.42
128	4.53
129	4.66
130°	4.78
131	4.91
132	5.03
133	5.15
134	5.28
135	5.41
136	5.55
137	5.70
138	5.84
139	5.98
140	6.13
141	6.29
142	6.45
143	6.61
144	6.76
145	6.92
146	7.08
147	7.25
148	7.41
149	7.61
150	7.80
151	8.00
152	8.20
153	8.40
154	8.59
155	8.79
156	8.99
157	9.20
158	9.41
159	9.62
160	9.84
161	10.06
162	10.28
163	10.51
164°	10.75
165	11.01
166	11.28
167	11.56
168	11.85
169	12.05
170	12.36
171	12.66
172	12.96
173	13.26
174	13.56
175	13.86
176	14.16
177	14.47
178	14.78
179	15.09
180	15.41
181	15.73
182	16.06
183	16.40
184	16.75
185	17.10
186	17.46
187	17.83
188	18.21
189	18.60
190	19.00
191	19.42
192°	19.86
193	20.30
194	20.74
195	21.19
196	21.64
197	22.11
198	22.57
199	23.04
200	23.52
201	24.00
202	24.50
203	25.00
204	25.52
205	26.05
206	26.59
207	27.14
208	27.69
209	28.25
210	28.83
211	29.40
*212	30.00
213	30.61
214	31.24
215	31.89
216	32.56
217	33.24
218	33.93
219	34.63
220°	35.35
221	36.08
222	36.80
223	37.54
224	38.31
225	39.11
226	39.94
227	40.70
228	41.66
229	42.55
230	43.46
231	44.29
232	45.14
233	45.95
234	46.78
235	47.58
236	48.39
337	49.21
238	50.04
239	50.86
240	51.70
241	52.53
242	53.37
243	54.22
244	55.07
245	55.93
246	56.73
247	57.60
248°	58.48
249	59.37
294.7	60.00
250.	60.27
274.1	90.00
291.9	120.00
306.8	150.00
319.2	180.00
329.9	210.00
339.3	240.00
348.8	270.00
355.6	300.00
363.0	330.00
369.4	360.00
375.5	390.00
381.3	420.00
387.0	450.00
391.9	480.00
396.7	510.00
401.3	540.00
405.8	570.00
410.0	600.00
444.6	900.00
470.5	1200.00
491.4	1500.00

55. The formulæ thus given are in such perfect accordance with our best experimental knowledge, that we cannot withhold our assent from the correctness of the principles from which they have been deduced. At the same time, we desiderate very much a better series of experiments than we yet possess, as the range of doubtful temperature above 212° is far wider than the present perfect state of experimental science, and our improved means of observing, can at all warrant. The discrepancies between the experiments above and below 212° show, that the two series should if possible be performed with identical apparatus.

The formulæ we have obtained have been founded on the *hypothesis, that bodies expand nearly equal proportions of bulk in equal intervals of true temperature; and we have found that the elastic force of steam increases in equal proportions, from equal increments of temperature, reckoned in true intervals from the bottom of the scale.*

Our formula should, however, be capable of being reduced into a form closely resembling those which have preceded it, in so far as these have represented approximately the experiments they were made to represent; thus the formula of Laplace and his followers is of the form

$$F = C^{m\,t + m\,t^2 + m\,t^3 + \&c. \ ad\ infinit.}$$

So, in like manner, we should obtain from Equation T the following:

$$\text{Log. } 2 \times \left\{ 2\log c - \log.(c - t^\circ) - k\left(\frac{t}{c^2} + \frac{c}{2c^4} + \frac{t^6}{3c^6} + \&c.]\right) \right\}$$

$$-\log. C - \log. (1.11401) \log. F = 0$$

which is easily presented in a form absolutely the same.

In like manner, it may be presented at once in the form adopted by Dr Thomas Young and all his followers, viz.

$$\left(\frac{m\,t + c}{c}\right) = F$$

for, if we take our formula S_2

$$\text{Log. } F = 7.71307 \,(\log. t - 2.587711)$$

we get, resuming the natural number,

$$F = \left(\frac{t + 175}{387}\right)^{7.713} \quad \ldots\ldots\ldots\ldots S_3.$$

Or, if we take formula T_2, we get

$$F = \left(\frac{t + 121}{333}\right)^{6.42} \quad \ldots\ldots\ldots\ldots T_3.$$

We thus find, that the old formulæ have all approximated in a greater or less degree to the representation of am. ida- ital ciple.

the very hypothesis on which ours has now been formed. They thus add greatly to the probability of its truth.

We do not, however, mean to assert, that the zero of the mercurial thermometer is absolutely at 175° or 121° below the present 0. or that the progression of the temperatures has been fixed accurately for mercury or for vapour. On the contrary, we have seen that the discrepancies of the results obtained by different physical experimenters are great, and do not admit of obtaining unchangeable numerical indices of progression, either of the temperatures or the corresponding elastic force. The existence of these two progressions, and their character, has, we think, been established, and our research has the effect of confirming, the profound views of Dr Dalton, which have, we think, been ill understood and insufficiently appreciated.

Steam. Comparative Tables of Elastic Force.

56. The following table exhibits some formulæ and experiments collated:

Table of the force of Steam at different temperatures from 0° to 500°.

I. Temperature. Fahrenheit.	II. Dalton.	III. Ure.	IV. Young.	V. Ivory.	VI. Tredgold.	VII. Southern	VIII Robison.	IX. Watt.	X. Frank. Inst.	XI. New Formula.	XII. Diff. Dalt. & Ure's Expts.	XIII. Diff Acad. Inst.	XIV. Diff. Tred. & Dalton.	XV. Diff. New Formula & Dalton.	XVI. Temperature. Fahrenheit.
0°	0.08	...	...	...	...	...	...	...	...	0.07	...	...	...	— .01	0°
10	0.12	...	...	...	...	...	...	...	..	0.10	...	...	...	— .02	10
20	0.17	...	0.11	...	...	...	...	...	...	0.15	...	...	— .09	— .02	20
32	0.26	0.20	0.18	...	0.17	0.16	0.00	...	...	0.24	— .06	...	— .10	— .02	32
40	0.34	0.25	0.20	...	0.24	0.22	0.10	...	...	0.32	— .09	...	— .11	— .02	40
50	0.49	0.36	0.36	0.36	0.37	0.33	0.20	...	...	0.45	— .13	...	— .10	— .04	50
60	0.65	0.52	0.53	...	0.55	0.48	0.35	...	...	0.64	— .13	...	— .09	— .01	60
70	0.87	0.73	0.75	0.73	0.78	0.68	0.55	0.77	...	0.88	— .14	...	— .05	+ .01	70
80	1.16	1.01	1.05	...	1.11	0.95	0.82	...	...	1.20	— .16	...	— .06	+ .04	80
90	1.59	1.36	1.44	1.36	1.53	0.34	1.18	...	...	1.61	— .23	...	— .04	+ .02	90
100	2.12	1.86	1.95	...	2.08	1.84	1.60	1.55	...	2.15	— .24	...	— .00	+ .03	100
110	2.79	2.45	2.62	2.46	2.79	2.56	2.25	...	...	2.83	— .34	...	+ .05	+ .04	110
120	3.63	3.30	3.46	...	3.68	3.46	3.00	...	...	3.69	— .33	...	+ .10	+ .06	120
130	4.71	4.37	4.54	4.41	4.81	4.43	3.95	...	...	4.78	— .34	...	+ .16	+ .07	130
140	6.05	5.78	5.88	...	6.21	5.75	5.15	5.14	...	6.15	— .27	...	...	+ .08	140
150	7.73	7.53	7.55	7.42	7.94	7.46	6.72	...	...	7.80	— .20	...	+ .21	+ .07	150
160	9.79	9.60	9.62	...	10.05	9.52	8.65	8.92	...	9.85	— .19	...	+ .26	+ .06	160
170	12.31	12.05	12.14	12.05	12.60	12.14	11.05	11.37	...	12.38	— .26	...	+ .29	+ .07	170
180	15.38	15.16	15.23	...	15.67	15.20	14.05	14.73	...	15.41	— .28	...	+ .29	+ .03	180
190	18.98	19.00	18.96	18.93	19.00	...	17.85	19.00	...	18.90	+ .12	...	+ .02	+ .02	190
200	23.51	23.60	23.44	...	23.71	...	22.62	...	...	23.52	+ .09	...	+ .20	+ .01	200
210	28.82	28.88	28.81	28.81	28.86	...	28.65	...	...	28.82	+ .07	...	+ .04	+ .00	210
212	30.00	30.00	30.00	30.00	30.00	30.00	30.00	29.40	...	30.00	0.00	...	+ .00	0.00	212
220	35.18	35.54	35.19	...	34.92	...	35.8	33.65	...	35.10	—0.36	...	— .26	— .15	220
230	44.60	43.10	42.47	42.63	42.00	...	44.5	40.+	...	42.60	—1.50	...	—2.13	—2.00	230
240	53.45	51.70	51.66	...	50.24	...	54.9	49.0	...	51.42	—1.75	...	—3.21	2.03	240

Table of the Force of Steam at different Temperatures (continued).

I. Pressure in Atmospheres.	II. French Acad.	III. Dr Ure.	IV. Young.	V. Ivory.	VI. Tredg.	VII. South.	VIII. Robison.	IX. Watt.	X. Franklin Institut.	XI New Form.	XII Diff. Dr Ure's Experimts.	XIII. Diff. Acad. Inst.	XIV. Diff. Tred. & Dalton	XV. Diff New Form & Ac. Inst.	XVI Pressure in Atmospheres.
1st At.	212.0°	212°	212°	212°	212°	...	212°	212°	212°	212°	0.00	000.2	0.00°	0.00°	1st At.
2d At.	250.5	250.0	240.3	249	250.+	250.3+	...	252.5	250.0	249.7	...	— 0.5	0.+	— 0.55	2d At.
3d At.	275.2	275.0	271	...	274.+	...	267	...	275.2	274.1	...	— 0.2	— 1.+	— 1.0	3d At.
4th At.	293.7	291.5	288	290	294.+	293.4+	...	...	291.5	291.9	...	— 2.2	+1.4	— 0.7	4th At.
5th At.	308.8	304.5	302	...	309.+	...	...	...	304.5	306.8	...	— 4.3	+3.7	— 0.1	5th At.
6th At.	320.4	315.5	...	...	322.—	...	...	...	315.5	319.2	...	— 4.9	+4.0	+1.2	6th At.
7th At.	331.7	325.5	...	...	...	...	...	...	326.5	329.9	...	— 5.7	...	+1.1	7th At.
8th At.	362.0	336.0	...	337	342.+	343.6+	...	...	336.0	339.3	...	— 6.0	+3.3	+0.3	8th At.
9th At.	374.8	345	...	...	...	...	...	...	345.0	348.8	...	— 5.0	...	+0.9	9th At.
10th At.	358.9	...	...	...	...	...	...	...	352.5	355.6	...	— 6.4	...	— 0.1	10th At.
11th At.	366.8	...	...	...	...	...	...	...	...	363.0	...	...	...	...	11th At.
12th At.	374.0	...	...	...	372.—	...	...	...	...	369.4	...	...	+3.0	...	12th At.
13th At.	380.6	...	...	...	...	...	...	..	...	375.5	...	...	...	...	13th At.
14th At.	386.9	...	...	...	...	...	...	...	...	381.3	...	...	...	...	14th At.
15th At.	392.8	...	...	...	...	...	...	...	383.8	387.0	...	— 9.0	...	— 0.3	15th At.
16th At.	398.5	...	...	...	...	...	...	...	...	391.9	...	...	...	...	16th At.
17th At.	403.8	...	...	...	...	...	...	...	...	396.7	...	...	...	...	17th At.
18th At.	408.9	...	...	...	...	...	...	...	...	401.3	...	...	...	...	18th At.
19th At.	413.9	...	...	...	...	...	...	...	...	405.8	...	...	...	...	19th At.
20th At.	418.5	...	...	...	414	...	...	...	405	410.	...	— 13.5	+2.3	— 1.7	20th At.
30th At.	457.2	...	...	...	...	...	...	...	...	444.6	...	...	...	...	30th At.
40th At.	466.6	...	...	...	...	...	...	...	...	470.5	...	...	...	...	40th At.
50th At.	510.6	...	...	...	...	...	...	...	...	491.4	...	...	...	...	50th At.

The first and last columns contain the successive temperatures, as far as 240°, and after that the number of atmospheres of pressure; and their reference extends wholly across the table.

Col. II. contains the later experiments of Dr Dalton, interpolated, where necessary, down to 240°; the remainder of that column is from the experiments of the French Academy.

Col. III. contains the experiments of Dr Ure.

Cols. IV. V. and VI. contain the formulæ of Dr Young, Mr Ivory, and Mr Tredgold.

Cols. VII. VIII. IX. and X. contain the experiments of Southern, Robison, Watt, and the Franklin Institute.

Col. XI contains the numbers given by our formulæ.

Col. XII. exhibits the differences between the experiments of Drs Dalton and Ure.

Comparative Tables of Elastic Force.

Col. XIII. exhibits the differences between the experiments of the French Academy and the Franklin Institute.

Col. XIV. exhibits the deviations of Tredgold's formula from Dalton's experiments, down to 240°; and below that point, from the mean of the experiments of the French Academy and the Franklin Institute, interpolated where required.

Col. XV. exhibits the difference between our formulæ and the best experiments, Dr Dalton's being taken down to 240°; and the mean between those of the French Academy and the Franklin Institute from that point to the end of the table—interpolations being used when necessary.

SECTION IV.—ON THE CONSTITUTIONAL CALORIC OF STEAM, ITS DENSITY AND VOLUME AT DIFFERENT TEMPERATURES, AND ITS GENERATION AND CONDENSATION.

Constitution of Steam.

57. Having now ascertained the force that may be given to steam by heating water in a confined space, so that we can always obtain any force we desire by raising it to the proper temperature, we have next to enquire what quantity of heat is necessary to produce steam of that temperature and force. The answer to this question is, to determine the quantity of fuel necessary to generate steam of a given power, and direct the economic application of that power.

The quantity of caloric necessary to transform a given quantity of water into steam of the same temperature, is called the *caloric of elasticity* of that substance. The quantity of heat which it will contain at any given temperature is called its *capacity* for heat; and the relation which subsists between the quantity of heat which some well-known body, such as water or air, gives out or acquires, in a given change of temperature, and that which any other substance will give out or acquire in the same circumstances, is called the *specific caloric* of that substance.

58. Of the quantity of the caloric of elasticity of any substance, of its capacity for containing heat, and of its specific caloric, the *thermometer* gives us no information. An instrument for doing so may be called, as a distinction, the *calorimeter*. Thus the thermometer measures the intensity of heat—the calorimeter its quantity.

Capacity for Caloric.

If in three several vessels there be contained, at the temperature of 32°, a pound weight of three different fluids, water in one, mercury in the second, and oil in the third; and if the heat of an alcohol lamp be applied, first of all to the mercury, then to the water, and next to the oil, a thermometer being inserted in each, it will require much longer time to heat the water to 212° of the thermometer than the mercury, twenty-five times as much alcohol being burnt in the process; whereas the oil will be warmed to the same temperature on the thermometer, by half the quantity of caloric which is necessary to heat the water to 212°. Therefore, the capacity of water for heat is said to be twenty-five times as great as that of mercury, and twice as great as the capacity of oil; and the specific heats of these substances, in relation to water, are thus represented:

Water, 1.000; oil, 0.520; mercury, 0.040 nearly.

If, instead of taking equal weights of these substances, we had filled equal vessels with them, and then applied the quantity of water necessary to heat them to equal temperatures, we should have had the capacities and specific heat of equal volumes, instead of equal masses as formerly; and it would have been found, that the quantity of alcohol required to heat them to the same temperature, was only half as much for the mercury as the water, and greater for the water than the oil, in the proportion of 20 to 9; showing that the capacity of water was still the greatest, and that the specific caloric, in equal volumes of these substances, are nearly

Water, 1.000; oil, 0.450; mercury, 0.550.

The capacities for heat, and the specific caloric of different substances, may be determined by cooling as well as heating them. An ounce of ice thrown upon a pound of mercury will cool it or an equal weight of oil much more than water; and, in general, the quantity of ice, or of cold water, or of cold air, or any other fluid required to cool a body, will exactly correspond to the quantity of caloric required to heat it to the same degree of temperature. A calorimeter measures the quantity of ice which must be melted in cooling different substances, and is described in our article "HEAT." The following are the results of such of the most valuable experiments upon this subject as are appropriate to our present enquiry:

Table of the specific Caloric in different substances.

	Equal Weights.	Equal Volumes.		
Water, ...	1.000	1.000		
Mercury, ...	0.033	0.470		Dulong and Petit.
Alcohol, ...	0.700	0.570		Dalton.
Sulphuric ether, .	0.660	0.500		Dalton.
Spermaceti oil, .	0.520	0.450		Dalton.
Olive oil, ...	0.309	....		Lavoisier & Laplace.
Sulphuric acid, .	0.350	0.650		Dalton.
Nitric acid, . . .	0.620	0.870		Dalton.
Muriatic acid, . .	0,600	0.700		Dalton.
Sol. of salt (1.197)	0.780	0.930		Dalton.
Sol. of sugar (1.117)	0.770	0.900		Dalton.
Ice, ...	0.900	0.830		Dalton.
Coal, ...	0.280	0.360		Dalton.
Flint glass, . . .	0.190	0.550		Dalton.
Iron, ...	0.110	0.880		Dulong and Petit.
Copper, ...	0.095	0.850		Dulong and Petit.
Lead, ...	0.040	0.450		Dalton.
Tin, ...	0.070	0.510		Dalton.
Zinc, ...	0.100	0.690		Dalton.
Silver, ...	0.055	....		Dulong and Petit.
Gold, ...	0.029	....		Dulong and Petit.
Platina, ...	0.335	....		Dulong and Petit.
Atmospheric air, . .	0.267	1.000*	1.000*	Delaroche and Berard.
Hydrogen gas, . . .	3.294	12.340	8.903	
Oxygen gas, ...	0.236	0.885	0.976	
Nitrogen gas, . . .	0.275	1.032	1.000	
Nitrous oxide gas, . .	0.237	0.888	1.350	
Olefiant gas, ...	0.420	1.576	1.553	
Carbonic oxide gas, .	0.288	1.080	1.034	
Carbonic acid gas, . .	0.221	0.828	1.258	

69. Besides the capacity of different bodies for heat, and the specific heat of each at given temperatures, there is another condition of heat still more striking, and of which the thermometer gives no indication. It is this: that the same substance, at different times, may contain different quantities of caloric, and yet the thermometer in both cases give the same indication of temperature. Ice at 32°, which is in the process of melting, and while its bulk is diminishing by one-tenth part, receives as much caloric as would raise its temperature, when melted, to 172°; and after having received it all, remains still at the same temperature as before, indicating 32° on the thermometer. In like manner, when the particles of the water have acquired so much sensible heat as to raise its temperature to 212°, it may receive as much more heat as would have raised its temperature 950° or 960°, if it had continued to be shown by the thermometer; but the water now assuming the state of steam, the thermometer indicates no accession, but remains in the water or in the steam still at the temperature of 212°. In these two conditions, there-

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* In these two columns air is assumed as unity, the first being the specific heat under equal weights, and the second under equal volumes.

fore, when the particles of ice are leaving the solid and taking the liquid form, and again passing out of the liquid into the vaporous state, a large accession of caloric passes into the substance without being detected by the thermometer; this heat, *insensible* to the thermometer, and manifested only by the calorimeter, is called LATENT HEAT. The doctrine of latent heat was discovered by Dr Black.

The quantity of heat thus latent in the mass of a solid, when it assumes the liquid state, is called the *caloric of fluidity*. The latent caloric of a liquid passing into vapour is called the caloric of elasticity or vaporization.

Caloric of Fluidity.		Caloric of Vaporization.	
Sulphur, . .	144°	Water, . .	967°
Spermaceti, . .	145	Alcohol, . .	442
Lead, . .	162	Ether, . .	302
Bees' wax, . .	175	Petroleum, . .	178
Zinc, . . .	493	Oil of turpentine,	178
Tin, . . .	500	Nitric acid, .	532
Bismuth, . .	550	Liquid ammonia,	837
Ice, . . .	140	Vinegar, . .	875

60. The determination of the latent heat of ordinary steam is a problem of considerable practical difficulty. It may be obtained rudely by very simple contrivances. If a lamp, which burns with tolerable uniformity, be applied to a vessel containing cold water, at the temperature of 32°, so long as to heat it to 212°, the boiling point, and if the lamp be then weighed and the consumption of oil ascertained by the loss of weight; and if the lamp be still applied to the boiling water so as to keep it constantly in ebullition until the whole has been converted into steam; the steam passing off at the same temperature as the water, it will be found, when the whole water has been boiled away, or converted into steam, that 6 times as much oil has been consumed, or that 6 times as much heat has been employed in the conversion of the water into steam as was required formerly to heat the water from 32° to 212°, or to give it 180° of temperature; so that 6 times 180° or 1080°, will appear to have been absorbed or carried off in the steam of 212°—that is, the latent heat of steam is 1080°.

Otherwise, the same determination may be obtained, if the steam, when passing off from the boiling water, be led carefully in a pipe to a vessel of cold water, so as to take from it the heat which it has thus carried off; if the water to which the heat of the steam is given out be at a temperature of 32° and of 6 times the quantity of the water from which the steam was formed, the whole of it will be heated by the caloric of the steam to 212°, showing that the quantity of caloric of the steam amounts to what gives 180° to 6 times the quantity of water; giving, as formerly, 6 times 180° or 1080° as the amount of the latent heat of the steam.

It is to Mr Watt that we owe the earliest determination of the latent heat of steam. Dr Black endeavoured to ascertain this point by the first of the methods we have pointed out, by comparing the time of raising the temperature of water a certain number of degrees, with the time of boiling it off a certain number of degrees; but his result was not correct, being only 800° Mr Watt's result for the latent heat of steam was 1006° 79.

Mr Southern's experiments were made in 1803; and he was assisted in them by Mr William Creighton, and communicated them to Mr Watt for an appendix to this article. He obtained the number 950°. The thermometers employed in his experiments were made and graduated with the greatest care, the tubes having been accurately measured as to the proportional capacity of their different parts.

A similar series of experiments was afterwards made by M. Schmidt, who determined the heat latent in steam to be about 5.33 times that necessary to heat water from 32° to 212° = 5.33 times 180° or 960 nearly.

Latent Heat.

Count Rumford determined the latent heat of steam by condensing it in a calorimeter formed by pushing a long spiral steam pipe through a vessel of cold water, by which he obtained 1040.8 as the latent heat of steam of water.

M. Despretz in the *Annales de Chimie et Physique*, gives 955.8° as the result of his experiments on the latent heat of steam.

Lavoisier and Laplace make the latent heat of steam 1000.°

From the experiments of Gay Lussac and of MM. Clement and Desormes, the number 990° is generally used by the French to represent the latent heat of steam. The diversity of the results obtained from experiments made by so many excellent experimenters, with so much precaution, is remarkable—to eliminate from them the precise truth with certainty is not within our present resources of analysis. There is high probability in favour of the numbers 990. or 1000., as representing nearly enough the latent heat of steam, being 5.555 times the caloric of boiling water, its whole caloric reckoned from 32° being 6.666 times that of boiling water.

61. A doctrine of great simplicity is now pretty generally held as expressing with an accuracy quite within the limits of experimental precision, the result of our knowledge of the heat latent in steam. It is found that in steam of great elasticity and of corresponding high temperature, the heat latent is in quantity less; and that, on the contrary, when steam is of lower elastic force and of lower temperature that at 212°, its latent heat is greater than at 212°. And it appears that we are warranted in the conclusion first suggested by Mr Watt and afterwards by Dr Dalton, that the whole amount of caloric in a given quantity of elastic vapour remains the same at all temperatures and under all pressures. When the volume of the vapour is great the greater is its capacity and the less its temperature; while, by compressing it into smaller space, its elasticity is encreased and its temperature raised. The doctrine is thus expressed, *that the sum of the sensible and latent heat of vapour is a constant quantity*. M. Despretz has extended this to the vapours of several other fluids.

There is another expression for the law of the constitutional heat of the vapour, which is, in the language of the Atomic Theory, *that every atom of a fluid in the state of vapour possesses, under every degree of elasticity and pressure, the same quantity of caloric*. This doctrine leads to very important consequences both of a theoretical and practical nature.

It follows immediately from this doctrine, that if a quantity of vapour have once been formed by adding to the liquid the quantity of caloric necessary to the constitution of the vapour, the same particles of matter surrounded by the same spheres of caloric may pass through all gradations of density, and through all gradations of temperature, without either parting with caloric or obtaining fresh supplies. Vapour of the temperature of 212°, as it rises from water boiling in the open air, may be collected in a vessel and compressed by the force of 30 inches of mercury into half its bulk, it will become steam of a higher temperature, viz., 250° from the increased quantity of caloric in the diminished volume, and in this case the latent heat will only be 970° instead of 1000°. If compressed still further into again one half of that bulk, the temperature will rise to 292°, and leave only 920° latent. Compressed still further into half of the last-mentioned space, that is into $\frac{1}{8}$ of its original bulk, the temperature is raised to 339°, leaving only 873° latent; and another step would raise the temperature to 392°, leaving only 820° latent; less than seven steps more would bring the steam into less than its original bulk of water, with a temperature of between 900° and 1000° of sensible heat, and

Latent Heat.

an amount of latent heat not much greater than its original proportion of sensible heat, or 212°. In this case, we should have steam as heavy as water and as hot as flame.

If, on the contrary, this process were reversed, and the steam produced at 212° under the pressure of an atmosphere permitted to expand in vacuo to double its bulk, a portion of the sensible heat would become absorbed into the spheres of caloric around the atoms of water, increasing the latent heat by 32°, and diminishing the sensible heat to 180°. The bulk being again doubled, and the steam expanded to four times its original bulk, the temperature would sink to 150°, and three more repetitions of the expansion would give a vapour of 71° temperature, and 1141° of latent heat.

This expansion and contraction of the steam, accompanied by diminished temperature, is exactly what would exist if our atmosphere, instead of oxygen and nitrogen, were wholly composed of vapour of water. Suppose the temperature of the ocean to be 1000 , an atmosphere of vapour would be raised of 2000 times the weight of the present atmosphere: the under part of this atmosphere, compressed by the superincumbent weight, would be of great density, but in ascending, the diminished pressure would be attended with diminished temperature, until at last a cloud of white ice would be seen floating on the surface. Must not the sun, from his intense heat, be a body of this nature, having an atmosphere of enormous depth, on the summit of which the beautifully crystalline and sparkling crust is continually preserved by its diminished temperature in a state of renewed whiteness?

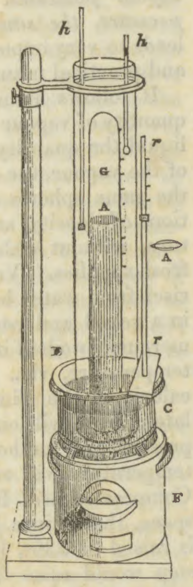
Specific gravity, density, and volume of Steam.

62. The specific gravity, density, and volume occupied by steam at different temperatures, have been correctly determined by experiment; and it has been ascertained that the expansion of vapour follows the law of the expansion of other gases by heat; viz., the law of Dalton and Gay Lussac, that all gases expand from 1. to 1.375 in bulk, by 180° of temperature, or $\frac{1}{480}$ for each degree of Fahrenheit; and, secondly, that steam obeys the law of Boyle and Mariotte, contracting in volume proportionally to pressure. It is first of all necessary to know what bulk a given quantity of water converted into steam will occupy at a given pressure, and the application of these laws will determine the specific gravity, density, and volume at all other pressures and temperatures.

Gay Lussac's experiments,

63. The experiments of Gay Lussac upon this subject are simple, elegant, and satisfactory. His apparatus is as follows:—A chauffer, F, contains burning fuel, by which heat is communicated to B C, a bath of mercury. A spherule A, of thin glass, hermetically closed, contains a given weight of water. G is a glass tube of considerable diameter, filled with pure dry mercury, and inserted in the bath, after which the spherule, A, containing the water, is allowed to ascend to the top of the mercury, and is then broken by concussion, so that a given quantity of water is thus placed in the Torricellian vacuum at the top of the mercury. By the fuel in F heat is then communicated upwards, by the fluids, to the whole apparatus, and to the water in the summit of the tube G; and the mercury descends until the whole of the water is converted into steam, after which it ceases to descend in the same rapid proportion to the increase of temperature. This change shows that the whole of the water is evaporated, and the heat must again be allowed gradually to diminish, until the depression of the mercury corresponds to the temperature indicated in our table of Elastic Force. The capacity of the tube, G, is shown by divisions on its surface previously fixed, and the height of the mercurial column by a graduated rule and vernier *r r*, supported on the edge of the bath. The thermometers, *h h*, indicate the temperature of the fluids.

Fig. 23.



By means of this apparatus, Gay Lussac has determined the specific gravity of steam, to be .625, air being 1000.; that is to say, steam from boiling water is lighter than common air in the proportion of 5. to 8.

64. Dr Dalton's recent experiments make the weight of a cubic foot of air at 60° = 535.68 grains; therefore a cubic foot of common steam weighs 334.8 grains at 60°, under a pressure of 30 inches of mercury; but as this pressure would convert it into water, the true weight will be found, by the law of Mariotte, thus:

$$30 \text{ in.} : .065 :: 334.8 : 7.254$$

the true weight, in grains, of a cubic foot of steam at 60°, and under the former pressure due to its own elasticity in vacuo; but if we wish to know the weight of a cubic foot of steam at 212°, we must use the law of Gay Lussac and Dalton, thus:

$$\frac{(212^\circ - 60^\circ) \text{ or } 152^\circ}{480} + 1 : 1 :: 334.8 : 254.3$$

254.3 grains is, therefore, the weight of a cubic foot of steam, as it passes off from water boiling in the air at 212°.

But the weight of one cubic inch of water at 60° is 253 grains; therefore, the weight of a cubic inch of water at 60° is almost exactly equal to one cubic foot, or 1728 cubic inches, of steam.

Hence we find, that the particles of water, when they form steam, are so much repelled by their spheres of caloric, as to be kept at twelve times their original distance from each other; that, in this gaseous state, water is 1728 times rarer than when liquid; and that one gallon of water, with the requisite supply of caloric, will make 1728 gallons of steam.

65. The source from which caloric is obtained for the conversion of water into steam, is either the heat of the sun, the central heat of the earth, or of artificial fires. It is upon the intensity and quantity of this heat that the elastic force, temperature, density, and volume of the steam obtained for any particular purpose must depend; and it is therefore an important point to determine how it is to be obtained.

The most important and common sources of heat for the production of steam, are the combustion of coal, charcoal, wood, resin, and oil. Many experiments have been made upon the quantities of caloric given out during their combustion; but the results vary much with the methods of applying the heat. The six following are some of the results of Dr Dalton's experiments; the rest are selected from the best authorities:

One lb. of Hydrogen, burnt with 7 lbs. oxygen, produces 8 lbs. of water, and raises 250 lbs. of water 180°.

Charcoal,	2.8	3.8 carbon. acid,	31 lbs.
Oil, wax, tallow,	3.5	4.5 water and carb. ac.,	81
Oil of turpentine,			46.4
Carburetted hydrogen,	4.	5. water and carb. ac.	66
Olefiant gas,	3.5	4.5 water and carb. ac.	67
Naphtha,	3.20		73
Rape oil,			90
Caking coal,			54
Olive oil,			76
Charcoal,			57
Coke,			51
Peat,			22
Newcastle coal,			55.5
Culm,			11

The numbers in the last column represent the number of pounds of water at 32°, which will be heated to 212°, when the fuel is applied in the most economical manner; and hence the quantity of fuel to heat any other quantity

Steam produced by Fuel

of water any number of degrees, can be found by the common arithmetical rules of proportion.

The quantity of water at 212°, which will be converted into steam, may be found, by dividing the number of pounds of water in the table by 5.55. Thus, from the table—

1 lb. of Newcastle coal gives 180° to 55.5 lbs. of water.

Therefore, 1 lb. of Newcastle coal converts into steam, $\left.\right\} \frac{55.5}{5.55} = 10$ lbs. of water.

This is to be taken as the effect that may be produced if there be no material loss of heat; and in the Cornish engines I find that even 10.5 lbs. are actually accomplished.

In general, however, for the purposes of ordinary manufactures, in Lancashire, Staffordshire, and the vicinity of London, it appears that not more than 6.6 lbs. of water are converted into steam by one pound of coal; so that not more than 33.3 lbs. of water are heated with ordinary boilers from 32° to 212°. The following table may be taken as the numbers usually given to represent the actual state of practice. But a late investigation by Mr Parkes shows, that in the best constructions of boilers now used in Cornwall, Warwickshire, and elsewhere, these effects are nearly doubled:

1 lb. of the best coal is generally required to heat 33.3 lbs. of water from 32° to 212°.
1 lb.......................6.6 lbs. of water at 212° into steam.
and 1 lb.................5.5 lbs. of water at 32° into steam.
2 lbs. nearly............one cubic foot of water from 32° to 212
11 lbs. nearly.........one cubic foot of water at 212° into steam.
13 lbs. nearly..........one cubic foot of water at 32° into steam.

Now, as a gallon contains ten pounds of water, it follows that

1 lb. of coal will raise $3\frac{1}{3}$ gallons of water from 32° to the boiling point.
5 lbs. of coal will convert $3\frac{1}{3}$ gallons of water at 212° into steam.
6 lbs. of coal will convert $3\frac{1}{3}$ gallons of water at 32° into steam.

We have given these approximate numbers for practical use, in the application of steam to some of the ordinary purposes and processes of art and domestic use, upon which we are about to enter; and they are such as may, with very ordinary care, be safely calculated on. But for a full exposition of the processes, and principles, and mechanical arrangements connected with the best methods of generating steam from fuel, we must refer to the article "STEAM-ENGINE," where the generation and condensation of steam find their most important uses.

It may perhaps be proper to remark, that a boiler, which is there called a boiler of one, two, or three horses' power, is one which is capable of raising one, two, or three cubic feet of water into steam in an hour. Whatever, therefore, be the application for which steam is wanted, if twenty cubic feet of water per hour are required to be converted into steam, a twenty horse-power boiler is that

Density of Steam.

Dr Dalton's Table of the Density of Air and Steam.

100 cubical inches of air under 30 in. Barom. and 60° Fahrenheit, being 31 grs.											
Temperature.	Vol. Air. under 30 in.	Weight of 100 cubic inches of steam.	Elasticity of steam.	Temperature.	Vol. Air. under 30 in.	Weight of 100 cubic inches of steam.	Elasticity of steam.	Temperature.	Vol. Air. under 30 in.	Weight of 100 cubic inches of steam.	Elasticity of steam.
Fahr				Fahr.				Fahr.			
32°	480	.178 grs.	0.26	48°	496	.303 grs.	0.46	64°	512	.468	0.73
34	482	.191	0.28	50	498	.323	0.49	66	514	.492	0.77
36	484	.203	0.30	52	500	.341	0.52	68	516	.521	0.82
38	486	.206	0.32	54	502	.366	0.56	70	518	.551	0.87
40	488	.229	0.34	56	504	.384	0.59	72	520	.580	0.92
42	490	.245	0.37	58	506	.402	0.62	74	522	.610	0.97
44	492	.267	0.40	60	508	.420	0.65	76	524	.645	1.03
46	494	.284	0.43	62	510	.444	0.69	78	526	.680	1.09
								80	528	.721	1.16

Gay Lussac's Table of the Density and Volume of Steam.

Water at 32° being the unit of Density and Volume.															
Temp.		Density.	Volume.	Temperat.		Density	Vol.	Temperat.		Density.	Vol.	Temperat.		Density.	Volume.
Fah.	cent.			Fah.	cent.			Fahr.	cent.			Fah.	cent.		
32.°	0°	0.00000540	182323	89.6°	32°	0.00003263	30650	147.2°	64°	0.00015010	6662	204.8°	96°	0.00051613	1938
35.6	2	609	164332	93.2	34	3619	27636	150.8	66	16356	6114	208.4	98	55191	1812
39.2	4	686	145886	96.8	36	4017	24897	154.4	68	17797	5619	212.	100	58955	1696
42.8	6	772	129587	100.4	38	4442	22513	158.	70	19355	5167	250.5	121.4	0.0011147	897.09
46.4	8	869	115305	104.	40	4916	20343	161.6	72	21013	4759	275.2	135.1	16150	619.19
50.0	10	974	102670	107.6	42	5418	18659	165.2	74	22794	4387	293.7	145 4	20997	476.26
53.6	12	0.00001092	91564	111.2	44	6023	16805	168.8	76	24702	4048	307.54	153.8	25763	388.16
57.2	14	1224	81686	114.8	46	6585	15185	172.4	78	26739	3741	320.3	160.2	30402	328.93
60.8	16	1372	72913	118.4	48	7242	13809	176.	80	28889	3462	331 9	166.5	34911	286.12
64.4	18	1534	65201	122.	50	7970	12546	179.6	82	31195	3206	341.7	172 1	39434	253 59
68.	20	1718	58224	125 6	52	8753	11424	183.2	84	33637	2973	358.8	181.6	48226	207.36
71.6	22	1914	52260	129 2	54	9606	10410	186.8	86	36237	2760	418 4	214.7	89863	111.28
75.2	24	2133	46877	132 8	56	0.00010525	9501	190.4	88	38984	2565	457 1	236.2	0.0129030	77 50
78.8	26	2376	42084	136 4	58	11523	8680	194.	90	41891	2387	478 6	265.9	203060	49.315
82.4	28	2643	37838	140.	60	12599	7937	197.6	92	44956	2224				
86.	30	2938	34041	143.6	62	13760	7267	201.2	94	48201	2075				

which must be procured for the purpose—and of course from 220 to 260 pounds of the best coal will be consumed in that time.

Section V.—The application of our knowledge of the properties, phenomena, and laws of steam, to practical and economical purposes.

Application of Steam.

1. Warming apartments and buildings by steam. 2. Heating greenhouses &c., by steam. 3. Evaporating solutions, drying fabrics, paper, gunpowder, grain, &c., by steam. 4. Warming baths, boiling liquids, and distilling by steam. 5. Preparation and economy of wholesome food by steam. 6. The steam-engine.

1. *Warming Apartments by Steam.*

Warming by Steam.

66. One of the most important applications of steam in the economy of fuel, is its employment as a vehicle for transferring to a distance, and distributing uniformly, the heat of a fire for the purpose of warming an apartment or building. Its great efficiency for this purpose arises from the largeness of its capacity for caloric, because, as it holds a quantity of caloric equal to 1000 degrees, it will communicate as much heat as a mass of red hot iron; and it will have this advantage over the iron, that it can carry this heat to a distance without a similar loss; because, the heat being latent, will not be given out until it arrive at its destination and become condensed, when the whole of its 1000° will be usefully applied.

The manner in which warming by steam is to be effected, is this. At a convenient part of the building, and as low as possible, there is to be placed a close steam boiler of the ordinary construction. From this boiler a small steam pipe is to be carried to the part of the building which is to be warmed. This small pipe should be pretty thick, and carefully rolled round with a fillet of flannel to a quarter of an inch thick, and the boiler should be wholly covered with bricks and plastered over to keep it warm. This smaller steam pipe should have an area of one square inch for every six gallons of water that the boiler can boil off in an hour. Pipes of a larger size are to be laid round the room above the floor, or under the floor if apertures be left to allow a free circulation of warmed air to enter the room; but the best method we have seen is, to make the surbase, which passes round the room of thin iron plate or copper having the external figure of the surbase, and sufficiently strong to withstand the pressure of the steam, which strong tin plate or copper of $1\frac{1}{2}$ lb. to the foot will sufficiently effect, if the surbase be not more than about 4 inches square. Into these larger pipes the steam is to be conducted, and in them the steam will be condensed into water, and will give 1000° of heat to the colder air of the room which is in contact with the outside of these pipes. In doing so the steam being condensed into water, small pipes of lead or tin must be provided, for the purpose of bringing back this condensed water into the boiler; and, in order that they may act well, care is to be taken that a gentle slope, of about an inch in 20 feet, be given to all the pipes. The condensed water being thus conducted back to the bottom of the boiler, it will there be replenished with heat, and in the form of steam will again carry up its supply of 1000° to the apartment, again to be given off as formerly to the room, and then returning once more to the boiler, a continual circulation of the same particles of water, giving out in each circuit a quantity of heat equal to red hot iron, is uniformly and gently imparted to and diffused equally over the apartment. The pipe which brings the steam from the boiler may be called the feeding pipe, the pipes which give off the heat the radiating pipes, and the pipes which lead back the water to the boiler the return pipes. We have already given dimensions for the feed pipe. The return pipes need not be more than $\frac{1}{12}$ of the diameter of the feed pipe, but an increase of size could do little harm, and may have the effect of preventing accidental obstruction: the boiler will require to have a pint of water added now and then to supply accidental waste; and a safety-valve on the boiler is indispensable. A self-regulating feeder, such as that mentioned in the article Steam-Engine, among the apparatus of boilers, is also to be recomended where it can be readily attained. It is necessary, however, to give directions at greater length for the dimensions of the warming or radiating pipes, as it is upon their proper construction and arrangement that the efficiency of the apparatus entirely depends; and the apparatus has frequently failed from the want of proper precaution. The radiating pipes in the room are generally too small. It is their extent of surface, and the free circulation of air round them, which determines how much of the heat will be given out, and how rapidly. From very accurate experiments I am induced to conclude, that a room containing 500 cubic feet of air, and exposing 400 feet of surface, may be maintained at a temperature of 20° above that of the air without—that is to say, at 60° in the inside of the room when the atmosphere is at 40o without—for a space of twelve hours, by the evaporation of 2 gallons of water, and at the expense of about three pounds of coal of the value of one farthing. But this supposes that there is no ventilation, and that the air of the room is never changed; whereas, the presence of one individual would render it necessary to introduce nearly 400 cubic feet of external air every hour. Now, the heat of 20° given to 400 cubic feet of air would require the evaporation of 3 gallons of water; and, therefore, the evaporation of 3 gallons of water would be required for such a room, and 3 gallons for every person in it, if properly ventilated, and for every 2 gallons there should be at least one square foot of radiating surface; so that such a room, occupied by one person, would require a surface of warming pipe equal to $2\frac{1}{2}$ square feet, and so on for every such room and occupant, for a space of 12 hours in the day.

Thus, the evaporation of 1 gallon per day for every 400 feet of surface, with a difference of temperature of 20 from the external air, and $1\frac{1}{2}$ gallons per day for each person, and 1 square foot of radiating surface, is a standard from which we easily calculate.

A room 30 feet long, 20 feet wide, and 10 feet high, has a surface of 2200 feet, which would require $5\frac{1}{2}$ gallons; six people would require 9 gallons; therefore, $14\frac{1}{2}$ gallons of water and $7\frac{1}{4}$ feet of radiating surface will heat the well-ventilated room 12 hours for 6 persons at an expense of 25 lbs. of coal, or about threepence per day; or a whole house, occupied by 6 persons, may be warmed, if 30 feet high, 30 feet wide, and 30 feet deep, at tenpence a-day, the price of coals being twenty shillings a-ton.

It is scarcely necessary to add, that the radiating pipes may be best constructed of thin copper, and ought to be roughened and blackened on the outside.

In the same way the calculation may be made for any other room, building, and number of occupants.

For more extensive and minute information on the subject of Warming, the reader is requested to consult the article "Warming and Ventilation," in the Encyclopedia.

The form in which the radiating surface may be distributed admits of variety.

Provision must be made for the expansion and contraction of the pipes.

The arrangement of steam in the apartment to be heated is of some consequence. It is, we have already stated, sufficiently out of the way in the surbase, but, in that case, much heat passes out into the walls and wood. It may stand on the hearth like a stove, and consist

Steam.

Warming by Steam.

of concentric cylindric chests within each other (fig. 24), filled with steam, and allowing air to ascend by the sides and through the intervening spaces, so as to be made warm, and the outer surface radiating directly on the surface exposed. It may be tubular, and coiled in a large quantity in a small box fitted up externally in the appearance of a cabinet or pedestal in the apartment, thus: (Figs. 25 and 26); the feed pipe commencing at the top of the coils, and the return pipe passing off from the bottom. As the conducting power of tin is nearly equal to that of iron, a quantity of tin pipe will suffice, and be more economical than iron or copper. This coil may be placed in a cabinet or pedestal of the form of Fig. 26, and the warm air will have free egress through the wire work of the panel.

Fig. 24

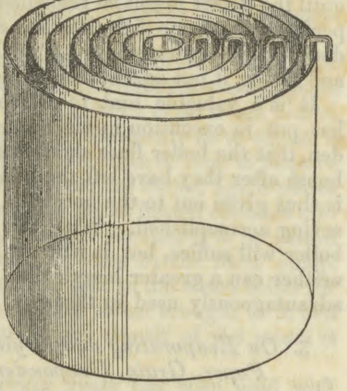


Fig. 25.

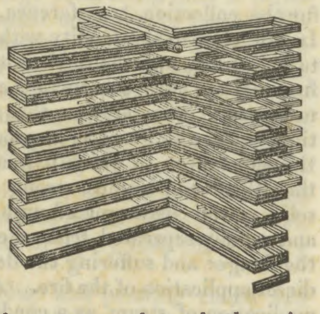
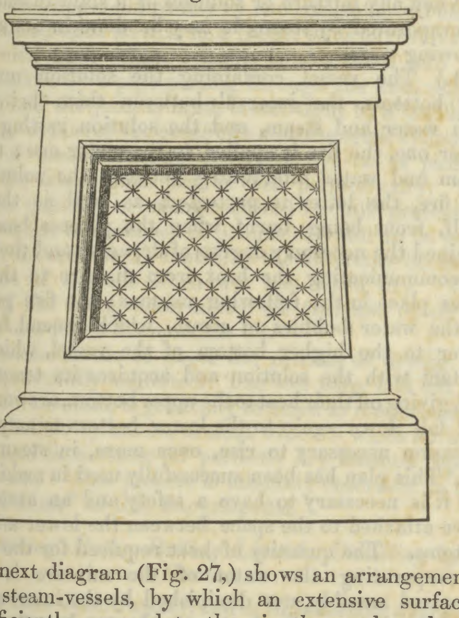


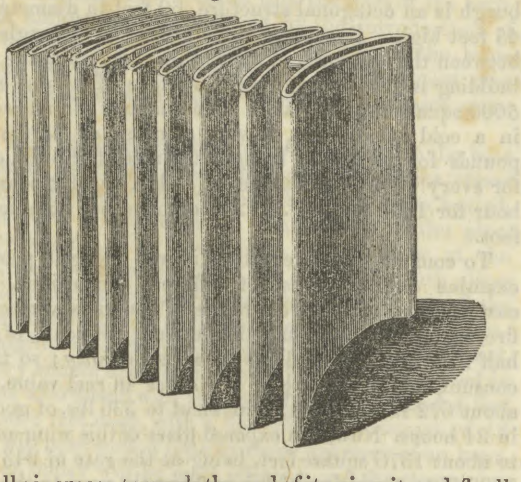
Fig. 26.



The next diagram (Fig. 27,) shows an arrangement of copper steam-vessels, by which an extensive surface is very efficiently exposed to the air, the condensed water being drawn off at the bottom.

There is one case in which warming by steam may be employed with especial advantage, and where it is frequently neglected—where the power of steam is already employed to drive machinery. Let the engine employed be what is called high-pressure, or non-condensing, in which the steam escapes from the engine and is passed off into the air; and, instead of the common plan, let the steam from the engine be conveyed in pipes through the apartments to be warmed, and let the diameter of the pipe gradually increase towards the end of its circuit, and finally terminate in a hot-water pipe, which may also circulate in the building and there will be given out the whole original heat of the steam after having done its work in the steam-engine, and that as effectually as if there had been no steam-engine at all, and the whole power of the engine will thus be clear saving. This will be the case to a still greater extent if the steam-engine work expansively, and may further be increased if the pipes be so formed as to constitute an aerial condenser. For further information on this subject see article STEAM-ENGINE.

Fig. 27.



2. *Warming Hothouses, Greenhouses, &c. by Steam.*

Greenhouses, &c. warmed by Steam.

67. The principles which regulate this application of steam are similar to those mentioned already in Art. 66, and steam possesses the same advantages in the distribution of heat for this purpose, which it does in the cases already mentioned. The warmth thus distributed is freed from those risks of injury to the vitality of the plants, which accompany the old method of warming by hot air flues, in which a contaminated and unwholesomely dry air and unequable temperature were inevitably produced, and an occasional annoyance from smoke. The warmth given out by the steam is of uniform intensity throughout the whole length of the glass; it occupies very small space —one furnace and chimney is all that is required for any extent of range of glasshouses, as the steam may be conveyed to any usual distance in well swathed pipes without sensible loss. The saving thus effected by the concentration of the fire, and by its equable distribution, has been found to produce an economy of more than one-third of the fuel commonly used. At Sion House, the seat of the Duke of Northumberland, there are nearly a thousand feet in length of glasshouses heated by one such apparatus. The boiler and chimney may also be placed at a convenient distance from the houses—a circumstance which contributes much to the beauty of this arrangement.

Those who wish to study the details of this subject are referred to Mr Loudon's Horticultural Works, and to the article "HORTICULTURE," in this Encyclopedia. The following are the mechanical principles and arrangements that belong exclusively to this article.

Our first subject of enquiry, is into the amount of heat requisite to sustain the glass at a given temperature higher than that of the external air; if we take the temperature of the atmosphere at 35°, and that of the hothouse at 65°, giving 30° of difference, we shall have a case approaching near to that of a glasshouse in winter. In order to determine this question, which can only be ascertained by experiment, the author has examined a case upon a large scale, which may furnish a standard of comparison.

Green-houses, &c. warmed by Steam.

The large palm house of the Botanic Garden of Edinburgh is an octagonal structure, 60 feet in diameter, and 45 feet high. Excepting stone pillars at the angles, and between the windows, of about three feet wide, the whole building is glass, presenting a surface of almost exactly 5000 square feet of glass. The quantity of fuel required in a cold atmosphere, having a mean of 35°, is 1344 pounds for 24 hours; being at the rate of 269 lbs. of coal for every 1000 feet of glass in a day, or 11.2 pounds an hour for 1000 feet, or .0112 of a pound per hour for each foot.

To confirm this observation, it was thought proper to examine another house of different dimensions. The eastern wing of the great range of houses is warmed by a fire, which consumes half that quantity of coals, of about half the value, being dross of a bad quality; so that its consumption is about $\frac{1}{4}$ of the other in real value, being about 672 lbs. of dross, equivalent to 336 lbs. of good coal in 24 hours. Now, the exposed glass of this wing amounts to about 1376 square feet, being at the rate of 243 lbs. to 1000 feet—a result which is sufficiently near to the other, to allow us to assume 250 or 260 lbs. of fuel in 24 hours for each thousand feet, as a standard of tolerable accuracy in such cases. It may be useful to add, that these houses are in tolerably sheltered situations, and that the glass faces in every direction, so as to be acted on with tolerably uniformity.

Hence we have the following results:

Temperature of the air 35°—temperature of the hothouse 65°.

Heat sustained 24 hours, by 250 lbs. of good coal, for 1000 square feet of glass.

Heat sustained 1 hour, by 10.4 lbs. of good coal for 1000 feet of glass.

Heat sustained 1 hour, by 0.0104 lbs. of good coal, for one foot of glass.

To find what amount of steam will be required to warm such a house, we have only to apply the calculations of Art. 66; 10.4 lbs. of good coal will convert seven gallons of water into steam; therefore, a boiler of one horse's power is necessary to evaporate a sufficient quantity of water for the supply of steam for each 1000 feet of glass; that is to say, for the palm-house alone, a boiler of five horses' power would be required to furnish steam; and this supposes the hot water of the condensed steam to be returned into the boiler immediately; and if this were not the case, six horses' power would be the size of boiler ordered for this purpose: hence—

To warm a hothouse by steam, there is required the boiler of a steam-engine, reckoned at one horse's power for every thousand feet of glass.

The method of distributing the heat through the rooms of the hothouse, is not a matter of so nice calculation as in a common apartment. There is much greater convenience for this purpose in a greenhouse than a common room, on account of the necessary vacuities under the ranges and beds. In general, a single circuit of steam-pipe four inches in diameter, round the apartment, with a return pipe of equal dimensions laid parallel to it, is sufficient.

It is, however, of great importance to provide a remedy for one of the practical inconveniences of steam. When the fire is not very carefully tended, as during the night, the steam in the boiler falls below the proper point, and the supply instantly ceases. This is remedied by the following method. Cast iron boxes, a foot square and five or six feet deep, are filled with stones, and ranged round the forcing rooms—a pipe passing into each of them communicates a supply of steam to them, and the stones they contain. The caloric entering first of all with rapidity into the stones, is afterwards given out gradually by them to the house; and the advantage of this arrangement is, that even if neglect or accident were to occasion a temporary cessation of the supply, this heat would still continue to be given out from the matter of the boxes for several hours until the defect might be remedied. These boxes of stones perform the same function for caloric that a fly-wheel does for mechanical power—absorbing it when in excess, and giving it out again when deficient.

It is a valuable hint to economy, which Mr Macnab has put in execution in his houses at the Botanical Garden, that the boiler flues should be extended to the greenhouse after they have left the boiler; the remaining heat is thus given out to the hothouse, and the last degree of saving accomplished. With this arrangement a smaller boiler will suffice, but it will not always be convenient; neither can a greater length than about 30 feet of flue be advantageously used in this way.

3. *On Evaporating and Drying Solutions, Cloths, Paper, Grain, Gunpowder, &c., by Steam.*

Evaporating by Steam.

68. We have already observed how well the peculiarities of steam enables us to make use of it as a vehicle for the collection, transference, and distribution of heat. In addition to the facility with which it may be carried to a distance, and the uniformity of temperature resulting from it, we have this further adaptation to the purposes now under consideration, that the temperature can at no time become so great as to produce injury, or deteriorate the substances to which it is applied. Hence it follows that thickened liquids, strong solutions, and any porous solid matter impregnated with fluid may be evaporated, and wholly separated from the fluid, without incurring the danger and suffering the deterioration resulting from direct application of the fire. And, further, by the proper application of steam, as a conductor of heat, liquids may be warmed, evaporated, and even boiled in vessels of wood, which is in some cases, as in brewing and delicate distributions, a matter of much importance.

When any mixture or solution of a solid in water is to be evaporated by steam, it may be done in some of the following ways.

(1.) The vessel containing the solution may have two bottoms, the interval between them being filled with water and steam, and the solution resting on the upper one, the fire is applied to the under one; thus the steam and water intervening between the solution and the fire, the latter is protected, as well as the vessel itself, from being burnt when the process has nearly attained the necessary degree of dryness; and the process of communicating the heat from the fire to the water takes place in the following manner; the fire generates in the water bubbles of steam, which ascend from the lower to the higher bottom of the vessel, which is in contact with the solution and acquires its temperature, and, giving off their heat to the upper bottom, are condensed, and fall down again to the lower bottom to acquire the accession necessary to rise, once more, in steam to the top. This plan has been successfully used in making salt; and it is necessary to have a safety and an atmospheric valve attached to the space between the lower and upper bottoms. The quantity of heat required for the purpose of evaporating the water of the mixture is neither increased sensibly, nor diminished by the intervention of the steam between the bottoms; the number of gallons of water to be evaporated from the solution will determine the quantity of heat by Art. 66.

(2.) A second method of producing evaporation is to introduce among the mixture a steam pipe, so as to wind amongst it either in the form of a helix, like a cork-screw or worm of a still, or to perform such a circuit as shall expose a large quantity of surface, with tolerable uniformity, to the fluid for the absorption of heat from the steam. Copper is the best material for the tubes, and wooden tanks lined with lead or tin will contain the mixture. The fuel required for evaporation will be 5 lbs. for every $3\frac{1}{3}$ gallons of water to be evaporated, and the steam boiler must have one horse's power for every 6 gallons to be evaporated in an hour.

(3.) A third method is the invention of Mr Goodlet of Leith. The substance to be evaporated is forced by means of a pump into a long copper pipe, which enters a close steam boiler, and after winding through it so frequently as to expose a sufficient surface for a sufficient length of time to acquire the necessary supply of heat from the boiler, again passes out from the boiler and discharges its heated contents into an appropriate reservoir, again, if necessary, to be passed once more through the same process by the force pump. In this case the substance is brought to the steam boiler for evaporation instead of having the steam brought to it, and thus any loss of heat during the transit of the steam is prevented.

A steam kiln for drying grain has been used with great success by the same person. The grain is spread out on the iron floor of a large room—this floor is perforated with a multitude of small openings, or formed of a very fine grating; immediately under the floor steam pipes of 6 inches diameter lie parallel to each other at small intervals apart, and radiate heat directly to the floor and the grain, and also to the surrounding air, which in this hot state ascends through the grain; numerous large ventilators being provided for the escape of the vapour thus impregnated with moisture, after it has ascended through the grain. This method has been found effectual, and is attended with less risk of injury than the ordinary one.

In the processes of drying and printing cloths and fabrics of various kinds, rapid and complete drying is of much importance. This is effected principally in what is called a drying frame: this consists of a dozen of tin cylinders, a foot in diameter and 6 or 8 feet long; these cylinders are closed completely by two hemispherical ends, and are placed upon an axis in a frame, so as to revolve in contact with each other. Steam is conducted into all these cylinders by a pipe passing through the axis, which is hollow, and the joint is made steam-tight by a stuffing-box similar to that of the cover of a steam-engine cylinder. A piece of cloth dripping from the dye-vat is passed through the frame once and is then perfectly dry. Of course, the quantity of steam required for this process is proportional to the number of pounds of water to be evaporated from each piece, that is, to the difference between the weight of a piece when wet and when dry. The number of lbs. being ascertained, the fuel and power of the boiler are found from article 66.

In the manufacture of paper the process of drying by steam is beautifully exhibited. The wet pulp, laid out on the web of wire cloth, is gradually strained as it approaches the large hollow cylinders, around which it winds for half a minute and then comes off perfectly dry finished paper, ready for use. This process is minutely described in the article "PAPER" of this Encyclopedia.

4. *Warming Baths, Boiling Liquids, Distilling by Steam.*

69. To heat water rapidly, and in considerable quantity, by means of a fire placed at some distance, is a problem frequently proposed; and steam for such a case is an excellent vehicle for the heat. Let there be placed in a steam boiler 10 gallons of water, and heated into steam; these 10 gallons conveyed to a reservoir or bath of water at a distance, by a small lead pipe, will heat nearly 55 gallons of water from 32° to the boiling point, or 165 gallons from 40° to 100°, the usual temperature of a warm bath. A bath of the ordinary construction will require about 160 gallons, and the said 10 gallons will require 18 lbs. of coal, value sixpence. Besides this, the sides of the bath, if made hollow, may be warmed by the introduction of steam between the lining and the outside, at the same time that the water is warmed; and the apartment may further be heated with steam pipes from the same apparatus.

Warming Baths by Steam.

The most effectual method of communicating the heat of steam to water is to pass the open end of the steam pipe from the boiler directly into the water to be heated, so as at once to mix with it. The mouth of the pipe, properly regulated by a stopcock, should enter at the bottom, and be directed from one end of the bath along one side towards the other, and thus the impetus of the steam on entering will communicate to the water a circulation highly conductive to an equable distribution of heat.

A very simple apparatus of this kind may be placed in the same apartment with the bath itself. A boiler 4 feet long and 2 feet deep, with a fire covering a square of 18 inches, will heat such a bath in three quarters of an hour. A copper boiler will be most effective, and the steam pipe should first be matted with bandages of flannel, and then stitched with canvass painted, from the boiler to where it enters the bath.

In establishments where there are many baths, a reservoir at the top of the building may be kept constantly filled with water ready to descend into the baths, the reservoir being supplied with heat from the steam pipe of a boiler placed in the outer buildings, or some other suitable place. It is to be recollected that the boiler used must be what is called a one, two, or three horse power boiler, according as one hundred, two hundred, or three hundred gallons per hour are wanted; and so on for every additional hundred gallons of water at 100° of temperature—one horse power of boiler for one hundred gallons.

Boiling Liquids by Steam.

The same process may be used for heating and even for boiling a liquid or solution, in which no injury will result from adding the steam of this condensed water to the liquid. In a dye-work, or other work where much boiling and many solutions are used, steam boiling in this manner is a process of great convenience and value. The vessels containing dyes of various kinds, including leys and solutions of various substances, in which cloths, yarns, wools, and various materials are to be boiled, are ranged around a spacious apartment. Around this apartment, attached to the wall, circulates a steam pipe of two inches diameter, from which smaller branch pipes go off to each of the boilers from the nearest point, and pass down to the bottom of their respective vessels. The exit of the steam is governed by a stopcock under the hand of the operator; and by this means he can easily, by allowing a smaller or greater supply of steam to enter the liquid, produce a uniform and gentle simmer or excite an instantaneous and tumultuous ebullition. Two great advantages give this method much superiority over the common mode of boiling by the direct action of the fire. The condensed steam supplies to the solution exactly as much water as is lost by evaporation, so that it remains of the same strength through a protracted process, and there is no injury sustained by allowing the substances immersed to settle down and rest at the bottom.

Where it is not allowable for the caloriferous steam to be condensed in contact with the liquid to be warmed or boiled, we must resort to the method of heating by surface; that is to say, the steam must be conveyed through the mass of liquid by a pipe, or other conductor best fitted to give out the heat or retain the water. A very thin pipe of the purest soft copper is best for this purpose; 2 inches in diameter and $\frac{1}{20}$ to $\frac{1}{40}$ of an inch in thickness will be found good dimensions, and a square foot of surface for every 10 gallons of water to be boiled per hour will be required. For some purposes, it will be enough to wind the pipe in a spiral

Boiling Liquids by Steam.

round the inside of the vessel to be heated; but if the vessel be large, numerous pipes must pass through the liquid. For boiling 1000 gallons per hour, 200 feet of copper pipe 2 inches in diameter are required.

Distillation by Steam.

In distillation by steam, the same method of communicating heat to the liquid to be distilled is employed as already described in boiling. But the vapours of other liquids, having less specific caloric than water, a smaller quantity of steam from the boiler will be required to evaporate than to evaporate an equal quantity of water; thus the heat of one gallon of water will evaporate and cause to be distilled 2 gallons of alcohol, 3 of sulphuric ether, and 4 of turpentine. It is a curious phenomenon, of which distillers should avail themselves in carrying off the vapour in distillation, that although alcohol floats on water, and ether on alcohol, nevertheless the vapour of water floats above vapour of alcohol, and vapour of alcohol above vapour of ether.

The densities of water, alcohol, and ether			
being	10.	8.	7.
and the densities of their vapours	6.	16.	25.
in round numbers.			

5. *Preparation of Food by Steam.*

Cooking by Steam.

70. The last of the applications of steam which we shall here examine is that which was historically the first, its application to cooking and other domestic uses. This invention makes its appearance in the following record of the Royal Society of London.

At a meeting of the Council of the Royal Society,
December 8, 1680.

Papin's Digester.

Ordered, that a book intituled A New Digestor, or Engine for softening Bones, &c., written by Denys Papin, Doctor of Physick, and Fellow of this Society, be printed and published.
Chr. Wren.

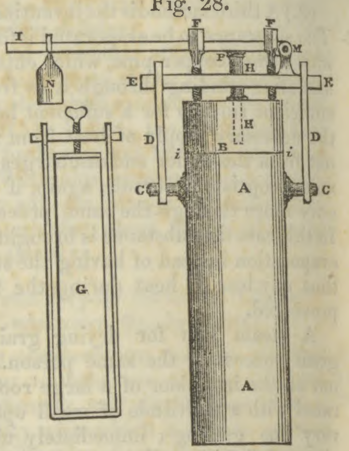
This work on the New Digester was accordingly published in 1681; "Containing the description of its make and use in these particulars, viz., Cookery, Voyages at Sea, Confectionary, Making of Drinks, Chymistry and Dyeing, with an Account of the Price a good big Engine will cost, and of the profit it will afford."

The following list will show the extent to which the learned doctor had proceeded in applying steam to the improvement of the dietetic art. It is copied from the Index to the work. "(1.) How to know the quantity of pressure in the Digestor. (2.) How to know the degree of heat. (3.) How meat may be kept upon the fire three times as long as is necessary to make it ready, and yet it will not be spoiled. (4.) The same experiment made upon bones. (5.) How to boil mutton. (6.) How to boil beef. (7.) How to boil lamb. (8.) How to boil rabbits. (9.) How to boil pigeons. (10.) How to boil fish. (11.) How to boil pulse. (12.) How to make jelly, very cheap. (13.) Glue for glasses. (14.) Hartshorn turned like Parmesan cheese. (15.) A macquerel kept without salt. (16.) Salt water as good for nourishment as fresh water. (17.) To make sweetmeats at a cheap rate, and of a new taste. (18.) To make two sorts of drink with the same fruit. (19.) To make a new sort of wine. (20.) Tinctures drawn in the hundredth part of the time usually required for them. (21.) New ways for distilling. (22.) How to hatch chickens (23.) How to save the labour of grinding cochenille. (24.) To dye with thick juices. (25.) To make horn and tortoiseshell soft for a great while."

This catalogue of uses of steam we shall shortly run over, as the modern uses of steam for cookery are principally applications of Dr Papin's methods, and as valuable economization in the preparation of food on a large scale has resulted from them, especially in the extraction of highly nutritious food from bones. A digester on the principle of Dr Papin is used in every modern kitchen.

"Description of the Digester and how to use it safely."

Fig. 28.



"A A is a brass (or copper) cylinder, hollow within, shut at the bottom and open at the top. B is another cylinder inverted upon it. C C are two appendices or ears cast to the cylinder A A, as the trunnions of a piece of ordnance. D D are two pieces of iron put upon the appendices at one end, and the iron bar E E at the other. F F are two screws, which serve to press both the cylinders A A, B B, against one another. G is another hollow cylinder, made of glass, pewter, or some other materials, fitted to receive those things that are to be included in the cylinders A A, and B B, with water all round it.

"To use this engine with convenience and ease, it ought to be fitted in a furnace built on purpose for it, and should go on as far as the appendices C C; so the fire being underneath, and the screws well fastened, and a piece of moistened paper laid between the cylinders at the joint *i i* to make it steam tight, you may boil your meat as long as you please without danger of wasting it by the exhalation of the volatile parts.

"To know the quantity of the inward pressure, you must have a little pipe open at both ends as H H: this being soldered to a hole in the cover B B, is to be stopped at the top with a little valve P, exactly ground to it. This must be kept down with an iron rod I M, one end of which must be put into an iron staple M, fastened to the bar E E, and the other end kept down by a weight N to be hung upon it nearer or further from the valve according as you would keep it less or more strong, after the manner of an ordinary Roman balance, or steelyard.

"To know the degree of heat, I hang a weight to a thread about 3 feet long, and I let fall a drop of water into a little cavity made for that purpose at the top of it, and I tell how many times the hanging weight will move to and fro before the drop of water is quite evaporated.

"*Experiment.* Having filled my pot with a piece of a breast of mutton, and weighed five ounces of coals, I lighted my fire, and by blowing gave such a heat that a drop of water would evaporate in 4 seconds, the inward pressure being about 10 times stronger than the atmosphere: I let the fire go out of itself, and then the mutton was very well done, *the bones soft* and the juice a strong jelly. So that, having had occasion to boil mutton several times since, I have always observed the same rule, and never have missed to have it in the same condition, which I take to be best of all."

Beef required 7 ounces of coal and the same heat, and the beef was very well boiled, although there were more parts of the bones not quite softened. Lamb, rabbits, and pigeons, mackerel, pike, and eel, were subjected to the same process; whence the doctor infers that the bones of young beasts require almost as much fire as those of old ones to be boiled, that rabbit bones are harder than those of mutton, that tough old rabbits may be made as good as tender young ones by this means, that pigeons may be best boiled with a heat that evaporates a drop of water in 5 seconds, that mackerel was cooked with gooseberries in a digester, the fish being good and firm, and the bones so soft as not to be felt in eating; and he particularly recommends, as an excellent dish cooked in this manner, cod fish and green peas.

The most important of Papin's experiments are those on the extraction of gelatine from bones, as now done on a large scale in France and in this country, as also the manufacture of essence of meat, soups, &c., especially suitable for long sea voyages.

"I took," says he, "beef bones that had never been boiled, but kept dry a long time, and of the hardest part of the leg; these being put into a little glass pot with water, I included in the engine, together with another little glass pot full with bones and water too, but in this the bones were ribs and had been boiled already. Having prest the fire till the drop of water would dry away in three seconds, and ten pressures, I took off the fire; and the vessels being cooled, I found very good jelly in both my pots; but that which had been made out of ribs had a kind of a reddish colour, which I believe might proceed from the medullary part, the other jelly was without colour like hartshorn jelly; and I may say, that having seasoned it with sugar and juice of lemon, I did eat it with as much pleasure, and found it as stomachical, as if it had been jelly of hartshorn. Mutton bones are better than beef bones; and he infers (1.) that one pound of beef bones afford about two lbs. of jelly; (2.) that it is the cement (gelatine) that unites the parts of the bones, which is dissolved in the water to make it a jelly, since after that, the bones remain brittler; (3.) that few glutinous parts are sufficient to congeal much water, for I found that when the jelly was dried, I had very little glue[-ten?] remaining; (4.) I used it to glue a broken glass, which did since that time hold very well, and can be washed as well as if it had never been broken; (5.) it is heavier than water, and sinks to the bottom; (6.) hartshorn produces five times its weight of jelly.

"From all these experiments, I think it very likely, that if people would be persuaded to lay by bones, gristles, tendons, feet, and other parts of animals that are solid enough to be kept without salt, whereof people throw away more than would be necessary to supply all the ships that England hath at sea, the ships might always be furnished with better and cheaper victuals than they used to have. And I may say, that such victuals would take up less room too, because they have a great deal more nourishment in them in proportion to their weight. They would also be more wholesome than salt meat. Vegetables, such as dried peas, may also be cooked by the steam of salt water without becoming salt."

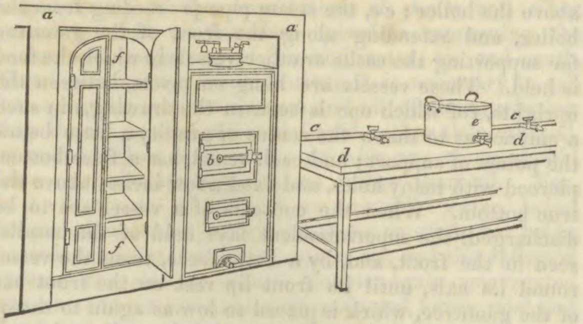
We have entered thus fully upon the work of Doctor Denys Papin, and the properties of his digester for cooking, and extracting jellies by high-pressure steam, because it contains nearly all that is at present practised in the preparation of food by steam.

If to what has been already stated, we add, that if the steam of salt water be collected in a vessel kept cold on the outside, the condensed water will not be impregnated with salt, and may be used as food, the importance of steam in the economical and menial capacity of cook, will be sufficiently apparent. The supply of water to the crew of a steam vessel may be obtained in this manner, and an apparatus for thus procuring fresh water from the condensation of steam from salt water, has been used with advantage in ordinary ships.

Fig. 29 contains the steam-cooking apparatus used in modern kitchens; *a a* is a portion of the kitchen fireplace. In one of the divisions of it, *b*, is placed a steam boiler, furnished with the usual apparatus of feeding pipes, gauge cocks, &c. From this boiler a steam pipe, *c c*, is led along the back of the cooking table *d d*, and at certain intervals, branch pipes, furnished each with a stopcock, project across the table at right angles to the main pipe.

Steam.
Cooking by Steam.

Fig. 29.

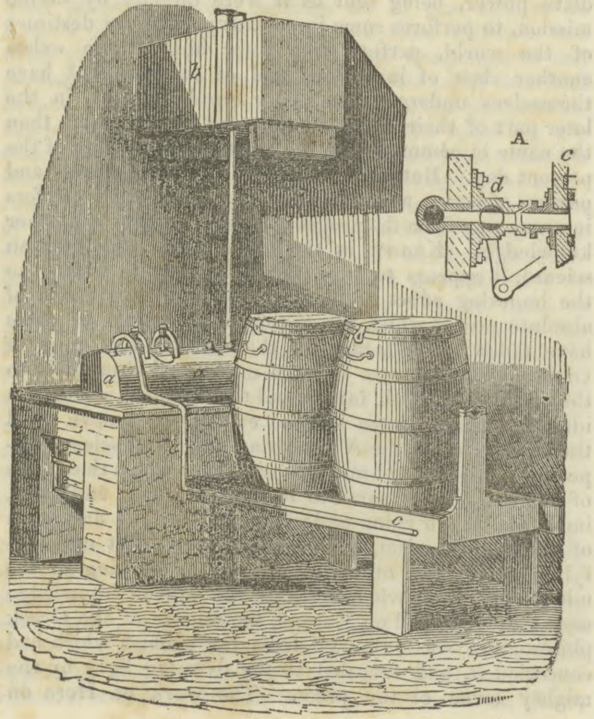


The extremities of these branch pipes are conical, and made accurately to fit into conical sockets inserted into the cooking pans, one of which, *e*, is seen in its place on the table. These pans have each a double bottom, the lower one close, the upper one perforated; between the bottoms the socket before mentioned, through which the steam enters, is inserted. The manner of using this apparatus is simple. The article to be cooked is laid in its place on the perforated bottom of the pan, the lid is applied, and the pan is joined to one or other of the branch pipes, by its socket receiving the conical end of the pipe; the stopcock is now turned, and the matter in the pan is subjected to the action of the steam. Each pan has a crane in front, to allow of the condensed steam being drawn off.

The remaining part of the apparatus is the hot closet, *f f*. This consists of a steam-tight iron box, containing shelves, inserted in another iron box of dimensions so much greater as to allow of a considerable vacuity being between them; into this vacuity the steam from the boiler is permitted to flow, and give out its heat to the articles placed in the closet to receive it.

Fig. 30 contains a steam-apparatus for cooking the

Fig. 30.



Steam.

food of cattle and horses, designed by Mr Newlands of Edinburgh. *a a* is a steam boiler, furnished with man-hole, safety-valve, gauge-cocks, supply pipe, and regulating float; *b*, water cistern, placed not less than six feet above the boiler; *c c*, the steam pipe proceeding from the boiler, and extending along the front of the gauntree for supporting the casks or other vessels in which the food is held. These vessels are hung on pivots, between the uprights, (of which one is seen in the drawing,) in such a manner as to throw the centre of gravity a little below the points of support; and each vessel has a false bottom pierced with many holes, and fixed a few inches above the true bottom. When the contents of a vessel are to be discharged, the superintendent lays hold of the handle, seen in the front, and, by a little force, turns the vessel round its axis, until its front lip rest on the front bar of the gauntree, which is placed so low as again to throw the centre of gravity of the vessel below the points of support; the contents may then be emptied into a close barrow, or other suitable vessel, or into a trough extending along the front of the gauntree.

The manner of connecting the vessels with the steam-pipe remains to be noticed. From the main pipe *c*, branches are carried through the front bar of the framing opposite to the centre of every vessel, of which there may be many, although two only are represented. Fig. A exhibits a section of the main pipe, the branch pipe, and a part of the bottom of the vessel. The branch pipe *d* terminates in a conical socket, and into this the plug fixed on the vessel *c* is fitted. When the vessel is in a vertical position, the connexion between it and the boiler is complete, but when, in being emptied, the vessel is overturned, the plug is withdrawn from the socket, and the communication cut off. When the vessel is again restored to its vertical position, the parts again fit each other without trouble or care on the part of the attendant. The branch pipe is moreover furnished with a stop-cock, the handle of which is wrought by a rod from either an eccentric or a crank fixed to one of the pivots of the vessel. When the vessel is overturned and the plug withdrawn, the eccentric shuts the stop-cock, and prevents the steam from escaping, and re-opens it when the vessel regains its vertical position.

THE STEAM-ENGINE.

Steam-Engine.

It is a singular peculiarity in the history of the steam-engine, that, ever since the period which exhibits the earliest traces of its embryo, it has continued slowly and gradually to advance with the flow of time towards its present state of high maturity, though not yet, perhaps, of ultimate perfection. Other arts and inventions, once well known and successfully used, after having attained a certain measure of perfection, have again been lost sight of amid the ruins of empires and the revolutions of nations, never more to be rescued from oblivion. While some of these, on the one hand, have sprung suddenly up into maturity, arrayed in the panoply of immediate power, being sent as it were directly by divine mission, to perform some important part in the destinies of the world, perfect from their birth, there exists another class of inventions and of sciences that have themselves undergone so many revolutions as, in the later part of their history, to present nothing more than the name in common with the maturer knowledge of the present day. But our knowledge of the properties and powers of steam, and its agency by a steam-engine, differs in every way from the progression of other arts and other knowledge. Known in the earlier ages of Egyptian science, it appears to have played its part in adding to the imposing effect of those stupendous monuments of absolute power which the storms of thousands of years have failed to obliterate. In the more refined ages of Greece, steam appears to have ministered alternately to the elegance of Attic luxury and the delusions of heathen idolatry; and to have become extensively known until the destruction of the Alexandrian schools of science dispersed those seeds of mechanical science which the flames of its library have spared to Western Europe; and there, imbedded in the ruins of learning during the dark ages of second barbarism, they lay preserved, but unfructifying, among the other remains of the learning of the middle ages; and when at length the light of knowledge once more dawned on Europe, the science of the Greek philosophers was exhumed from the rubbish which had concealed it, and revealed to the dawning light by the mighty lever of the press. The work of Hero on *Pneumatics and Steam Machinery* was one of the finest and earliest specimens of the art of printing. Since that time the science of steam, and the art of constructing the steam-engine, have made slow, regular, and progressive advancement, until this mighty work of many hands has at last attained a prominent importance in the interests of humanity, and become a mighty element in the future destinies of the world. In this remarkable course there has been no retrogradation. Centuries have added their contributions to the elucidation of its principles and the perfection of its mechanism; but no great revolution has ever thrown back, nor any single effort reproduced the mighty machine.

It is this peculiarity which has induced us to present to our readers the history of the steam-engine as the most apt and useful introduction to the perfect comprehension of its principles and structure. In many other subjects the history of the science or art is little more than an interesting and curious antiquarian research, fascinating to the virtuoso, and even instructive to the historian or philosopher, but by no means necessary, or even conducive, in any degree, to the acquisition or comprehension of the modern condition of our knowledge. What, for instance, have the astronomical systems of the Chaldees or the Greeks to do with the Copernican system of modern astronomy? In what degree would a learner be assisted in comprehending the sublime doctrines of the celestial mechanics of Newton, by having made himself thoroughly acquainted with the cycles of Hipparchus and Ptolemy, the crystal spheres of Frascatorius, or the multitudinous epicycles of Purbach? But with our knowledge of the phenomena and the powers of steam, the case has been widely different. The progress of the steam-engine has been co-ordinate with the progress of the human mind in physical truth. The history of the past improvements of the steam-engine is therefore the history of the human mind; and the same phases which have been severally presented, at widely separated epochs, by successive inventors, are the very phases of gradually growing knowledge by which a single individual mind does most naturally and most profitably proceed, step by step, to the full blaze of light which is thrown upon this subject by the illumination of modern science. Of so large a subject, one part only can be studied at a time, and that succession of parts by which they enter into the mind in easiest transition is the very succession in which history presents them to us.

We shall therefore divide this subject into two parts; the first containing a description of the steam-engine, and the elucidation of its principles, in historical order; the second forming a description of the functions and parts of the modern steam-engine.

Part I.—Historical Description of the Steam-Engine. 1. The Era of the Ancients. 2. The Era of Worcester. 3. The Era of Watt.

1. *The Era of the Ancients.*

The knowledge which some of the ancients possessed of the constitution of steam is remarkably in accordance with the most recent modern conclusions on this species of matter. Steam is now known to be only one of the common airs or gases whose particles at one degree of heat and of pressure assume a liquid form, and at another temperature and pressure become solid ice.

The modern doctrine concerning matter may be thus stated; that matter is known to exist in four conditions—solid, liquid, aerial, and etherial. Earth and stone are exemplars of solid matter; water and mercury of liquid matter; the atmosphere, and smoke, and steam, of aerial substances; caloric, light, and electricity, of etherial matter. It is further the doctrine of modern physics that no kind of matter exclusively possesses one of these conditions as its distinguishing property, but that all may, in certain circumstances, assume different conditions. Stone is not essentially solid, for, by the action of heat, it may be melted under pressure; and iron or lead, though usually solid, may be presented in the liquid form; and the earths have likewise assumed the form of liquids when the contrivance of the chemist has succeeded in placing them in appropriate circumstances. Neither is water essentially a liquid, for, when frozen, it becomes a solid, with which we may construct houses, bridges, utensils, and even floating structures capable of navigating the ocean; and, on the other hand, it is sometimes reduced into the vaporous or aerial form, as when the water of a vessel, acted on by heat, is wholly dissipated and dispersed in an invisible form in air.

It is also to be observed, that the condition of a body may be changed by the agency of heat. Solid ice, solid mercury, or solid lead, by the addition of heat, are converted into liquids, or are melted; and form liquid ice, (called water,) liquid mercury, (called quicksilver,) and liquid lead, (which has no separate name.) If to the liquid thus produced from the solid we add a certain other portion of heat, that will separate its particles still further from each other, and the matter thus diffused over more extended space becomes reduced to the aerial condition of steam, of mercurial or lithargical gas, or transparent vapour. But still the matter has undergone no constitutional change. It is only necessary to remove the heat, and the particles will again come together and resume their primitive form. By cooling down the aerial gas into which the matters had been dissipated, or even by compressing them, so as to contract them into their original bulk and bring them together into their original proximity, the particles will once more resume their pristine form, the vapour will respectively appear as drops of liquid water, mercury, or lead, and those liquids being more condensed, will congeal into the original solid masses of solid ice, solid mercury, and solid lead. The most refractory gases have actually been found to obey this law, and we have no doubt that every substance in nature might successively be presented to the senses in every one of these forms.

The following passages, taken from the *Timæus* of Plato, present a remarkable accordance with these enlarged views of the constitution of steam and other gases:—"Let us therefore speculate concerning the nature and properties of fire and water, air and earth. This is the more arduous, because it is necessary to call into question, concerning each and all of them, whether they should be denominated liquid rather than etherial, or aerial rather than solid; or why any thing should have one of these appellations rather than all. For, in the first place, that which we now call 'water,' being congealed, becomes (hard) as a stone or earth, but being melted and diffused becomes gas or air, and this inflamed becomes fire, and fire extinct becomes again congregated into air, and air collected and condensed forms mist and cloud, and these again, more compressed, form water, and from the water earth and stone are reproduced. And thus they, in an endless circuit, produce each other. Since, then, these now appear to be the same, who will assert that one of them is of the one kind rather than the other? It is most safe, therefore, to speak thus: that the thing we see is not absolute liquid, but something in the liquid state. That air is not necessarily a gas, but something in the gaseous state; not as being a particular thing of this or that specific nature, but that it is in such and such a condition."

"Let us then distribute the four modifications of matter into fire, earth, water, and air; and to earth let us assign an entical form, for it is the most immovable of all these kinds—to water that which is less movable than the other three—to fire the most easily movable form—and to air that which is intermediate."

It appears to us highly probable that the ancients knew more of the phenomena of steam than has been generally admitted. One evident cause of this mistake is the circumstance that no specific term equivalent to the word steam was generally used by them; and water, when heated, was said to be converted into an air. It is now almost perfectly established by the progress of modern science, that steam is an air, (or gas,) invisible and perfectly transparent, differing in none of its mechanical properties from common air or gas, and in no respect differing in its constitution from carbonic and other gases or airs which, at certain temperatures and pressures, do, like steam, leave the elastic aerial form and become condensed into steam. Many of the phenomena, therefore, for which the ancients use the word air, are effects of steam, or of steam mixed with air; and although they have not always carefully distinguished these separate effects, yet they have frequently made judicious use of them. While, therefore, it would be wrong to draw any parallel between the want of individualization manifested in their writings, and the high generalization of modern science, it would be equally wide of truth to deprive them, as has sometimes been attempted, of the merit of having discovered and used some of the properties of water in the aerial state, simply because they supposed it rarefied into an air, and confounded its phenomena with those of other gases, which, mixing with it, also contributed to the effect—as when we find that air rarefied by heat, and water rarefied into air, are mentioned.

Hero of Alexandria, in his *Pneumatics*, has collected the science and inventions of the ancients, along with some of his own, into a systematic treatise, written in Greek, more than 120 years before the Christian era, some passages of which are identical with portions of modern treatises on pneumatics: and many portions of his apparatus may be found transformed into modern experimental models in cabinets of the physical schools. Now, in the introductory portion of his work, we have such statements as these:—*Water is transformed into air by the action of fire. For the vapours of boiling caldrons are nothing else than attenuated moisture expanding into air.* Indeed, by the four elements the ancients appear to have meant the same things which we now designate by different terms. We comprehend all the material agents with which we are acquainted under the four great designations, solids, liquids, air, and ether. So exactly had the ancients their πυρ and αηρ, ὑδωρ and γη, to which they assigned different regions according to their weight; first, the solids or earth, then the liquids above, next the aerial covering, and finally the region of ether extending indefinitely beyond. The moderns have shown that all bodies are probably capable of assuming any of the three states, and becoming solid, liquid, or fluid, according to the circumstances in which they are placed; and we have every reason to believe that Timæus, of whom Plato speaks with so much reverence, entertained the same idea, and believed that even the air might assume the state of a crystalline solid. It is not a little curious to find a mathematician of the present day giving it as a result of his calculus, that the air at a great distance from the earth is actually frozen into a crystalline solid by the extreme depression of temperature. He was probably not aware that his notion had been anticipated more than 2000 years. In this same work of Hero, we have descriptions and explanations of apparatus, in which the power of fire acting on moisture and air is made to produce phenomena of motion. He does not arrogate to himself the merit of these inventions, but has given them as principally a collection from the works of those ancients who had long preceded him—*the ancient philosophers and mechanics.*

His *Pneumatics* commence with a lucid and excellent dissertation on the properties of air as a medium for the communication of pressure and motion, and especially upon the nature and effects of a vacuum, subjects to be thoroughly understood by all who would master the theory of the steam-engine. It is, indeed, as the means of producing a vacuum, that steam obtains much of its value as a mechanical power. The mode of raising water by a vacuum is thus described by him:—"When they wish to fill with water the round medical glasses which have slender long necks, they suck out the air which is contained in them, and, closing the orifice with the finger, they invert them in the water, and on removing the finger the water is drawn up into the vacuous space, in contradiction to the usual law of fluids." He then proceeds to state that, "in like manner, air may be rarefied by heat even as other substances are; for water is changed by fire into air, the vapours from boiling caldrons being nothing else than expanded water taking the form of air, and that mists and clouds are nothing else than water raised in the air by heat, which are partly afterwards converted into air, while portions again descend in rain." He also attributes the origin of winds to the "expansion and contraction of air and moisture by the alternate heating and cooling produced by the sun's rays;" and illustrates the conversion of liquids into air or gas by the common observation, that, after a lamp has gone out, the vapour continues to rise up by the heat still left in it by the flame. Thus also, says he, a phial being filled with heated air and inserted in water, this air contracting will draw up water into the phial. Hence, he argues, that all airs consist of inconceivably small particles of matter, between which there are left wide vacuous spaces, so that, while the matter itself is incompressible, the volume occupied by the aggregate may be increased and diminished, and the air rarefied and condensed either by external force or the action of heat.

Fig. 1.

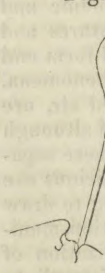


Fig. 2.

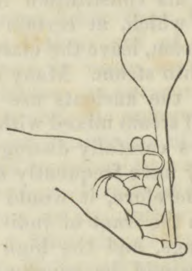


Fig. 3.

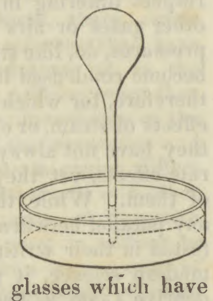
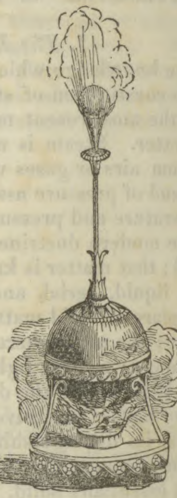


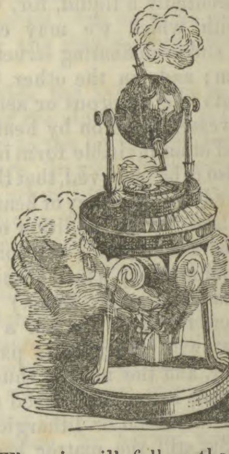
Fig. 4.



The following description of the manner in which the force of steam, issuing from a boiler, may be applied to supporting a weight, is given in the *Pneumatics.* "A boiler, perforated on the top, is placed on the fire. From the perforation there proceeds a tube, on whose extremity is fixed a hollow hemisphere perforated in like manner. If then we place a light ball in the hemispherical cup, it will follow that the vapour rising up from the boiler through the tube will support the sphere, and it will appear to dance."

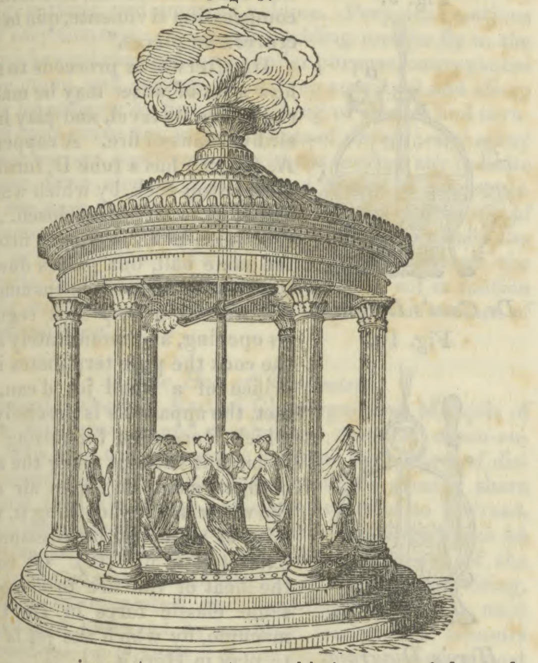
There is another apparatus in the *Pneumatics* for the purpose of producing a revolving motion by the action of steam—"by a caldron placed on a fire to give motion to a sphere around its axis. Let a boiler be set on the fire, and nearly filled with water, and let its mouth be closed in by a cover, and let it be pierced with an opening through the bent tube, whose extremity exactly fits into the hollow sphere. But at the opposite extremity of the diameter let there be an iron axis supported from the top of the cover; and let the sphere have two bent pipes at the ends of a diameter perforated along with it, and bent round in opposite directions; and let the bendings make right angles and be in the plane perpendicular to the axis. Then it will follow that, on the boiler being heated, the vapour rushing through the tubes into the sphere will rush out through the reversed pipes of the ball, and whirl it round on its axis."

Fig. 5.



The same apparatus, on similar principles, is next applied by Hero to the construction of a machine still more curious. The agent mentioned in this case is rarefied air, although the action is of precisely the same nature. Here the science of the philosopher appears to have been degraded to the base use of assisting an idolatrous priesthood in deceiving the populace by the resemblance of miraculous interference. "A fire having been kindled upon an altar, living figures will appear to lead a choral dance, even although the altar itself be of transparent glass or horn. Through the epipyrus a pipe is to be let down to the base of the altar, where it is to revolve on an iron pin, the other end being passed through a tubular fitting attached to the epipyrus. And this pipe is to have other little bent pipes attached to it, and perforated so as to communicate with it, which are to radiate opposite to one another around it, and turned alternately in opposite directions. There shall likewise be a drum attached to it, upon which the figures of the dance are to be set. Then, by the action of the kindled fire, the air, being warmed, will proceed into the pipe, and, from it being driven out through the bent tubes into the base of the altar, will turn round the pipe and its drum."

Fig. 6.



The following is probably the most excellent of all Hero's apparatus, inasmuch as in it the action of steam produced by fire from water is employed for the purpose of elevating a fluid above its level, and transferring it from one place to another. The design of the apparatus is still, unhappily, to serve the purposes of superstitious worship. "The fire of an altar having been lighted, two figures of living things are to assist at the sacrifices, and the figure of a dragon is to sybillate," (or give forth sounds to be interpreted as oracles.)

"There is to be a hollow basis or pedestal $\alpha\,\beta$, (fig. 7,) upon which is set the altar γ, having a tube $\delta\,\varepsilon$ descending to the middle of the basis, and is there separated into three branches; the tube $\varepsilon\,\zeta$ passing to the mouth of the dragon, the tube $\varepsilon\,\theta\,\varkappa$ being carried to the vessel $\varkappa\,\lambda$ containing wine, and placed at the top of the figure μ, and accurately joined into its cover; and into the third tube $\varepsilon\,\nu\,\varrho$, which, in like manner, ascends into ϱ, another vase holding wine, and is also accurately united to the top of the vase. Both ends of the two vases are to be carefully closed. There are to be in both the wine vessels bent syphons $\varrho\,\sigma\,\tau\,\varkappa$, of which the one extremity is in the wine, and the other extremities, proceeding by an opening rendered perfectly close through the covers of the vases, are conducted to the hands of the figures officiating at the sacrifice. When, therefore, you are about to sacrifice, you must pour into the tubes a few drops lest they should be injured by heat, and attend to every joint lest it leak; and so the heat of the fire, mingling with the water, will pass in an aerial state through these tubes to the vases, and, pressing on the wine, make it pass through the bent syphons, until, as it flows from the hands of the living creatures, they will appear to sacrifice as the altar continues to burn, and the other tube being carried to the mouth of the dragon, will make it give forth sybilline sounds."

Fig. 7.

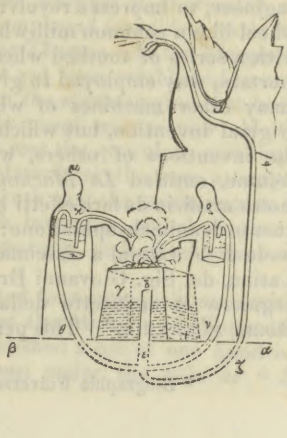
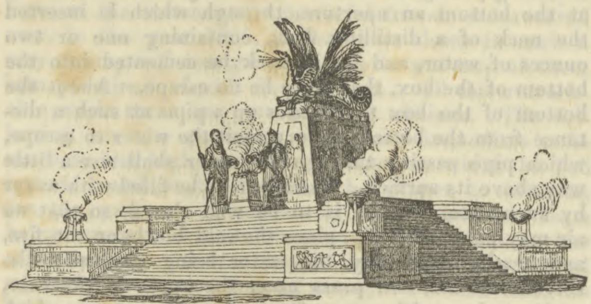


Fig. 8.



There appears to be considerable reason to suppose that, to their knowledge of the mechanical powers and the elements of machinery, the Egyptians added some acquaintance with the power of steam, applied, however, only to the degraded service of superstition. The statue of Memnon is said to have emitted sounds which Pausanias compares to those produced by the snapping of the strings of a harp. Strabo expressly states that he heard them; and Philostratus states, that when the sun shone strongly on the statue, sounds proceeded from its mouth similar to those of a stringed instrument. Hero of Alexandria in his *Pneumatics*, Salomon de Caus in his *Raisons des Forces Mouvantes*, Athanasius Kircher in his *Œdipus Egyptiacus*, and Cribellus in his *Machinosa Miracula Memnonis*, have all explained in different ways the mechanical arrangements by means of which effects of this kind might have been produced from the steam raised by the heat of the sun in close vessels contained in the statue, and having communication with organ pipes of different kinds.

The Romans appear to have done little for the mechanical arts, and nothing for the improvement of steam apparatus. It was not until the dawn of knowledge succeeded the darkness of the middle ages, that the light reflected from the works of Hero, and the older mechanicians, rekindled the flame of mechanical invention. The works of Archimedes and of Hero were read with great avidity, and formed some of the most popular productions of the young art of printing. The flame seems first to have been lighted in Italy, for we have editions and translations of Hero's *Pneumatics* rapidly succeeding each other; the Bologna edition of 1547, translated by Giov. Baptista Aleotti, was reprinted at Ferrara in 1589; Commandine's translation was published in 1575, Alessandro Giorgi's in 1592. There were other editions of less note; and thus in a single century eight or nine editions were issued. It was not to be expected that the seeds of mechanical knowledge, so widely sown, should not fall on some rich spots of soil, where they should bring forth fruit with increase.

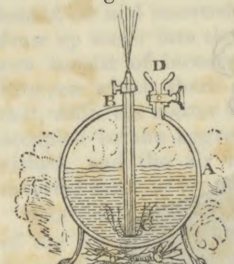
Giambattista della Porta was one of the ablest and most ingenious expositors of the principles of pneumatics. A work which he published on this subject contains the following passage:—"Make a box of glass or tin, having at the bottom an aperture, through which is inserted the neck of a distilling flask, containing one or two ounces of water, and let its neck be cemented into the bottom of the box, that there be no escape. About the bottom of the box there rises up a pipe at such a distance from the bottom as to permit the water to escape, which pipe passing through the cover shall rise a little way above its surface. The box is to be filled with water by an aperture which is to be well closed, so that no air may pass. Finally, place the said bottle on the fire, and heating it slowly, the water being gradually dissolved into air, will press upon the water in the case, and pressing with great force upon the water which issues through the pipe, (the steam) will not make its escape. And if we continue the application of heat, the whole of the water (in the flask) will be at last exhausted; and while the water is evaporating, the air (vapour or gas) will constantly press on the water in the vessel, and the water will continually issue out. The exhalation being finished, if you will measure how much water is out of the box; that which is in the place of the water gone out, will give the measure of the remaining water. Thus you find, from the quantity of water used, how much water was dissolved into so much air. And, in like manner, also, you can measure into how much of more rarefied air, air of the ordinary density can be dissolved."[1]

Here we perceive that the knowledge of the conversion of water into air or gas, taught by Hero's *Pneumatics*, was extending itself in that country, and leading to further contrivances; and we have also a beautiful and simple experiment, designed for the purpose of determining the philosophical question, which formed an interesting subject of research at a very recent period of physical enquiry, "how much aqueous gas is formed by a given quantity of water." The method is not perfect, for a considerable part of the vapour would be reconverted into water in the progress of the experiment; yet it shows an acquaintance with the fact, that water heated by fire is converted into aqueous air with sufficient force to raise water above its level, and form a running stream, although, in this case, of no very considerable height.

The spirit of invention, aroused by the first translation of Hero's works, did not confine itself to the country in which these works were first disseminated, but spreading gradually northwards, displayed itself in the works of an architect and engineer, Salomon de Caus, who had come to England in 1612, and was employed by the Prince of Wales, afterwards Charles I., to design grottoes, fountains, and other hydraulic ornaments, for the embellishment of the prince's palace at Richmond, and for the gratification of his Royal Highness's "gentille curiosité." These, with other machines, were published by him in a work entitled "Les Raisons des Forces Mouvantes, avec diverses machines tant utiles que plaisantes; auxquelles sont adjointes plusieurs desseins de grottes et fontaines, augmentées de plusieurs figures." Frankfort, 1615, fol.

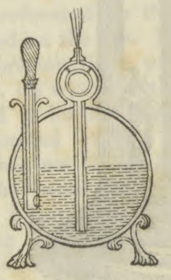
The work of De Caus is prefaced by an exposition of the principles of hydrostatics and pneumatics, evidently derived from the writings of Archimedes and of Hero. Among other things, he states that the violence with which water is dissolved into air by means of fire is very great, and that it is quite certain that a ball of copper containing water, if placed on a fire, would be infallibly burst. "La violence est grande quand l'eau s'exhale en air par le moyen du feu . . . . il est certain que si l'on met la dite balle sur un grand feu, en sorte qu'elle devienne fort chaude, il se fera une compression si violente, que la balle crevera en pièces."

Fig. 9.



De Caus's Diagram.

Fig. 10.



Hero's Diagram.

He afterwards proceeds to show how a jet of water may be made to rise above its level, and play in the air by means of fire. A copper ball A, (fig. 9,) has a tube D, furnished with a stop-cock, by which water is forced in and it is then closed. Another tube, B C, is closely fitted to the same ball, but passes down to the bottom, where it opens amongst the water; a stop-cock regulates its opening, and immediately above the cock the pipe terminates in the orifice of a small jet d'eau. In fact, the apparatus is precisely that which Hero uses for raising a jet d'eau, but without using the action of heat, when he forces air above the water, and condensing it, raises a jet of water by its pressure, (as exhibited in fig. 10.) Of course, the heat of the fire produces the same elastic force in De Caus's machine, by which the jet is made to play in Hero's.

There seems no reason to doubt that Salomon de Caus was a Frenchman by birth, and he is said to have been a native of Normandy.[2] In dedicating to the French monarch an edition of his work, he describes himself as one of his Majesty's subjects. After leaving England, he settled in Germany, where the Elector Palatine intrusted him with the superintendence of his buildings and of his gardens. He finally returned to France, and died there about the year 1630. He has sometimes been confounded with Isaac de Caus, a native of Dieppe, and a descendant of the same family. The latter published a work, entitled, "Nouvelle Invention de lever l'Eau plus haut que sa source, avec quelques machines mouvantes par le moyen de l'eau, et un discours de la conduit d'icele." Lond. 1644, fol. This work contains many machines identical with those described by Salomon de Caus; and the similarity of subject, treatment, and title of the two, has led those into much confusion who may not have examined both. Even the pains-taking and industrious Stuart seems to have been deceived, and calls Isaac's book a later edition of Salomon's.

The direct emission of steam from an orifice of the boiler, which had been used by Hero to sustain the ball in the air, was applied by Branca, an Italian architect and engineer, to impress a revolving motion on the vanes of a wheel like a common mill-wheel, and this communicating with a series of toothed wheels to a series of pestles in mortars, was employed to give them motion. This, and many other machines of which he does not claim the original invention, but which he states he collected from the inventions of others, were published in a quarto volume, entitled *Le Machine*. "Volume nuovo et di molto artificio da fare effetti maravigliosi si tanto spiritali quanto di animale operatione: arrichito di bellissime figure conle dichiarationi a ciascuna di esse in lingua volgare et Latina, del Sig. Giovanni Branca, cittadino Romano, ingegniero et architetto della sta. casa di Loretto. In Roma, M.DC.XXIX." This period appears to have teemed with curiosities of mechanical invention; and the learned virtuoso who would take the trouble of ransacking the mechanical productions of the sixteenth and seventeenth centuries, would be able to collect materials for an interesting, curious, and amusing volume. Perpetual motions were very common; wings for enabling men to fly in the air, mechanical chariots for a similar purpose, conveyances to the moon, and engines for making continual and cheap music by mills or by fire, for rocking of cradles and turning of spits, were favourite subjects of design; and many of these curious contrivances, without serving any definite purpose, form elegant and curious pieces of apparatus. We are now passing from the era of the curiosities of mechanical contrivance, into that period in which the same principles that actuated the toys of Hero and the automata of Kircher were to be applied to set in motion mighty machines for the advancement of the welfare of the human race.

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[1] J. B. Portæ Pneumaticorum libri tres. Neapoli, 1601, 4to.

[2] Biographie Universelle, tom. vii. p. 433.

2. *The Era of Worcester.*

Edward Somerset, Earl of Glamorgan and Marquis of Worcester, invented and constructed the first steam-engine. His title to this honour has been the subject of dispute, some historians attributing to him a greater share of merit than there was sufficient evidence to warrant, while others deprive him of even that honour to which he possesses an indefeasible claim. His life is one of the most romantic chapters of English history. Enterprising, generous, disinterested, and confiding, he was at once beloved and betrayed by his king, loaded with honours and reduced to poverty; at one time exercising almost without control the functions of the sovereign, conferring dignities from the rank of marquis down to baronet, and at another thrown into prison, and begging from a creditor the paltry loan of five pounds. Possessing inventive genius of the highest order, he was considered a mad enthusiast because his speculations were advanced so far before the age in which he lived, and has been set down a quack and impostor by men incapable of comprehending the nature or appreciating the value of his creations. The slow march of knowledge and of time has at last revealed the worth, and established the character, of an illustrious and unfortunate man of genius, who only lived to complete his mighty design and carry it happily into effect, and having done his work, went to take his rest in death.

That the Marquis of Worcester was acquainted with the nature and force of steam, no one has ever disputed; but it has been matter of serious doubt whether the machine which he has described had ever any real existence. Hitherto we have had nothing more than circumstantial presumptive evidence of the actual construction of the marquis's steam-engine. It is only a few years since the industry of the indefatigable antiquary Robert Stuart has presented us with an historical document of undoubted authenticity, affording undeniable proof of the existence and efficiency of one of the engines of the Marquis of Worcester, of more than two horse power, employed for raising water on the Vauxhall side of the river Thames. As the Marquis's title to the invention has not yet been established in any of the numerous treatises on the steam-engine that have hitherto appeared, and as the proof we are now able to adduce must for ever set at rest the querulous cavillings of those otherwise respectable writers who have attempted to controvert the great truth that the steam-engine is a machine wholly of British invention, we shall give a short account of what the marquis undoubtedly accomplished.

We are principally indebted for our acquaintance with the mechanical inventions of the Marquis of Worcester to a work in which he published a list of one hundred of his mechanical inventions, under the title of "A Century of the Names and Scantlings of such Inventions as at present I can call to mind to have tried and perfected, which (my former notes being lost) I have, at the instance of a powerful friend, endeavoured now, in the year 1655, to set these down in such a way as may sufficiently instruct me to put any of them into practice." Lond. 1663, 12mo. Of this remarkable work there are several other editions. The following are the passages which have immediate reference to the high-pressure steam-engine which he had invented and made. It may be proper to premise, for the purpose of preventing the supposition from being entertained that it was impossible to get devices of so complex a nature carried into effect at a period when the mechanical arts of construction had made so little progress, that he had employed constantly in his service, during a period of five-and-thirty years, one of the most eminent artificers of the time, one Caspar Kaltoff, and that he had provided him with suitable workshops, tools, and machinery, at an expense of more than ten thousand pounds. It thus appears that the marquis was no mere schemer, but that he submitted his devices to the test of experiment; and it is merely not passing the bounds of credibility to suppose, that, with fertile resources, an active and inventive mind, the best tools, an "unparalleled" artificer, and the expenditure of great sums of money, he had in five-and-thirty years constructed machines of such perfection as no other artist of his age had accomplished, and few of the hangers-on of a royal court could understand or appreciate. No one who is acquainted with the modern high-pressure steam-engine can fail to recognise it in the following specification, which, be it observed, was given by the marquis rather for the purpose of exciting curiosity than gratifying it—for stating the capabilities of his engine than explaining its principle, which he wished to keep secret for the purpose of obtaining a patent.

Marquis of Worcester's Inventions.

"Invention 68.—An admirable *most forcible way to drive up water by fire*; not drawing or sucking it upwards, for that must be, as the philosopher calleth it, 'intra spheram activitatis,' which is but at such a distance, *but this way hath no bounder, if the vessels be strong enough; for I have taken a piece of a whole cannon*, whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end, as also the touch-hole, *and making a constant fire under it; within twenty-four hours it burst and made a great crack:* so that, having found a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a *constant fountain forty feet high*. One vessel of water, rarefied by fire, driveth up forty of cold water; and a man that attends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively."

The internal evidence of the truth of this description is too strong to be resisted. We cannot say what ideas it may have suggested to such a man as Lord Orford, who was probably as ignorant of mechanical principles as he was devoid of candour and charity to a man of principles and religion different from his own; but to any one conversant with the mechanical contrivances and treatises even of that time, it was scarcely possible to read the sentence without forming a distinct conception of a similar apparatus to that here described by the marquis. We shall see that the description was so perfect as to enable a subsequent mechanician to reconstruct the machine of the marquis, with some additions, and produce an effective machine for draining mines. We see, too, how philosophical was the process by which he

Steam-Engine.

Marquis of Worcester's Inventions.

advanced to the construction of his machine. He made experiments of a conclusive nature on the boundless force of steam. He found that the only impediment to its use was the want of sufficiently strong boilers; and his having found a way to make his vessels so as to be strengthened by the force within them, merely shows that he overcame the difficulty of making steam-tight joints by using internal flanges, which should become tightened by the pressure of steam within them. There is also internal evidence of the genuineness of his description in the statement of the quantity of water converted into steam for the effect of raising the water,—"one vessel rarefied by fire driveth up forty of cold water," is a measure of the power of steam far within the compass of its capability. Even under most unfavourable circumstances, an unprincipled exaggerator would not have contented himself with this moderate statement of its actual power.

But we have not yet concluded the marquis's description of the nature of his stupendous prime-mover; for his mind, in dwelling upon its principles, applications, and powers, gradually became assured that his engine was to become the most important and powerful agent in the whole world, and appears, even at that remote era, to have obtained a glimpse of the multifarious avocations and powers of the modern steam-engine. He proceeds to describe "an engine so contrived, that working the *primum mobile* forward and backward, upward or downward, circularly or cornerwise, to and fro, straight upright or downright, yet the intended operation continueth and advanceth, none of the motions above mentioned hindering, much less stopping the other, but unanimously and with harmony agreeing, they all augment and contribute strength unto the intended work and operation; and therefore I call this a semi-omnipotent engine, and do intend that a model thereof be buried with me."

"How to make one pound weight to raise an hundred as high as one pound falleth, and yet the hundred pound descending doth what nothing less than one hundred pounds can effect."

"Upon so potent a help as these two last-mentioned inventions, a water-work is, by many years' experience and labour, so advantageously by me contrived, that a child's force bringeth up, an hundred foot high, an incredible quantity of water, even two foot diameter, so naturally, that the work will not be heard into the next room; and with so great ease and geometrical symmetry, though it work day and night from one end of the year to the other, it will not require forty shillings' reparation to the whole engine, nor hinder one day's work; and I may boldly call it the most stupendous work in the whole world; and not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as to keep them sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions, but likewise supply rivers with sufficient to maintaine and make them portable from towne to towne, and for the bettering of lands all the way it runs, with many more advantageous and yet greater effects of profits, admiration, and consequence; so that, deservedly, I deem this invention to crown my labours, to reward my expenses, and make my thoughts acquiesce in the way of further inventions."

To any one who is familiar with the advantages which such cities as London derive at this moment from having the water raised up by fire and distributed through the highest houses for private use; who has witnessed the incredible quantity of water brought up by a Cornwall, or Newcastle, or Staffordshire steam-engine from enormous depths, by the descent of a piston not one thousandth part of the weight which it raises through an equal height; who has observed the elastic force of steam as a *primum mobile* in a cylinder performing in any and every position its multifarious duties, and that a child's force is sufficient to control and guide the operation of that stupendous power, it must be most obvious that we have only carried to perfection that engine which the Marquis of Worcester first conceived and made.

Some points in the statement of the marquis, which had not formerly been noticed, have received considerable elucidation, by a manuscript account of his inventions, discovered a few years ago by Mr Robert Stuart, and by another document, of no small importance in this question, which was brought to light by the zeal and industry of the same writer, viz. a Diary of Cosmo de' Medici, Grand Duke of Tuscany, who visited England about the year 1656, in which he gives an account of the engine invented by the Marquis of Worcester, which he had an opportunity of witnessing in operation at Vauxhall.

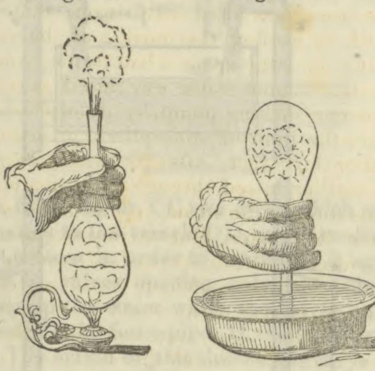
The Condensing Steam-Engine of Captain Savary.

About thirty years after the marquis's death, which happened in 1667, the condensing steam-engine was invented by an Englishman, Captain Thomas Savary, and was by him introduced for draining mines, raising water for buildings and gardens, and generating a revolving mechanical power. He exhibited a model of it to the Royal Society of London in 1699. (*Phil. Trans.* vol. xxi. p. 228.) We have seen that the marquis's model appears to have been placed on or below the level of the water to be raised, and that his vessels being filled, their contents were raised by the elastic force only of the steam. Mr Savary, on the other hand, erected his engine at a height of nearly thirty feet above the level of the water. A large close vessel was filled with steam; this steam was reconverted, by cooling the outside of the vessel, into water, leaving the large space it had formerly occupied vacuous; into this vacuum water was raised, as into the vacuum of a common sucking pump, by atmospheric pressure, and so within the limit of atmospheric pressure, raised twenty-eight or thirty feet. After this was accomplished, the water was further raised through any remaining height by the elastic force of the steam, just as in the engine of the Marquis of Worcester. But the improvement was great. The same force of steam, strength of vessels, and consumption of fuel which was sufficient on the marquis's plan to raise water thirty feet high, would be capable first of drawing up the water thirty feet, and then raising it thirty feet more; or doing double the work, or sixty feet of height on Savary's plan. This was certainly a notable improvement.

There has been considerable discussion among the historians of mechanics regarding the merits of Worcester and of Savary. Those who have thought proper to praise the inventive talent of the one, have thought it essential to their purpose to depreciate the merit of the other. We think their claims rest on independent grounds. The Marquis of Worcester expressly disclaims the use of a vacuum, which, on the other hand, is the distinguishing feature of Captain Savary's, when he says, "not by drawing or sucking it upward, for that must be as the philosopher calleth it, *infra sphæram activitatis*, which is but at such a distance; but this way (by high-pressure) hath no bounder, if the vessels be strong enough." It appears, therefore, to us, that the inventions were quite independent and different; and we have no hesitation in admitting it as exceedingly probable, that when Captain Savary added the principle of high-pressure to his own principle of a vacuum from condensation, he was not unacquainted with the marquis's works, and even with his engine for raising water by fire, for which he had obtained a patent, and which he had erected at Vauxhall. While we have thus expressed our own opinion of the independence of their claims, we must not omit the opinions of others who lived nearer to the epoch of these rival candidates.

Dr Desaguliers, an eminent mechanist, and an experimental philosopher of considerable reputation, has given, in his *Course of Experimental Philosophy*, vol. ii., an account of the "fire-engine," and after adverting to the claims of the Marquis of Worcester, makes the following statement in regard to Savary:—"Captain Savary having read the Marquis of Worcester's book, was the first who put in practice the raising water by fire, which he proposed for the draining of mines. His engine is described in Harris's *Lexicon*, (see the word Engine,) which, being compared with the Marquis of Worcester's description, will easily appear to have been taken from him; though Captain Savary denied it, and the better to conceal the matter, bought up all the Marquis of Worcester's books that he could procure in Paternoster Row and elsewhere, and burn'd 'em in the presence of the gentleman, his friend, who told me this. He said that he found out the power of steam by chance, and invented the following story to persuade people to believe it, viz., that having drunk a flask of Florence at a tavern, and thrown the empty flask upon the fire, he called for a bason of water to wash his hands; and perceiving that the little wine left in the flask had filled up the flask with steam, he took the flask by the neck and plunged the mouth of it under the surface of the water in the bason, and the water of the bason was immediately driven up into the flask by the pressure of the air. Now, he never made such an experiment then, nor designedly afterwards, which I thus prove: I made the experiment purposely with about half a glass of wine left in a flask, which I laid upon the fire till it boiled into steam; then putting on a thick glove to keep the neck of the flask from burning me, I plunged the mouth of the flask under the water that filled a bason; but the pressure of the atmosphere was so strong, that it beat the flask out of my hand with violence, and threw it up to the ceiling. As this must also have happened to Captain Savary, if ever he had made the experiment, he would not have failed to have told such a remarkable incident, which would have embellish'd his story."

Fig. 11. Fig. 12.



Dr Desaguliers's Experiment.

We have performed the doctor's experiment frequently, with various results. If the mouth of the flask happens to be large and its neck short, the water very cold, and the flask very perfectly filled with steam, the effect is exactly what Desaguliers describes; for the vacuum being suddenly and completely formed, the flask is first pressed down towards the basin, which the hand resists by sustaining the flask in the opposite direction, and just then the water rushes with great velocity up into the vacuum, and striking on the bottom of the flask, now turned upwards, is apt to knock it suddenly out of the hand, especially when held merely by a soft glove. But if, on the other hand, the flask has a narrow mouth and long neck, and if, when inverted, its neck be allowed to rest on the bottom of the vessel, and if the water in the basin be not very cold, it will rise slowly and gently, and the flask will be completely filled.

The doctor's inference is not, therefore, perfectly just to Savary, and allowing that Savary had read Worcester's book, he would not find in it any principle of this nature, but an express exception from it, as we have already stated.

Switzer's Evidence on Savary's Engine.

Stephen Switzer, author of a *System of Hydrostatics and Hydraulics* published at London in 1729, takes a different view of the matter. In the chapter "On the Engine for raising Water by Fire," he gives the following account of it:—"Amongst the several engines which have been contrived for the raising of water for the supply of houses and gardens, none has been more justly surprising than that for the raising of water by fire; the particular contrivance and sole invention of a gentleman with whom I had the honour, long since, to be well acquainted—I mean the ingenious Captain Savary, some time since deceased, but then a most noted engineer, and one of the Commissioners of the sick and wounded.

"This gentleman's thoughts (as appears by a preface of his to a little book entitled *The Miner's Friend*) were always employed in hydrostatics or hydraulics, or in the improvement of water-works; and the first hint from which it is said he took this engine, was from a tobacco-pipe, which he immersed to wash or cool it, as is sometimes done. He discovered that the water was made to spring through the tube of the pipe in a wonderful and surprising manner; though others say that the learned Marquis of Worcester, in his *Century of Inventions*, (which book I have not seen,) gave the first hint for this raising water by fire.

"It was a considerable time before this curious person, who has been so great an honour to his country, could bring this, his design, to perfection, on account of the awkwardness of the workmen who were necessarily to be employed in the affair; but at last he conquered all difficulties, and procured a recommendation of it from the Royal Society, (*Phil. Trans.*, 252,) and soon after a patent from the Crown, for the sole making this engine; and I have heard him say myself, that the very first time he play'd, it was in a potter's house at Lambeth, where, though it was a small engine, yet it (the water) forced its way through the roof, and struck up the tiles in a manner that surprised all the spectators."

"About the year 1699, he wrote a small pamphlet or treatise concerning this engine which I have just now mentioned, wherein he has exhibited a draught of it; but as that consisted of a double receiver, and a great many particulars not so easy for a learner at first sight to understand, I have, first of all, inserted that draught of it, and the account thereof, which Mr Bradley, in his new improvements of planting and gardening, has given us of that at Cambden House, it being an engine of Mr Savary's own invention, and which is the plainest and best proportioned of any that I have seen.

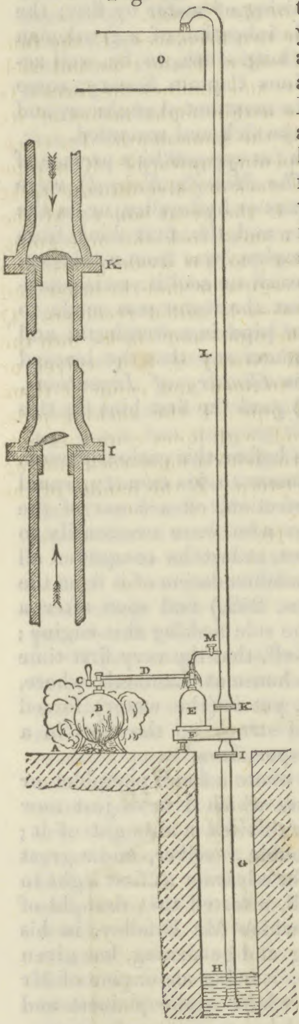
Switzer's Description of Savary's Engine.

"A the fire; B the boiler, a copper vessel of a spherical figure in which the water is boiled and evaporated into steam, which passes through the regulator C, which opens to let it into D the steam pipe, of copper, through which it descends into E the receiver, which is a vessel of copper also, that at first setting to work is full of air, which the steam discharges through F the engine tree, and up the clack valve at K, and so the air ascends in L the force pipe.

"After E is void of air, which is found by its being hot (with steam) all over, then stop the steam at C, and throw a little cold water on the outside of the hot receiver E, so as to cool down the steam in the inside, and so make it resume the condition of water, leaving E a vacuum, into which the pressure of the atmosphere will raise a column of water through the sucking pipe G from H, the pond, well, or river.

"This being done, and the receiver now being filled with water, first turn C, and let the steam pass into the receiver E, and it will force the water therein through F by K up to L, which water cannot descend because of the clack valve I. When E is thus emptied, which may be easily perceived by its being hot, as before, turn C, and confine your steam in B, then open the cock M, which will let a little cold water into E, and that, by condensing the steam in E, will cause the water to ascend immediately from H and replenish E. Then turn C to let the steam into E, and it will force the water out of it up L, into a cistern at O, placed at the top to receive it. Then confine your steam at C as before, and turn M for the space of a second or two of time, and E will be refilled, and may again be discharged up L as before; so that this work may be continued as long as you please. The valves placed in the pipes at I and K are shown on a larger scale at the side, and will enable the reader to see how they permit the water to ascend, but prevent its return by the weight of the water pressing down the clack.

Fig. 13.



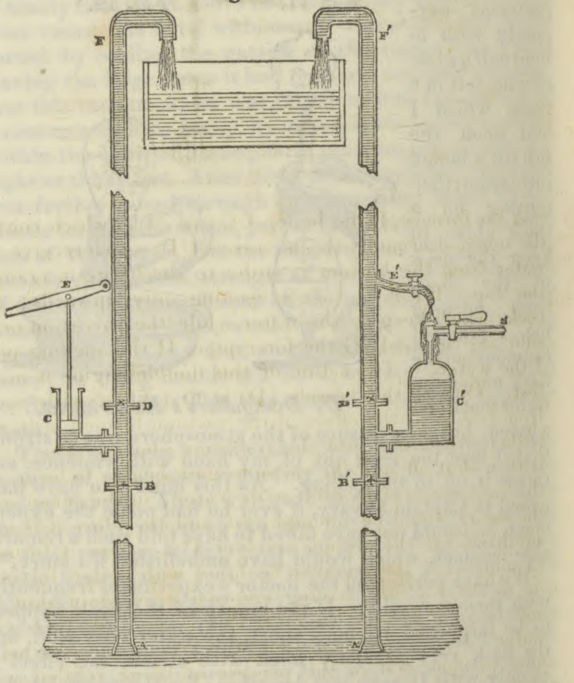
"It must be noted that this engine is but a small one in comparison of many others of this kind that are made for coal-works; but this is sufficient for any reasonable family, and other uses required for it in watering all middling gardens. Its dimensions are as follows:—the pipe from the surface of the water to F is 16 feet, and from F to the upper cistern 42 feet high; the diameter of both pipes 3 inches, and of the steam-pipe D, an inch. The receiver E holds 13 gallons of water, and the boiler three times that quantity.

"This engine will throw up four of the receivers full in one minute=52 gallons, which is 3110 gallons an hour, =52 hogsheads an hour, or 1248 hogsheads in 24 hours. The prime cost of such an engine is about L.50, as I myself have had it from the ingenious author's own mouth, and the quantity of coals required to work it about one bushel in twenty-four hours. The expense is not considerable to what horse-work is, which must be shifted twice or thrice a-day, especially in all wood or coal countries."

Savary's Engine a Steam-Pump.

It seems to us very probable, from the form of Savary's engine, that it was taken directly from that of a common drawing and forcing pump, with the substitution of the force of steam only for that of the pump piston. In Fig. 14, A B C D E F represent a common forcing pump, as given in the hydraulic works of that epoch. A′ B′ C′ D′ E′ F′ are the parts of one of Savary's steam-pumps. In the case of the common pump, the solid piston or plug at C, exactly fitted to the cylindrical chamber at C, is forced down by the lever E upon the water in the chamber C, which is pressed out through the pipe at the bottom, and being prevented from passing down to A by the closing valve B, is carried up through the open valve D, and raised towards the top of the reservoir F. When the chamber C is thus emptied, the piston is again raised, and as it is perfectly tight, so that no air can enter, the water is carried up through the valve B, which only opens upwards, and thus the vacuum at C is filled from below, by atmospheric pressure, with water, which is again to be forced back by the descent of the piston; but as the valve B closes by the pressure above it, and the valve D opens upwards, the water is carried upwards and delivered at F, the top of the reservoir. For the solid piston of the pump we have only to substitute the agency of steam, and we have Savary's machine. The close chamber C′ being conceived full of water, steam from the boiler is admitted by S′, and, by its elastic force, presses downwards on the surface of the water at C′, so as to force it out of the receiver; and finding no exit by the closed valve B′, it is forced through the rising valve D′ towards the receiver F′; in these circumstances, the little jet brought from the pipe E′ is allowed to throw cold water for a second or two on the close chamber C, now filled with steam, which is immediately condensed into the small quantity of water from which it was originally formed, and leaves the remaining space vacuous—into which vacuum, as in the former case, water is carried up by the force of the atmosphere, so as again to replenish the chamber C′, as at first, with water, which is in its turn to be acted on by the elastic force of steam admitted through S′, and carried up through D′ F′ to be delivered at F′.

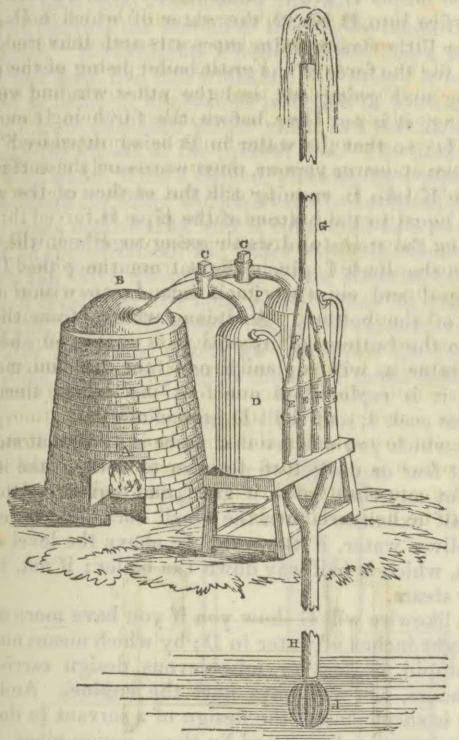
Fig. 14.



The reader who has followed this examination of Savary's steam-engine in its earlier form, is now prepared to understand the more complex but more efficient form in which the engine was more generally used. This form is that of the double receiver. The form hitherto examined does not produce a uniform stream, because the receiver, after having emptied its contents, requires a considerable interval to fill again. The double machine renders the stream nearly constant, for there are two receivers placed in communication with the boiler and the water-pipes, in such a manner that when the one is being filled the other is being emptied, and when the latter is again being charged with water from below, the other is discharging its contents in the receiver above.

In this double form a model of the engine was exhibited to the Royal Society in June 1699, and approved of. The following figure and description are those given in the *Philosophical Transactions,* vol. xxi:—

Fig. 15.



"A the furnace, B the boiler, CC two cocks which convey the steam alternately to the vessels DD, which receive the water from the bottom in order to discharge it again at the top. EEEE, valves opening only upwards; FF cocks which keep up the water while the valves on occasion are cleansed; G the force-pipe, H the sucking-pipe, I the water." The action of this double engine is manifest. One of the vessels (D) is first filled with water from below, by the effect of the vacuum formed in it, and is then discharged into the reservoir above. The steam is then shut off, and the vacuum again begins to form, and this first receiver to refill with water; in the mean time the steam would be unemployed, and therefore it is now admitted into the second receiver D 2, where it forms a vacuum, or if the receiver be filled with water, forces it up to the top, and having emptied it, is again shut off and forms a vacuum to refill this second receiver with water. But in the mean time, this second receiver being now vacuous, and in the process of being refilled with water from below, the steam being unemployed upon it may be admitted to the first receiver D, which has in the interval been charged with water from below, and the steam acting upon it will continue the stream into the reservoir at the top, until the other receiver, D 2, being again filled, is again ready to be discharged in the same direction, and so on as long as the cocks are turned.

But this working model of the Royal Society was by no means a perfect machine for performing work on a large scale. We have, therefore, extracted the following description of the machine of Savary, in the form which he gave it when introduced for the purpose of draining mines. The description and figure are taken from an old work in the Advocates' Library, entitled, "The Miner's Friend; or, a Description of an Engine for Raising Water by Fire, with an Answer to the Objections against it. By Thomas Savary, Gent." London, 1702.

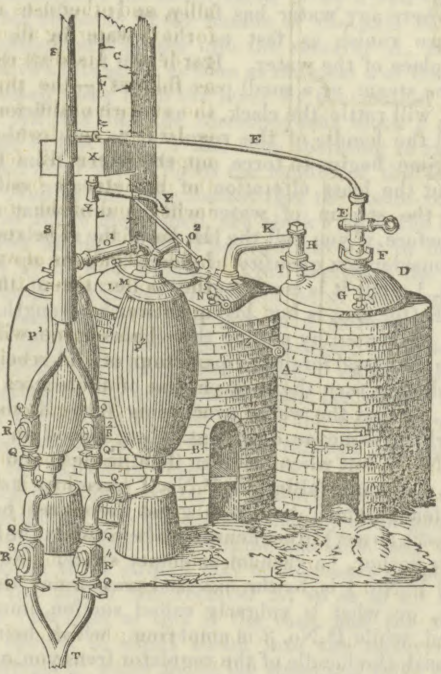
Fig. 16 represents the engine of Savary as applied to the purpose of drawing water from the bottom of deep mines. The furnaces, boilers, and receivers are placed under ground, on a platform raised sixteen or twenty feet above the level of the water at the bottom of the mine. From this platform the chimney ascends to the surface along the shaft of the mine, and a pipe through which water is forced to the surface accompanies it.

A Description of the Engine.

Savary's Description of his Steam-Engine.

A the furnaces; B^1 B^2 the two fireplaces; C the funnel or chimney; D the small boiler; E the pipe and cock of it; F the screw that covers and confines the force; G a small cock going to a pipe within eight inches of its bottom; H a large pipe going the same depth; I a clack on the top of the said pipe opening upwards; K a pipe going from the box of the said clack or valve into the great boiler about an inch into it; L the great boiler; M the screw with the regulator; N a small cock and pipe going half way down the great boiler; O^1 O^2 steam pipes, one end of each is screwed to the regulator, and the other end to the receivers; P P^2 the vessels called receivers; Q the screws which bring on the pipes and clacks into the front of the engine; RRRR Nos. 1. 2. 3. 4. valves or clacks of brass, with screws to open and come at them upon occasion; S the force-pipe; T the sucking-pipe, having a square frame of wood, with holes round its bottom in the water; X a cistern, with a buoy-cock coming from the bottom of the said cistern; Z the handle of the regulator.

Fig. 16.



"The manner of working this engine is first: there is a good double furnace so contrived that the flame of the fire may circulate round and encompass the two boilers to the best advantage, as you do coppers for brewing. Before you make any fire, unscrew G and N, being the two small gauge-pipes and cocks belonging to the two boilers, and at the holes fill L, the great boiler, two-thirds full of water, and D, the small boiler, quite full;

Savary's Description of his Steam-Engine.

then screw in the said pipes again, as fast and tight as possible; then light the fire at B. No. 1; when the water in L boils, the handle of the regulator, marked Z, must be thrust off from you as far as it will go, which makes all the steam rising from the water in L press with irresistible force through O No. I, into P No. 1, making a noise as it goes; and when all is gone out, the bottom of the vessel P No. 1 will be very hot. Then pull the handle of the regulator towards you, by which means you stop O No. 1, and force your steam through O No. 2 into P No. 2, until that vessel has discharged its air through the clack R No. 2 up the force pipe. In the mean time, by the steam's condensing in the vessel P No. 1, a vacuum of emptiness is created, so that the water must and will necessarily rise up through T, the sucking-pipe, lifting up the clack R No. 3, and filling the vessel P No. 1.

"In the mean time, the vessel P No. 2 being emptied of its air, turn the handle of the regulator from you again, and the force is upon the surface of the water in P No.1; which surface being only heated by the steam, it does not condense it, but the steam gravitates or presses with an elastic quality like air, still increasing its elasticity or spring, till it counterpoises or rather exceeds the weight of the water ascending in S, the forcing pipe, out of which the water in P No. 1 will be immediately discharged, when once gotten to the top; which takes up some time to recover that power, which having once got, and being in work, it is easy for any one that never saw the engine, after half an hour's experience, to keep a constant stream running out the full bore of the pipe S. For on the outside of the vessel P No. 1 you may see how the water goes out, as well as if the vessel was transparent; for as the steam continues within the vessel, so far is the vessel dry without, and so hot, as one is scarce able to endure the least touch with one's hand; but as far as the water is, the said vessel will be cold and wet, where any water has fallen on it; which cold and moisture vanish as fast as the steam in its descent takes place of the water. But if you force all the water out, the steam, or a small part thereof, going through R No. 1, will rattle the clack, so as to give sufficient notice to pull the handle of the regulator to you, which at the same time begins to force out the water from P No. 2, without the least alteration of the stream; only sometimes the stream of water will be somewhat stronger than before, if you pull the handle of the regulator before any considerable quantity of steam be gone up the clack R No. 1; but it is much better to let none of the steam go off, (for that is but losing so much strength,) and is easily prevented by pulling the regulator some little time before the vessel forcing is quite emptied. This being done, immediately turn the cock or pipe of the cistern X on P No. 1, so that the water proceeding from X, through L Y, (which is never open but when turned on P No. 1 or P No. 2, but when between them is tight and stanch;) I say, the water falling on P No. 1 causes by its coolness the steam (which had such great force just before, by its elastic power) to condense—to become, in the language of our author, 'a vacuum or empty space.' So that the vessel P No. 1 is, by the external pressure of the atmosphere, or what is vulgarly called suction, immediately refilled while P No. 2 is emptying; which being done, you push the handle of the regulator from you, and throw the force on P No. 2, causing the steam in that vessel to condense, so that it fills while the other empties. The labour of turning these two parts of that engine, viz. the regulator and water cock, and tending the fire, being no more than what a boy's strength can perform for a day together.

"The ingenious reader will probably here object, that the steam being the cause of this motion and force, and that steam is but water rarefied, the boiler L must be in some certain time emptied, so as the work of the engine must stop to replenish the boiler, or endanger the burning out or melting the bottom of the boiler.

"To answer which, be pleased to observe the use of the small boiler D, when it is thought fit, by the person tending the engine, to replenish the great boiler, (which requires an hour and a half, or two hours' time to the sinking one foot of water.) Then I say, by turning the cock of the small boiler E, you cut off all communication between S the great force pipe and D the small boiler, by which means D grows immediately hot; by throwing a little fire into B No. 2, the water of which boils, and in a very little time it gains more strength than the great boiler; for the force of the great boiler being perpetually spending and going out, and the other winding up and increasing, it is not long before the force in D exceeds that in L; so that the water in D being depressed in D by its own steam or vapour, must necessarily rise through the pipe K into L, running till the surface of the water in D is equal to the bottom of the pipe H.

"Then the steam and water going together, will, by a noise in the clack I, give sufficient assurance that D has discharged and emptied itself into L, to within eight inches of the bottom. And inasmuch as from the top of D to the bottom of its pipe H is contained about as much water as will replenish one foot; so you may be certain it is replenished one foot—of course then you open the cock I, and refill D immediately.

"By which you will see that there is a constant motion, without fear or danger of disorder or decay; and if you would at any time know if the great boiler L be more than half exhausted, turn the small cock N, whose pipe will deliver water, if the water be above the level of its bottom, which is half way down the boiler; if not, it will deliver steam.

"So likewise will G show you if you have more or less than eight inches of water in D; by which means nothing but a stupid neglect or mischievous design carried on some hours, can any ways hurt the engine. And if a master is suspicious of the design of a servant to do mischief, it is easily discovered by those gauge-pipes. For if he comes when the engine is at work, and finds the surface C of the water in L below the bottom of the gauge-pipe N; or the water in D below the bottom of G, such a servant deserves correction, though three hours after that the working on could not damage or exhaust the boiler. So that, in a word, the clacks being in all water-works always found the better the longer they are used; so here the same effect is found, and all the moving parts of the engine being of like nature, the furnace being made of *Sturbridge* or *Windsor* brick or fire-stone, I don't see it possible for the engine to decay in many years.

"For besides, the clacks, boxes, and water-pipes, regulator and cocks, are all of brass, and the vessels are made of the best hammered copper, of sufficient thickness to sustain the force of the working engine. In short, the engine is so naturally adapted to perform what is required, that even those of the most ordinary and meanest capacity may work it for some years without injury, if not hired or employed by some base person on purpose to destroy it. For after the engine is once fixed and at work, I may modestly affirm that the adventurer or supervisor of the work will be freed from that perpetual charge, expense, and trouble of repairs which many engines are generally liable to."

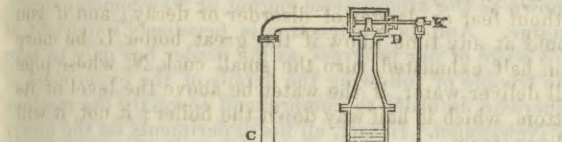
One of the first uses of Savary's engine, proposed by himself, was to raise water into a reservoir, from which it should be allowed to fall on a mill-wheel, turning round the machinery in the same way as a common fall of water; and after reaching the bottom, it was again to be raised by the steam-engine to the upper reservoir, for the pur-

Savary's Revolving Steam-Engine.

pose of again descending on the wheel. We are not, however, aware that any machine was applied in this manner during Savary's life; but after his death several of them were erected by a Mr Joshua Rigley, at Manchester, and throughout Lancashire, to impel the machinery of some of the earliest cotton-mills and manufactories of the district. One of these, of which we have here given the figure, was erected at St Pancras, London, at the manufactory of a Mr Kier, where it long continued to turn lathes, &c. We have taken the following description of it from Nicholson's Journal.

"The figure is the section of this engine taken through the centre. B represents a boiler shaped like a waggon, seven feet long, five feet wide, and five deep; it was considered as being of dimensions sufficient to work a larger engine; a circumstance which must, in a certain degree, diminish the effects of the present one. The boiler feeds itself with water, from a cistern, elevated by a pipe which descends into the boiler and has a valve in it at the upper end, which shuts downwards, and is connected by a wire with a float on the surface of the water within the boiler, so as to open the valve whenever the water subsides below its intended level; for the float which swims on the water then sinks, and by its weight draws the valve up to allow the water from the cistern to run down the pipe, and supply the deficiency; but as the water in the boiler rises the float closes the valve. The boiler, therefore, remains constantly, or nearly, at the same degree of fulness.

Fig. 17.



"The steam is conveyed by a pipe C to a box D, through which, by the opening and shutting of a valve, it can be admitted to the cylindrical receiver A. The axis K serves as a key to open and shut the valve, which is a circular plate formed conical on the edge, and fits in a corresponding aperture in the bottom of the box D; H is a cistern from which the engine draws its water, through a vertical suction-pipe, in which a valve G is placed, to prevent the return of the water; F is another cistern, into which the water is delivered from the receiver A, through the spout F, which is provided with a valve opening outwards; W W represents an overshot water-wheel, 18 feet in diameter, of which the axis S communicates motion to the lathes and other machines used in the manufactory.

"The engine raises the water from the lower cistern H, by suction, into the receiver A, from which it runs into the upper cistern F, and thence flows through a sluice into the buckets of the water-wheel W, to give it motion. The water as it is discharged from the buckets of the wheel falls again into the lower cistern H. As the same water circulates continually in both the cisterns, it becomes warmer than the hand, after working a short time; for which reason the injection-water is forced up by a small forcing pump from a well. This injection-pump is worked by the water-wheel by means of a loaded lever or pump handle, which is raised up by the motion of the wheel, and then left to descend suddenly by its weight and force up the water into the receiver. A leaden pipe passes from this forcing-pump to the upper or conical part of the receiver A, for the purpose of injecting cold water at the proper time. Neither of these could be represented with convenience in the present section.

"The manner in which the steam and cold water are alternately admitted into the receiver A, remains to be explained. Upon the extremity of the axis S of the water-wheel a solid wooden wheel T is fixed; it is about four feet in diameter, and turns round with the water-wheel. It is represented separately, as seen in the front. *a b c d* are four cleats, all or any number of which may be fixed on the wheel at a time. Each cleat has its correspondent block, *e f g h* on the opposite surface of the wheel. The use of these is to work the engine. Thus, suppose the water-wheel and this wheel T, with all the revolving apparatus, are turning round, one of the cleats, *a*, meets in its rotation with a lever, which it lifts up, and this opens the steam-valve D by a rod of communication reaching to the handle of the axis K. The steam consequently passes into the receiver A, and the steam-valve shuts again as soon as the cleat *a* of the wheel T has passed away from the lever by the motion of the wheel. All this time the correspondent block *e* on the other side of the wheel T had been operating to raise up the loaded lever which forms the handle of the forcing-pump. And at the same instant that the steam-valve D is shut, as above mentioned, the block *e* quits the loaded lever, after having raised it up, and leaves it to descend suddenly by its own weight. This depresses the forcer of the pump, and thereby throws a jet of cold water up into the receiver A, and it falls in a shower of drops through the steam which fills the receiver, so as to cool and condense the steam, and make a vacuum therein. The pressure of the atmosphere upon the surface of the water in the cistern H then causes the water to mount up the perpendicular suction-pipe, through the valve G, towards the exhausted receiver.

"When the engine is first set to work, the water-wheel being motionless, the steam-valve and injection-pump are moved by hand; and if the engine has been long out of work, two or three strokes may be necessary to raise the water to the top of the receiver A, so as to fill it full of water. As soon as this is the case, and the steam-valve is opened to admit steam into the receiver, the whole contents of water above the spout and valve F then flows out of the receiver A, by its own gravity, into the upper cistern R.

"The water which is thus raised is suffered to flow from the cistern upon the overshot water-wheel W, through a sluice, and by that means keeps the wheel in motion, and replenishes the lower cistern. There is no reservoir for the injection-water, but the requisite quantity is driven up at each stroke; and as this is done by the sudden descent of the loaded lever of the pump, the water is injected very suddenly into the receiver."

The Atmospheric Steam-Engine of Newcomen and Cawley.

Atmospheric Steam-Engine.

The title of this steam-engine correctly indicates the principle of its action. The effect which it produces is not by the direct and immediate agency of steam, but of the atmosphere. All that the steam does in this machine is merely to make way for the atmosphere, and give effect to its pressure. It is therefore necessary to retrace our steps, and give some consideration to the mode of operation of atmospheric pressure as an introduction to this description. A full exposition of the nature and laws of the pressure of atmosphere has been given in the article **Pneumatics**, to which our readers are referred for a more perfect acquaintance with this subject. We shall only touch upon such branches of experiment, concerning atmospheric pressure, as are so closely intertwined with our more immediate investigation as to constitute an essential part of it.

Atmospheric experiments of Otto Guericke.

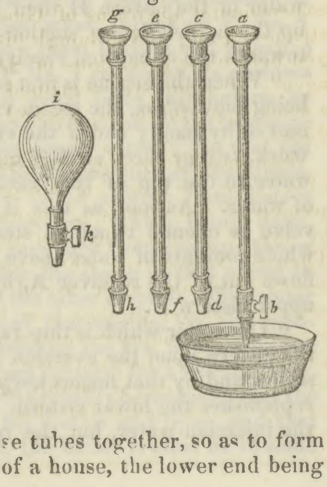
We have merely to notice, that after the discovery of the laws of atmospheric pressure by the pupils of Galileo, we owe most of our information on the phenomena resulting from the pressure of the atmosphere, and of the apparatus constructed for exhibiting its powers on a large scale, to Otto Guericke, privy councillor of his serene highness the Elector of Brandenburg, and consul of Magdeburg, who had in 1654 brought his pneumatic apparatus to considerable perfection, and continued to make his experiments to an advanced age. They were published by Gasparus Schottus in his work " De Arte Mechanica Hydraulica Pneumatica," in 1657, and again by the author himself, in a thin volume, entitled " Ottonis Guericke Experimenta Nova Magdeburgica de Vacuo Spatio, Aeris Pondere," &c. Amstelodami, 1672, fol.

We have extracted and translated the following passages of this rare work from a copy in the library of the College of Physicians at Edinburgh. They show us that the mode of raising water above its level by atmospheric pressure, and by a vacuum, was by him so clearly made known, that the use of steam as the instrument for effecting that vacuum was a very direct and easy transition. Indeed the apparatus we have first to consider is a very simple illustration of the action of Savary's machine.

Raising water by atmospheric pressure into a vacuum.

Illustration of raising water by a vacuum, and the pressure of the atmosphere, taken from chapter xx. of Otto Guericke.

Fig. 18.



" Make four tubes or pipes *ab*, *cd*, *ef*, *gh*, each about eight feet long, made of glass, and mounted at the extremities with conically tapered fittings, so as to be accurately joined to each other, each joint surrounded by a small cup, into which liquid being poured, the joints may be prevented from taking in air; let there also be a stopcock on the lowest, and let there be taken a glass flask *i*, also fitted air-tight with a stopcock *k*.

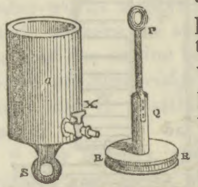
" Having joined all these tubes together, so as to form a tube erected on the wall of a house, the lower end being immersed under water in the open vessel; the large flask or receiver having been previously emptied of air by the air-pump, and being now placed on the top of the long tube, and the stopcock *k* being opened, the water will violently rush up the tube to the height of above thirty feet. The rationale is this, that the external air presses on the surface of the water in the bucket, which finds free exit from this force up the vacuous space of the tube, from which the air has been withdrawn, into the flask *i*; and settles at such a height as will balance by the weight of the column of water the weight of the circumambient air."

The reader of this very clear and accurate exposition may easily perceive that when it has once been discovered that water, after having been rarefied by heat into steam, so as to fill a large space, is afterwards condensed by cold, so as to leave a portion of that space vacuous, nothing remains to be done except to make the vacuum of the flask *i* by steam instead of an air-pump and the machine of Savary is obtained. In fact, the flask *i* of Otto Guericke corresponds accurately to the receiver of Thomas Savary. The reader has only to understand the former, in order to perceive at a glance the action of the latter.

This first experiment of Otto Guericke, therefore, represents with fidelity the principle of Savary's engine for raising water by the formation of a vacuum. Not less beautifully does another experiment of the same philosopher exemplify the principle of the species of engine known as the atmospheric engine, or Newcomen's steam-engine. And its construction is peculiarly important at this stage of our progress, as the reader has only to take the trouble of following the details of the experiment of Guericke, in order to comprehend correctly the machine of Newcomen. In fact, all his experiments on the power of the atmosphere are admirable illustrations of the principle of the atmospheric steam-engine; so that the reader will do well to remember that the only use of the steam in the atmospheric steam-engine is to form a vacuum.

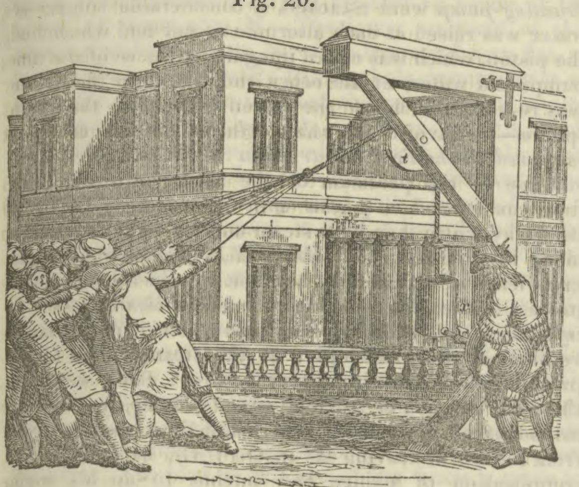
Description and operation of the atmospheric apparatus for raising great weights by a vacuum under a piston in a cylinder, exhibited amongst other experiments, at the diet of Ratisbon in 1654, to the court and their Majesties Ferdinand III. and his son Ferdinand IV, &c., chap. xxvii. and xxviii.

Fig. 19.



" A large vessel of copper, *a*, made truly cylindrical, and having its sides perfectly even and parallel, and about twenty inches high and eight inches wide, was fixed firmly in a vertical position by the strong ring S. In the next place, a piston, PQR, was made to fit exactly the inside of the aforesaid cylinder, P being of iron and Q wood, and the rounded head R, formed of the hardest oak, being hollowed out on the edge like the pulley of a common well, in which groove flax or hemp is to be rolled round so as to fill it up, and the whole is then to be placed in the aforesaid cylinder *a*, (like as a piston and its head in a common syringe or pump for extinguishing fires,) and fitted so exactly that air can neither pass outwards or inwards through between the piston and cylinder. Thirdly, the cylinder *a* is to be attached to the great upright beam, Fig. 20, by an iron bracket, through the ring aforesaid S, and the piston PQR is to be let into the cylinder *a*, and the iron handle PQ of the piston is to be passed through the ring of a second iron arm O, in such a manner that it can play freely up and down through the whole height of the cylinder, and at the same time be steadily preserved in the straight line, but not permitted to rise further than O. In the *fourth* place, a rope, to the end of which is firmly attached a hook, is carried round the wheel *t*, and fastened by its hook to the piston rod PQ, and the other end of the rope has other ropes attached to it, to be grasped by the men, as in the figure.

Fig. 20.



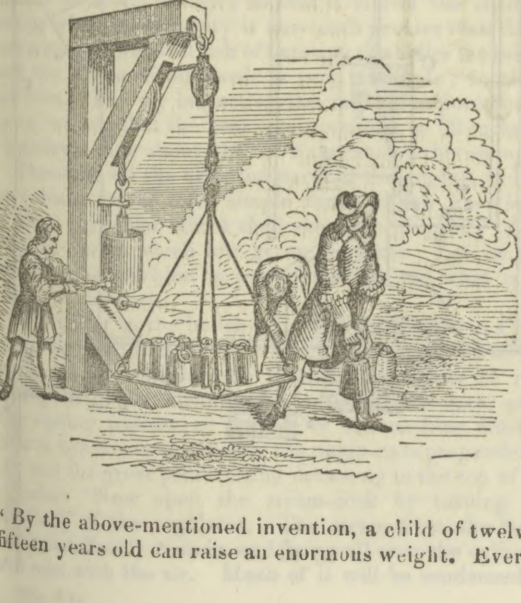
" Now, if the stopcock X be closed, the piston being nearly at the bottom, the joint efforts of fifty or more men will not be able to raise it more than about half way up the cylinder.

" If, now, in the *fifth* place, the large glass receiver, formerly mentioned, which has been previously made perfectly vacuous, (by an air-pump,) be applied to the stopcock X, and then when the men are exerting their utmost force, the stopcocks at X of the vacuous receiver and the cylinder be opened, so as to make a free communication from the one into the other; the piston P Q R will be suddenly forced down to the bottom of the cylinders in spite of the greatest efforts of the men to keep it up.

" The whole cause of this matter is to be attributed to the gravity of the air, which, when the vacuum is formed below, instantly presses down the piston into it with a force which, according to our former calculation, amounts in that size of cylinder to 2686 pounds' weight."

The next of the Magdeburg experiments still more closely resembles the atmospheric steam-engine in its mode of application, and still further illustrates it.

Fig. 21.



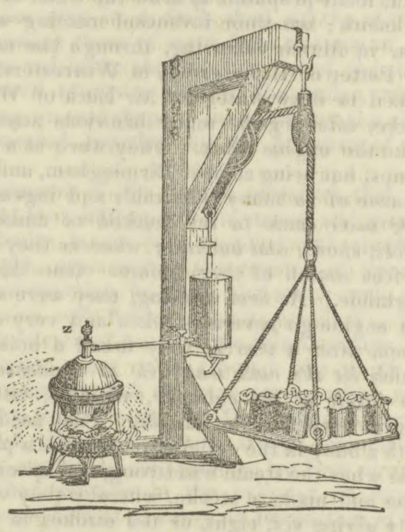
Atmospheric pressure applied by using steam to form a vacuum.

" By the above-mentioned invention, a child of twelve or fifteen years old can raise an enormous weight. Every thing being left as formerly, only the piston being nearly at the top of the cylinder *a*, you are to pass the rope round a second pulley, hung from a staple; and by a hook to suspend from the rope the scale of a large balance, which you are to load with a weight of 2686 pounds. If a small syringe be applied by a little boy to the stopcock X to pump out the air, it will follow that, as the air is pumped out from below the piston, the atmosphere above will press it down and raise the weight."

Atmospheric steam-engine.

The transition from this to the engine of Newcomen is immediate. To the last-described apparatus of Guericke let there be added a small copper globe or boiler, Z, Fig. 22, to be placed over a fire till the water which it contains boils into steam. This steam, entering below the piston, will occupy the whole space of the cylinder; but if now the stopcock X be suddenly closed, and especially if cold water be sprinkled on the outside of it to cool it, the steam will be condensed back into its original bulk of water, and leave the space it formerly occupied in the cylinder a vacuum, into which the atmosphere will press down the piston P Q R, just as in the former instance, raising up the weights at the other end of the rope. This is just the atmospheric engine of Newcomen. It is the atmosphere which does the work; the steam acts indirectly as the medium through which a vacuum is effected; and it is only the efficient agency of the atmosphere which is thus rendered useful in giving motion to a weight.

Fig. 22.



We hope that nothing which we have here said concerning the discoveries of Guericke will be misunderstood, as intended in any way to depreciate the value set upon the inventions of Mr Savary or Mr Newcomen; they are only introduced as illustrations by which we are most easily conducted to a thorough comprehension of the principles on which they act, and of the state of knowledge of atmospheric pressure which existed at that date. The experimental apparatus of Guericke was in no respect a steam-engine; and although his speculations were divulged before the inventions of Savary and Newcomen, the agency of steam still remained to be introduced, before a machine useful to the arts and industry of man was produced.

Newcomen's atmospheric steam-engine described by Switzer.

Newcomen's Fire-Engine.—Switzer, in his Hydrostatics, (1729) has the following passage:—" To finish this long account of the surprising engine for the raising of water by fire, I produce this last improvement of it by Mr Thomas Newcomen, which makes it undoubtedly the beautifullest and most useful engine that any age or country ever yet produced, as the best and most useful inventions and improvements which have been discovered either in art or nature, have, in process of time, been liable to improvement, so this, of the fire-engine, has been subject to the same, for this ingenious gentleman to whom we owe this late invention, has, with a great deal of modesty, but as much judgment, given the finishing

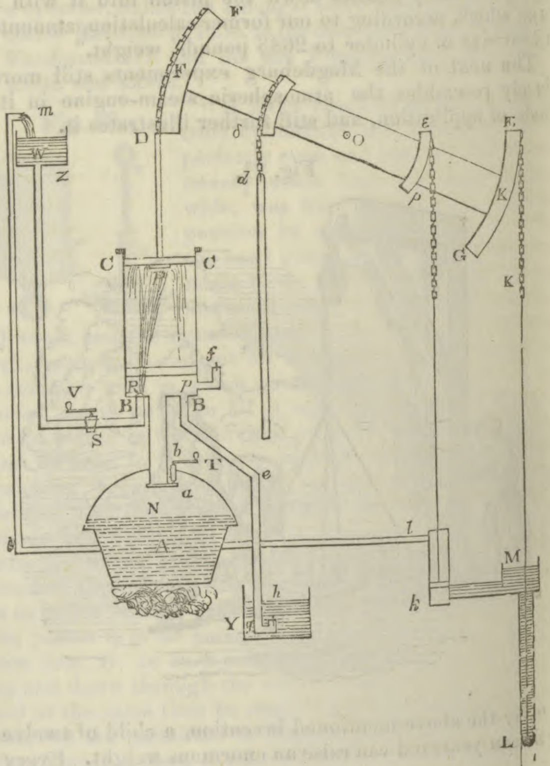
Desaguliers's account of improvements of Newcomen's engine.

stroke to it. It is, indeed, generally said to be an improvement to Mr Savary's engine; but I am well informed, that *Mr Newcomen was as early in his invention as Mr Savary was in his,* only the latter being nearer the court, had obtained his patent before the other knew it, on which account Mr Newcomen was glad to come in as a partner to it." Dr Desaguliers speaking of Savary's engine also says, "these discouragements (the difficulty of making sufficient high-pressure boilers, &c.) stopped the progress and improvement of this engine till Mr Newcomen, an ironmonger, and John Cawley, a glazier living at Dartmouth, brought it to the present form in which it is now used and has been near these thirty years." (1744.) *Experimental Philosophy*, ii. 467. And again, "about the year 1710, Thomas Newcomen, ironmonger, and John Cawley, glazier, of Dartmouth, in the county of Southampton, (Anabaptists,) made then several experiments in private, and having brought it to work with a piston, &c., in the latter end of the year
A.D.1711. 1711, made proposals to draw the water at Griff in Warwickshire; but their invention meeting with no reception, in March following, through the acquaintance of
A.D.1712. Mr Potter of Bromsgrove, in Worcestershire, they bargained to draw water for Mr Back of Wolverhampton, where, after a great many laborious attempts, they did make the engine work. They were at a loss about the pumps, but being so near Birmingham, and having the assistance of so many admirable and ingenious workmen, they soon came to the method of making the *pump-valves, clacks, and buckets;* whereas they had but an imperfect notion of them before. One thing is very remarkable. At first working, they were surprised to see the engine go several strokes and very quick together, when, after a search, they found a hole in the piston which *let the cold water in to condense the steam in the inside of the cylinder,* whereas, before, they had always done it on the outside. They used before to work with a buoy in the cylinder inclosed in a pipe, which buoy rose when the steam was strong, and opened the injection-pipe and made a stroke, whereby they were capable of only giving six, eight, or ten strokes in a minute, till a boy named Humphrey Potter, who attended the engine, added what he called *scoggan, by which the beam of the*
A.D.1713. *engine always opened and shut its own valves,* and then it would go (entirely without the attendance of a man) fifteen or sixteen strokes in a minute. But this being perplexed with catches and strings, Mr Henry Beighton, in an
A.D.1718. engine he had built at Newcastle-on-Tyne in 1718, took them all away, *the beam itself supplying all much better.* The way of leathering the piston was found by accident about 1713. Having screwed a large broad piece of leather to the piston, which turned up the sides of the cylinder two or three inches: in working it wore through, and cut that piece from the other, which, falling flat on the piston, wrought with its edge to the cylinder, and having been in a long time, was worn very narrow, which being taken out, they had the happy discovery
A.D.1713. whereby *they found that a bridle rein or even a soft thick piece of rope or match going round, would make the piston air and water tight.*"

Summary of the history of the atmospheric steam-engine.

This short note of Dr Desaguliers, who, with Switzer, is our authority for the historical facts of this date, contains the leading points of the history of the steam-engine as generally used for raising water during the eighteenth century. Newcomen gave to the engine a *cylinder* and *piston:* he formed *a vacuum in the cylinder below the piston,* by first admitting steam from the boiler so as to expel air and balance the pressure of the atmosphere, and afterwards *condensing the steam* so as to reduce it back to its primitive bulk of water, and thus, by leaving the space below the piston empty, allow *the pressure of the atmosphere upon the whole surface of the piston* to carry it with a force somewhat less than fourteen pounds on each inch of that surface downwards to the bottom of the cylinder, so that by suspending the piston with a chain from the end of a *rocking beam* to the opposite extremity of which the *rod and buckets of a large draining-pump* were attached, a considerable volume of water was raised at each alternate ascent and descent of the piston, which was raised up again by the weight of the pumps and water, at the other end, whenever the steam was re-admitted below the piston to balance the atmosphere—he gave to the *valves, clacks, buckets,* &c., that *improved mechanical construction* which rendered them suitable to the precision of the action of steam. He first constructed a *piston with an elastic packing* of hemp, by which it is kept steam and air-tight as it moves along the cylinder; and, above all, availed himself of the experience of an unlucky accident to add the important process in the steam-engine of *condensation of steam by injection of cold water* directly amongst it. All these inventions of Newcomen give to the steam-engine of the present day its most important features; and if we add to these the *scoggan* or *sculking gear of Potter,* by which the attendant of the engine was enabled to scog or *sculk* from his work, leaving *the engine itself,* by an ingenious complication of strings and catches to do his work, *opening and shutting its own valves,* with much greater *precision, quickness, and regularity,* than the listless attendant had ever exercised or even the very closest attention could attain; and if, further, we include the ingenious and more permanent *mechanism which* Beighton *introduced* as a substitution for the rude expedients of strings and straps; and, finally, if we include the *admirable proportions and constructions, and adaptations* of all the various parts of the engine to each other, and to the boilers and furnaces, and of these to the nature of the work to be done, as displayed in the magnificent atmospheric engines of the sagacious and philosophical Smeaton, we shall comprehend, in this succinct view, all that had been done for the steam-engine previously to the time of Watt.

Fig. 23.



The following is Dr Robison's description and explanation of Newcomen's engine:—

Let A (fig. 23) represent a great boiler properly built in a furnace. At a small height above it is a cylinder CBBC of metal, bored very truly and smoothly. The boiler communicates with this cylinder by means of the throat or steam-pipe N. The lower aperture of this pipe is shut by the plate N, which is ground very flat, so as to apply very accurately to the whole circumference of the orifice. The plate is called the regulator or steam-cock, and it turns horizontally round an axis *b a* which passes through the top of the boiler, and is nicely fitted to the socket, like the key of a cock, by grinding. The upper end of this axis is furnished with a handle *b*T.

A piston P is suspended in this cylinder, and made air-tight by a packing of leather or soft rope, well filled with tallow; and, for greater security, a small quantity of water is kept above the piston. The piston-rod PD is suspended by a chain, which is fixed to the upper extremity F of the arched head FD of the great lever or working beam FK, which turns on the gudgeon O. There is a similar arched head EG at the other end of the beam. To its upper extremity E is fixed a chain carrying the pump-rod KL, which raises the water from the mine. The load on this end of the beam is made to exceed considerably the weight of the piston P at the other extremity.

At some small height above the top of the cylinder is a cistern W called the injection cistern. From this descends the injection-pipe ZSR, which enters the cylinder through its bottom, and terminates in a small hole R, or sometimes in a nozzle pierced with many smaller holes diverging from a centre in all directions. This pipe has at S a cock called the injection-cock, fitted with a handle V.

At the opposite side of the cylinder, a little above its bottom, there is a lateral pipe, turning upwards at the extremity, and there covered by a clack-valve *f*, called the snifting valve, which has a little dish round it to hold water for keeping it air-tight.

There proceeds also from the bottom of the cylinder a pipe *p e g h*, (passing behind the boiler,) of which the lower end is turned upwards, and is covered with a valve *h*. This part is immersed in a cistern of water Y, called the hot well, and the pipe itself is called the eduction-pipe. Lastly, the boiler is furnished with a safety-valve called the puppet-clack, (which, for want of room, is not represented in this sketch,) in the same manner as Savary's engine. This valve is generally loaded with one or two pounds on a square inch; so that it allows the steam to escape when its elasticity is one-tenth greater than that of common air. Thus all risk of bursting the boiler is avoided, and the pressure outwards is very moderate; so also is the heat. For, by inspecting the table of vaporous elasticity, we see that the heat corresponding to 32 inches of elasticity is only about 216° of Fahrenheit's thermometer.

These are all the essential parts of the engine, and are here drawn in the most simple form, till our knowledge of their particular offices shall show the propriety of the peculiar forms which are given to them. Let us now see how the machine is put in motion, and what is the nature of its work.

The water in the boiler being supposed to be in a state of strong ebullition, and the steam issuing by the safety-valve, let us consider the machine in a state of rest, having both the steam-cock and injection-cock shut. The resting position or attitude of the machine must be such as appears in the sketch, the pump-rods preponderating, and the great piston being drawn up to the top of the cylinder. Now open the steam-cock by turning the handle T of the regulator. The steam from the boiler will immediately rush in, and flying all over the cylinder, will mix with the air. Much of it will be condensed by the cold surface of the cylinder and piston, and the water produced from it will trickle down the sides, and run off by the eduction-pipe. This condensation and waste of steam will continue till the whole cylinder and piston are made as hot as boiling water. When this happens, the steam will begin to open the snifting-valve *f*, and issue through the pipe; slowly at first, and very cloudy, being mixed with much air. The blast at *f* will grow stronger by degrees, and more transparent, having already carried off the greatest part of the common air which filled the cylinder. We supposed that the water was boiling briskly, so that the steam was issuing by the safety-valve which is in the top of the boiler, and through every crevice. The opening of the steam-cock puts an end to this at once, and it has sometimes happened that the cold cylinder abstracts the steam from the boiler with such astonishing rapidity, that the pressure of the atmosphere has burst up the bottom of the boiler. We may here mention an accident of which we were witnesses, which also shows the immense rapidity of the condensation. The boiler was in a frail shed at the side of the engine-house; a shoot of snow from the top of the house fell down and broke through the roof of the shed, and was scattered over the head of the boiler, which was of an oblong or oval shape. In an instant the sides of it were squeezed together by the pressure of the atmosphere.

When the manager of the engine perceives that not only the blast at the snifting-valve is strong and steady, but that the boiler is now fully supplied with steam of a proper strength, appearing by the renewal of the discharge at the safety-valve, he shuts the steam-cock, and opens the injection-cock S by turning its handle V. The pressure of the column of water in the injection-pipe ZS, immediately forces some water through the spout R. This coming in contact with the pure vapour which now fills the cylinder, condenses it, and thus makes a partial void, into which the more distant steam immediately expands, and by expanding collapses, (as has been already observed.) What remains in the cylinder no longer balances the atmospherical pressure on the surface of the water in the injection-cistern, and therefore the water spouts rapidly through the hole R, by the joint action of the column ZS, and the unbalanced pressure of the atmosphere; at the same time the snifting-valve *f*, and the eduction-valve *h*, are shut by the unbalanced pressure of the atmosphere. The velocity of the injection water must therefore rapidly increase, and the jet will dash (if single,) against the bottom of the piston, and be scattered through the whole capacity of the cylinder. In a very short space of time, therefore, the condensation of the steam becomes universal, and the elasticity of what remains is almost nothing. The whole pressure of the atmosphere is exerted on the upper surface of the piston, while there is hardly any on its under side. Therefore, if the load on the outer end E of the working-beam be inferior to this pressure, it must yield to it. The piston P must descend, and the pump-piston L, must ascend, bringing along with it the water of the mine, and the motion must continue till the great piston reaches the bottom of the cylinder; for it is not like the motion which would take place in a cylinder of air rarefied to the same degree. In this last case, the impelling force would be continually diminished, because the capacity of the cylinder is diminished by the descent of the piston, and the air in it is continually becoming more dense and elastic. The piston would stop at a certain height, where the elasticity of the included air, together with the load at E, would balance the atmospherical pressure on the piston. But when the contents of the cylinder are pure vapour, and the continued stream of injected cold water keeps down its temperature to the same pitch as at the beginning, the elasticity of the remaining steam can never increase by the descent of the piston, nor exceed what corresponds to this temperature. The impelling or accelerating force therefore remains the same, and the descent of the piston will be uniformly accelerated, if there be not an increase of resistance arising from the nature of the work performed by the other end of the beam. This circumstance will come under consideration afterwards, and we need not attend to it at present. It is enough for our present purpose to see, that if the cylinder have been completely purged of common air before the steam-cock was shut, and if none have entered since, the piston will descend to the very bottom of the cylinder. And this may be frequently observed in a good steam-engine, where every part is air-tight. It sometimes happens, by the pit-pump drawing air, or some part of the communication between the two strains giving way, that the piston comes down with such violence as to knock out the bottom of the cylinder with the blow.

The piston does not begin to descend the moment the injection is made.

The only observation which remains to be made on the motion of the piston in descending is, that it does not begin at the instant the injection is made. The piston was kept at the top by the preponderancy of the outer end of the working-beam, and it must remain there till the difference between the elasticity of the steam below it and the pressure of the atmosphere exceed this preponderancy. There must, therefore, be a small space of time between the beginning of the condensation and the beginning of the motion. This is very small, not exceeding the third or the fourth part of a second; but it may be very distinctly observed by an attentive spectator. He will see, that the instant the injection-cock is opened, the cylinder will sensibly rise upwards a little by the pressure of the air on its bottom. Its whole weight is not nearly equal to this pressure; and instead of its being necessary to *support* it by a strong floor, we must *keep it down* by strong joists loaded by heavy walls. It is usual to frame these joints into the posts which carry the axis of the working-beam, and are therefore loaded with the whole strain of the machine. This rising of the cylinder shows the instantaneous commencement of the condensation; and it is not till *after* this has been distinctly observed, that the piston is seen to start, and begin to descend.

The circumstances that succeed the descent of the piston.

When the manager sees the piston as low as he thinks proper, he shuts the injection-cock, and opens the steam-cock. The steam has been accumulating above the water in the boiler during the whole time of the piston's descent, and is now rushing violently through the puppet clack. The moment, therefore, that the steam-cock is opened, it rushes violently into the cylinder, having an elasticity greater than that of the air. It therefore immediately blows open the snifting valve, and allows (at least) the water which had come in by the former injection, and what arose from the condensed steam, to descend by its own weight through the eduction-pipe *d e g h*, to open the valve *h*, and to run out into the hot well. And we must easily see that this water is boiling hot; for while lying in the bottom of the cylinder, it will condense steam till it acquire this temperature, and therefore cannot run down till it condenses no more. There is still a waste of steam at its first admission, in order to heat the inside of the cylinder and the injected water to the boiling temperature; but the space being small, and the whole being already very warm, this is very soon done; and when things are properly constructed, little more steam is wasted than what will warm the cylinder; for the eduction-pipe receives the injection water even during the descent of the piston, and it is therefore removed pretty much out of the way of the steam.

This first puff of the entering steam is of great service: it drives out of the cylinder the vapour which it finds there. This is seldom pure watery vapour: all water contains a quantity of air in a state of chemical union. The union is but feeble, and a boiling heat is sufficient for disengaging the greatest part of it by increasing its elasticity. It may also be disengaged by simply removing the external pressure of the atmosphere. This is clearly seen when we expose a glass of water in an exhausted receiver. Therefore the small space below the piston contains watery vapour mixed with all the air which had been disengaged from the water in the boiler by ebullition, and all that was separated from the injection water by the diminution of external pressure. All this is blown out of the cylinder by the first puff of steam. We may observe in this place, that waters differ exceedingly in the quantity of air which they hold in a state of solution. All spring-water contains much of it; and water newly brought up from deep mines contains a great deal more, because the solution was aided in these situations by great pressures. Such waters sparkle when poured into a glass. It is therefore of great consequence to the good performance of a steam-engine to use water containing little air, both in the boiler and in the injection cistern. The water of running brooks is preferable to all others, and the freer it is from any saline impregnation it generally contains the less air. Such engines as are so unfortunately situated that they are obliged to employ the very water which they have brought up from great depths, are found greatly inferior in their performance to others. The air collected below the piston greatly diminishes the accelerating force, and the expulsion of such a quantity requires a long-continued blast of the best steam at the beginning of every stroke. It is advisable to keep such water in a large shallow pond for a long while before using it.

Let us now consider the state of the piston. It is evident that it will start, or begin to rise, the moment the steam-cock is opened; for at that instant the excess of atmospherical pressure, by which it was kept down in opposition to the preponderancy of the outer end of the beam, is diminished. The piston is therefore *dragged* upwards, and it will rise even although the steam which is admitted be not so elastic as common air. Suppose the mercury in the barometer to stand at 30 inches, and that the preponderancy at the outer end of the beam is $\frac{1}{9}$th of the pressure of the air on the piston, the piston will not rise if the elasticity of the steam be not equal to $30-\frac{30}{9}$, that is, 26.7 inches nearly; but if it be just this quantity, the piston will rise as fast as this steam can be supplied through the steam-pipe, and the velocity of its ascent depends entirely on the velocity of this supply. This observation is of great importance; and it does not seem to have occurred to the mathematicians, who have paid most attention to the mechanism of the motion of this engine. In the mean time, we may clearly see that the entry of the steam depends chiefly on the counter-weight at E: for suppose there was none, steam no stronger than air would not enter the cylinder at all; and if the steam be stronger, it will enter only by the excess of its strength. Writers on the steam-engine (and even some of great reputation) familiarly speak of the steam giving the piston a push; but this is scarcely possible. During the rise of the piston the snifting valve is never observed to blow; and we have not heard any well-attested accounts of the piston-chains ever being slackened by the upward pressure of the steam, even at the very beginning of the stroke. During the rising of the piston the steam is, (according to the common conception and manner of speaking,) *sucked in*, in the same way that air is sucked into a common syringe or pump when we draw up the piston; for in the steam-engine the piston is really drawn up by the counter-weight. But it is still more sucked in, and requires a more copious supply, for another reason. As the piston descended only in consequence of the inside of the cylinder's being sufficiently cooled to condense the steam, this cooled surface must again be presented to the steam during the rise of the piston, and must condense the steam a second time. The piston cannot rise another inch till the part of the cylinder which the piston has already quitted has been warmed up to the boiling point, and steam must be expended in this warming. The inner surface of the cylinder is not only of the heat of boiling water while the piston rises, but is also perfectly dry; for the film of water left on it by the ascending piston must be completely evaporated, otherwise it will be condensing steam. That the quantity thus wasted is considerable, appears by the experiments of Mr Beighton. He found that five pints of water were boiled off in a minute, and produced 16 strokes of an engine whose cylinder contained 113 gallons of 282 inches each; and he thence concluded that steam was 2886 times rarer than water. But in no experiment made with scrupulous care on the expansion of boiling water does it appear that the density of steam exceeds $\frac{1}{10000}$th of the density of water. Desaguliers says that it is above 14,000 times rarer than water. We have frequently attempted to measure the weight of steam which filled a very light vessel which held 12,600 grains of water, and found it always less than one grain; so that we have no doubt of its being much more than 10,000 times rarer than water. This being the case, we may safely suppose that the number of gallons of steam, instead of being 16 times 113, were nearly five times as much; and that only $\frac{1}{5}$ was employed in allowing the piston to rise, and the remaining $\frac{4}{5}$ths were employed to warm the cylinder. But no distinct experiment shows so great an expansion of water when converted into steam at 212°. Mr Watt never found it, under the pressure of the air, more than 1800 times rarer than water.

It scent ch y ow g to th eight of e pit pi n- ro

The moving force during the ascent of the piston must be considered as resulting chiefly, if not solely, from the preponderating weight of the pit piston-rods. The office of this is to return the steam-piston to the top of the cylinder, where it may again be pressed down by the air, and make another working stroke by raising the pump-rods. But the counter-weight at E has another service to perform in this use of the engine; namely, to return the pump pistons into their places at the bottom of their respective working barrels, in order that they also may make a working stroke. This requires force independent of the friction and inertia of the moving parts; for each piston must be pushed down through the water in the barrel, which must rise through the piston with a velocity whose proportion to the velocity of the piston is the same with that of the bulk of the piston to the bulk of the perforation through which the water rises through the piston. It is enough at present to mention this in general terms: we shall consider it more particularly afterwards, when we come to calculate the performance of the engine, and to deduce from our acquired knowledge, maxims of construction and improvement.

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From this general consideration of the ascent of the piston, we may see that that motion differs greatly from the descent. It can hardly be supposed to accelerate, even if the steam in the cylinder were in a moment annihilated. For the resistance to the descent of the piston is the same with the weight of the column of water, which would cause it to flow through the box of the pump piston with the velocity with which it really rises through it, and must therefore increase as the square of that velocity increases; that is, as the square of the velocity of the piston increases. Independent of friction, therefore, the velocity of descent through the water must soon become a maximum, and the motion become uniform. We shall see by and by, that in such a pump as is generally used, this will happen in less than the 10th part of a second. The friction of the pump will diminish this velocity a little, and retard the time of its attaining uniformity. But, on the other hand, the supply of steam which is necessary for this motion, being susceptible of no acceleration from its previous motion, and depending entirely on the briskness of the ebullition, an almost instantaneous stop is put to acceleration.

Accordingly, any person who observes with attention the working of a steam-engine, will see that the rise of the piston and descent of the piston-rods is extremely uniform, whereas the working stroke is very sensibly accelerated. Before quitting this part of the subject, and lest it should afterwards escape our recollection, we may observe, that the counter-weight is different during the two motions of the pump-rods. While the machine is making a working stroke, it is lifting not only the column of water in the pump, but the absolute weight of the pistons and piston-rods also; but while the pump-rods are descending, there is a diminution of the counter-weight by the whole weight lost by the immersion of the rod in water. The wooden rods which are generally used, soaked in water, and joined by iron straps, are heavier, and but a little heavier, than water, and they are generally about one-third of the bulk of the water in the pumps.

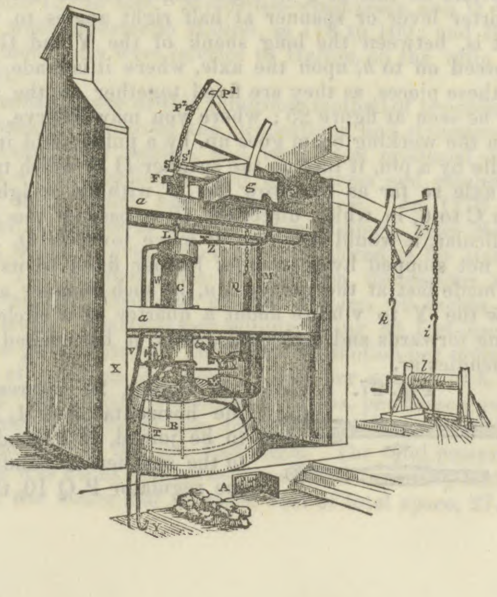
The counter-weight is different during the two motions of the pump-rods.

These two motions complete the period of the operation; and the whole may be repeated by shutting the steam-cock and opening the injection-cock whenever the piston has attained the proper height. We have been very minute in our attention to the different circumstances, that the reader may have a distinct notion of the state of the moving forces in every period of the operation. It is by no means sufficient that we know in general that the injection of cold water makes a void which allows the air to press down the piston, and that the re-admission of the steam allows the piston to rise again. This lumping and slovenly way of viewing it has long prevented even the philosopher from seeing the defects of the construction, and the methods of removing them.

1718.
Beighton's valve gear.

It was in 1718, as already mentioned, that Mr Henry Beighton improved the steam-engine of Newcomen, by a simple and effective arrangement of minor details, which left so little to be desired for the practical use of the engine in pumping water, that for more than half a century it remained in general use, without any change of form or arrangement. The following excellent diagrams and quaint descriptions are from the pen of Desaguliers, who had made himself very well acquainted with the subject as it existed in his time.

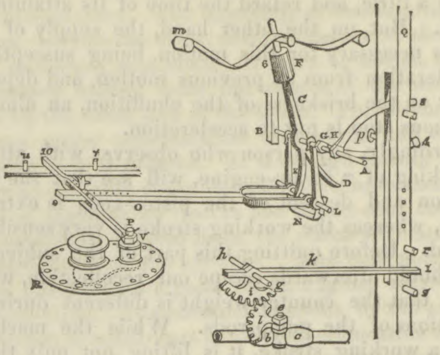
Fig. 24.



Steam-Engine.

Desaguliers' description of Beighton's gear.

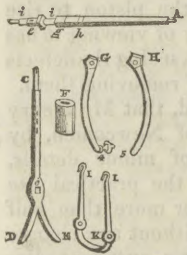
Fig. 25.



"The working perpendicular beam is in figure 24 represented in the whole, with all its contrivances for opening and shutting the regulator and injection-cock, and marked QQ.

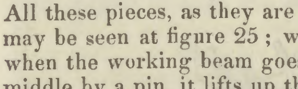
"Between two perpendicular pieces of wood on each side of P, there is a square iron axis, which has upon it four iron pieces subservient to the turning of the regulator, by shooting forward and drawing back the fork fastened to the hand of the regulator; it is marked LNO in fig. 25, and represented separately in fig. 27. There is a slit in the perpendicular working-beam contrived in such manner that its pins work on the fore part, middle, and back part, to raise and depress the levers 5, 4, (fig. 25,) that move the iron axle-tree above-mentioned as far about its centre as is necessary. But the reader will conceive the thing better by a view of the pieces in figs. 26 to 29, and then be enabled fully to understand the same things in fig. 25.

Fig. 26.



"Figure 26 represents the iron axle-tree already mentioned, and marked by the letters A B in figure 25. There is a piece *c e* D E, called the Y, from its representing that letter by its two shanks, only hanging down in an inverted order, with a weight F to be slipped on upon its upper part, where it is made fast, higher or lower, as is convenient, with a key or wedge. This Y being slipped on over the end of the iron axle is made fast by driving in a key after it at *e*: then there is a sort of a stirrup, I K I, with a long pin to be fixed occasionally into the holes on each side of K: this, by its hooks I I, is hung upon the axle at *i i*, then a spanner or handle G 4 is driven on upon the axle from the other end, so as to come and be fast at *g* at right angles to the Y: then a shorter lever or spanner at half right angles to this, (that is, between the long shank of the Y and G 4,) is forced on to *h*, upon the axle, where it is made fast. All these pieces, as they are fixed together on the axle may be seen at figure 25; where you may observe, that when the working beam goes up, by a pulley held in its middle by a pin, it lifts up the spanner H 5, which turns the axle so far as to throw the Y with its weight F from C to 6, in which direction, after passing the perpendicular, it would continue to move towards Q, if it was not stopped by a strap of leather fixed to its top and made fast at the points *m n*, in such manner as to allow the Y to vibrate about a quarter of a circle, in falling forwards and backwards, after it has passed the perpendicular.

Fig. 27.



"Figure 27 represents the horizontal fork L N O to be joined, at its end O, to the spanner or handle of the regulator P Q 10, there being several holes in these pieces, that any part of the end O may be kept in any part of the slit in the spanner, as may be requisite for the better motion of the two pieces. This may be seen in figure 24, where the other end of the fork is fastened to the bottom of the stirrup at K N L, by the long horizontal pin L, so that the fork may continue horizontal, as it is shot forward, and drawn back by the strokes that K and D, the shanks of the Y, make alternately on the fore part or back part of the pin L, in order to push forward, or draw back the spanner P 10, to shut or open the regulator in the manner that shall be further explained. We will only take notice now, that there is an horizontal piece *ul*, so placed, that the end 10 of the spanner may bear upon it, and be supported, as it slides backward and forward.

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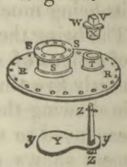
Engi
Beigh
work
gear.

"Before we proceed, it will not be improper to give a full description of the regulator. See fig. 28.

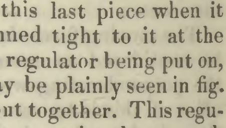
Fig. 28.



"A cock of four inches water-way, big enough to let the steam out of the boiler into the cylinder, would have so much friction, if made tight, as to require a great force to turn it, especially as it must open and shut 32 times in a minute; therefore the regulator has been contrived instead of it. The brass plate R, which you see here at RR in the middle of the top of the boiler, is cast with the pipe S S S of four inches' bore, and worked smooth at its hole under the plate, that it may be closely stopped by another smooth plate *y* Y *y* applied under it, (where the pressure of the steam will hold it the closer when shut.) There is also, in the plate RR, a short pipe or conic hole T, smallest downwards, to receive the piece V W X, which being ground into it can move round without letting air or steam pass by. There is a square shank ZZ, which is put through this last piece when it is let down into its hole, and pinned tight to it at the upper Z. Then the spanner of the regulator being put on, and made fast at V and W, as may be plainly seen in fig. 25, where the whole regulator is put together. This regulator opens very quick, and ten times easier than a cock of the same bore: and to help the whole, the weight F of the Y, when it has passed the perpendicular, falls with a good force, which makes the shank under it give a smart stroke, either within the fork or without, to drive the fork, and draw the handle of the regulator contrary to the way that the weight is falling: the weight causing the regulator to be shut when it tumbles towards it, and be open when it tumbles from it.

"When the regulator is shut, the next thing is to open the injection-cock to make the vacuum, and immediately to shut it when the piston begins to come down, (for the vacuum is made in a second of time.) *n* (fig. 29,) represents the adjutage of the injecting pipe within the cylinder; *a b* part of the pipe coming from the injecting-cistern, *c b* the cock, and *e* the key of the cock, that has a narrow, long, upright hole instead of a round one, that it may be the sooner opened. Upon the top of this key is fastened on a quarter of a wheel with teeth *l*, to be turned by another quarter of a wheel *i* hanging down from the axis *h g*, which is moved by the lever *h k*, commonly called the F. Examine fig. 25, where they are working together, and you may see how the perpendicular beam moves them by its pins.

Fig. 29.



"The present situation of the machine, as now represented by the 24th figure, is as follows. The regulator is open, as appears by its plate TY being removed from under the communication or throat-pipe S, that goes into the cylinder. The piston is now up about the place CW, at top of the cylinder in figure 24; consequently the great beam, and the working perpendicular beam are now almost at their utmost height, and the pulley in the slit of the working beam has so far raised the spanner H 5, that the weight or head of the Y is brought so far from under *n*, as to be past the perpendicular over the axle; and being ready to fall over towards *m*, it will with a smart blow of its shank K, strike the pin L, and drawing the fork O N horizontally towards the working beam, will draw the end 10 of the handle of the regulator toward *l*, and thereby shut it, by slipping the plate Y under the pipe S. The engine in figure 25 is in this very condition; but in figure 24 the blow is already struck, and the communication cut off; as may be known by observing that the weight at the head of the Y is got as far as the strap will let it go.

"The moment after the regulator is shut, the beam not immediately losing its motion upwards, the pin *s* on its outside lifts up the end I of the F, *h k i*, and opens the injection-cock; and the jet immediately making a vacuum, the beam begins to descend, and the pin *r* (which you may put higher or lower) depressing the F, shuts the injection-cock: then the beam continuing to descend, the pulley *p*, pressing on the handle G 4, throws back the Y, whose shank D throws forward the fork, and opens the regulator to let in fresh steam, in the manner already described; which steam is shut off, by shutting the regulator till the cock for injection of cold water is again opened,"

Newcomen, Potter, and Beighton, had thus rendered the atmospheric steam-engine an independent self-acting mechanical power of so great perfection in its principle of action, and its minor details, as to be very generally introduced as a substitute for the power of animals in draining mines and collieries, and to confer very great advantages in those important and primary sources of national industry and wealth. The saving of money resulting from this change was so great as to be continually opening up new avenues of mining enterprise; and, by the rapid progress of that enterprise, the capabilities of the engine were soon put to the severest trial. The cylinders, which had been originally of twelve and sixteen inches diameter, were increased to twenty, thirty, and forty inches, and at last even fifty and sixty inches in diameter. Along with this dimension, the other parts required to be increased in a still higher proportion; and at last the structures became so gigantic as to demand an amount of science and practical skill which in that period of engineering science was rarely to be found. The man suited to the emergency at last arose in the father of civil engineering, the justly celebrated Smeaton, who brought to bear on this subject endowments and accomplishments seldom united; fertile ingenuity, accurate philosophic conceptions, and sound practical sagacity. He conferred upon the atmospheric steam-engine all the extent and variety of application of which it was capable, and all the perfection of proportion and execution which the state of the mechanical arts would permit.

The manner in which Smeaton proceeded to the improvement of the atmospheric engine was one which is worthy of all praise and imitation. Unlike too many of the engineering experiments of the present day, as well as of past times, his were made at his own expense, not at the expense of his employers, and on a scale sufficiently large to ensure sound results, without being on that scale which should entail unwarrantable expense. Having encountered some anomalous results in the earlier parts of his experience with atmospheric engines, he resolved, as he says, "if possible to make himself master of the subject, and immediately began to build a small fire-engine, which could easily be converted into different shapes for experiments." This experimental engine was set to work at Austhorpe in 1769. With it he made a very great number of valuable experiments, so as to ascertain the length and velocity of stroke and return, the quantity and manner of injection, the proportion of load, the dimensions of cylinder, and the materials of construction, which were required to produce the maximum of useful effect from a given amount of fuel. Mr Farey has given us the dimensions of this model, and the results of the experiments of Smeaton as they are here set down. The cylinder was 9.9 inches in diameter, and had a working-stroke of 3 feet. The piston made $17\frac{1}{2}$ strokes per minute passing over 105 feet per minute in going and returning, or over 52.5 effective feet per minute; its load per square inch was 7.89 lbs., its total load 607 lbs. The quantity of coals consumed was 55 lbs. per hour. The work done was equivalent to 31,867 lbs. raised 1 foot high per minute = 0.966 horse power. The work of one bushel or 84 lbs. of coal was equal to 2,919,017 lbs. raised 1 foot high. The weight of water evaporated by 1 lb. of coal was 6.14 lbs., and the quantity of cold water injected was 10.66 the evaporated water.

Smeaton's experimental engine.

When the engine made its stroke the mercury was raised to 23.2 inches.

Mr Smeaton found that this engine produced its maximum effect both as regards quantity and economy when carrying a load of 7.81 lbs. on the inch. When the load was reduced to 6.6 lbs. the power of the engine was lessened in the proportion of 100. to 94. When the load was reduced to 5.5 lbs. the power of the engine was still further lessened in the proportion of 94 to 82. In these two cases the work produced by 1 lb. of coals was reduced in the proportion of 100 to 94, and 94 to 80.

When, on the other hand, the load was increased from 7.8 lbs. to 8.8 lbs. per inch, the work done was only increased from 100 to 107. When the load was still further increased to 9.1 lbs. the work was diminished from 100 to 96. But in both these the economy of fuel was diminished in a higher proportion, the work produced by each lb. of coals being reduced in the proportions 100 to 97, and 97 to 93.

Mr Smeaton also found, from the same engine, the best kinds and modes of burning the fuel. Round coals were found superior to small coal in the proportion of 100 to 80 nearly. Coke produced $\frac{5}{6}$ of the effect of an equal weight of the same coal from which the coke was made, and 66 lbs. of coke were obtained from 100 lbs. of coal. Ash-wood used as fuel was found inferior to common Yorkshire coals in the proportion of 42 to 100. The performance of the kind of Newcastle coals called Team Top, was found superior to the common Yorkshire or Halton coal, in the ratio of 120 to 100. Cannel coal, from Wakefield in Yorkshire, was superior to Halton in the ratio 133 to 100. Middleton-wood coals, and Welsh coals, were superior to Halton, as 110 to 100; and Berwick-moor coals were inferior to Halton, in the ratio 86 to 100.

In consequence of this admirable method of procedure, Mr Smeaton improved the proportions and structure of the atmospheric engine, and very soon produced machines which excelled in their dimensions and efficiency every thing which had preceded them. In 1772 he erected an engine at Long Benton colliery, near Newcastle, which he ever afterwards considered as his standard. The following are its principal dimensions and performance: Diameter of the cylinder, 52 inches—7 feet stroke, 12 strokes per minute, being 84 feet useful motion per minute, and 168 feet total motion per minute. Load of water = 7.1 tons. Load per square inch = $7\frac{1}{2}$ lbs. Consumption of coals, 17.63 lbs. per horse power per hour. Work of one bushel or 84 lbs. of coals = 9.45 millions of lbs. one foot high. The total power of engine was about $40\frac{1}{2}$ horse-power, and for every horse-power the boiler had 52 cubic feet of total space, 27.75

cubic feet of steam room, and 6.25 square feet of horizontal surface of water. The furnace had, for every horse power, 3.5 square feet of fire surface, 7.83 square feet of flue surface, and .867 square foot of fire grate. The total steam produced per minute was about 62.95 feet per horse power; of this 30.58 feet were used in moving the piston, 8.92 feet wasted to fill the extra space in the cylinder, and 23.45 condensed on the surface of the cylinder.

Mr Farey has given an excellent description and investigation of this engine, with two plates taken with his wonted fidelity and beauty, from the original drawings.

Smeaton's Portable Engine.

Mr Smeaton also constructed a portable fire-engine, for the purpose of being used to draw water from temporary excavations, shafts, quarries, &c., so framed as to require no erection of a building, and to be easily removed from place to place. The fire is wholly within the boiler. The framing of the engine is constructed of timber, trussed and arranged in such a manner as to contain within it every kind of strain whatever which the force of the machine and the resistance may produce. The details of this engine are given in his reports, from which we extract the following drawings and descriptions:

Fig. 30.

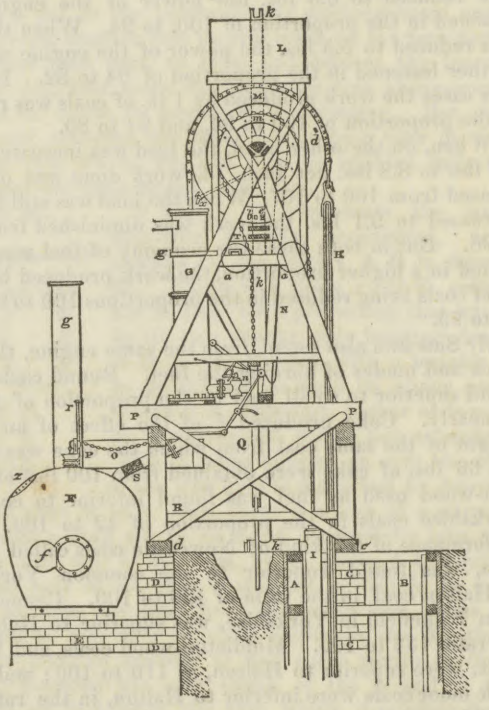
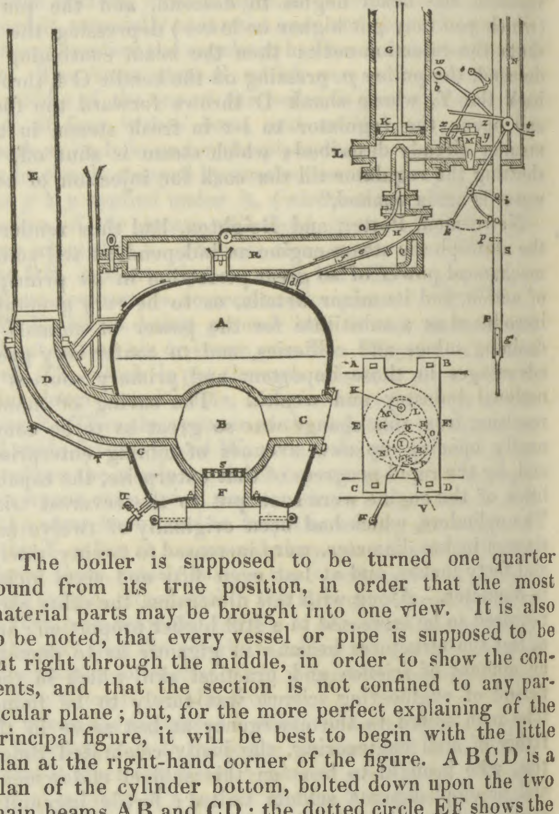


Fig. 30 contains a side view of the engine and boiler. AB is the pit or shaft. CC is the upright of the foundation walls on each side of the pit, for supporting the groundsill *c* across the pit, upon which one side of the engine-frame is raised. DD is the foundation wall for supporting the groundsill *d*, upon which the other side is raised; E the foundation wall for supporting the boiler, and forming the ash-hole. F is the boiler, *f* the fire-door, *g* the chimney, S the steam-pipe, *p* the puppet-clack, *r* the feeding-pipe funnel, *z* the man-hole, G the cylinder, H the main pump spear, I the jackhead-pump, by the continuation whereof, *k k k*, the water, is conveyed into L, the injection-cistern. M is a wheel serving instead of the great beam, *m* a rim of a smaller diameter, attached to the former, for working the jackhead-pump I, and plugframe Q. *a a* are pulleys to bring their chains into a convenient place for working. The wheel is stopped at the end of its intended stroke, which is to be $6\frac{1}{2}$ feet stop and stop, by means of the two iron fids *b b*, which, reaching out on each side of the great rim, stop against two strong iron pins *e e*, which are fixed into a cross beam S, framed into the piece T, and the whole firmly bolted together, as shown in the design. N is the injection-pipe, *n* the injection-cock, and *x* the piston water-cock. O is the hot well. R is a stage for the person to stand upon who hands the engine. PP are the two main beams or sleepers, upon which the cylinder is seated upon its bottom and bolted down. The whole is kept from springing or flying off by an iron strap.

The waste water pipes are omitted to prevent confusion. Fig. 31 shows a section of the boiler, cylinder, and pipes, with the working-gear, to a larger scale, the whole being divested of the framing in order to render every thing more distinct.

Fig. 31.



The boiler is supposed to be turned one quarter round from its true position, in order that the most material parts may be brought into one view. It is also to be noted, that every vessel or pipe is supposed to be cut right through the middle, in order to show the contents, and that the section is not confined to any particular plane; but, for the more perfect explaining of the principal figure, it will be best to begin with the little plan at the right-hand corner of the figure. ABCD is a plan of the cylinder bottom, bolted down upon the two main beams AB and CD; the dotted circle EF shows the extremity of the bottom flanch of the cylinder, and the circle GH, the diameter of the cylinder within; the hole I answers the steam-pipe and regulator, and the hole K the eduction or sinking-pipe, and the circle LM its flanch; the circle NO shows the size and position of the regulator-plate, and the dotted circle PQ the size of the receiver in which the sliding-valve of the regulator R works, and in this position is open; ST is the lever by which it is worked, and when that is brought forward into the position SV, then the valve covers the aperture of the regulator. In the principal figure A is the boiler, and B the fire-place which is of cast iron, and of a spherical form, and placed in the interior of the boiler. The coals are introduced by the large pipe C, and the smoke is conducted by the curved pipe D into the funnel or chimney E. The ashes fall through the grate S and the wide pipe F, into the ash-holes below. The other appendages of the boiler, are a cock for emptying it, marked T, two gauge-cocks for ascertaining the height of the water, the puppet-clack or safety-valve, loaded with a sufficient weight, and having a string attached to it, so that the attendant on the engine can raise it when necessary to allow the steam to escape. The boiler has also a man-hole, which is better seen at Z in fig. 30. The curved smoke-pipe D is surrounded by a copper casing, into which the water for feeding the boiler flows from the hot well, so as to be highly heated before being admitted into the boiler. The other parts of the engine shown in the figure are, G the cylinder, into which the steam from the boiler flows through the pipes *d e* H I, which are jointed at *f* for the readier taking asunder, K the piston, G the piston-rod, H the receiver for the steam, containing the regulator-valve, I the steam-pipe, L the snifting-clack, M the injection-cock, N the injection-pipe, P *p y* the plug-frame, *e m* arms of the tumbler on which the plugs act, *k o* a rod connecting the end of the tumbler with the handle of the regulator, *w b x z* the faller or F lever, with its detent or catch at *o*.

But the most magnificent of Smeaton's works in this department of his profession is his great Chasewater engine, of which the details are given in his Reports. This engine was of 150 horses' power, turning out 880 hogsheads of water per hour, by the heat of 16½ bushels of coal. We have given a cut of this engine, Fig. 32; and we recommend the engineer to consult the original in Smeaton's Reports, as it is full of ingenious contrivance and judicious arrangement. The cylinder A B is 72 inches in diameter, the stroke 10 feet 6 inches. The great beam of the engine, DD, consists of twenty large balks of timber, the four nearest the centre being each a foot square, and the whole firmly joggled together with heart of oak, and bolted with iron, forming a very elegant but ponderous beam. The cylinder beams FF, upon which the cylinder rests, and which are kept in their place by being entered into the side walls of the house, are joggled and framed together in a similar manner to the great lever. G is the boiler, H the furnace, I B the steam-pipe, J the injection-pipe, K the cistern for the injection water, fed by a pump L, which is wrought by the great lever of the engine, M the waste-pipe for the condensed steam, N the spear or pump-rod of the great draining-pump wrought by the engine, P P the plug-tree suspended from the main beam carrying plugs, which in its upward and downward progress act on the levers which open and shut the regulator and injection-cocks. The date of this engine is 1775. The working gear of the engine is very simple and good. It is represented on a larger scale in the accompanying cut, fig. 33.

1775.

Fig 32.

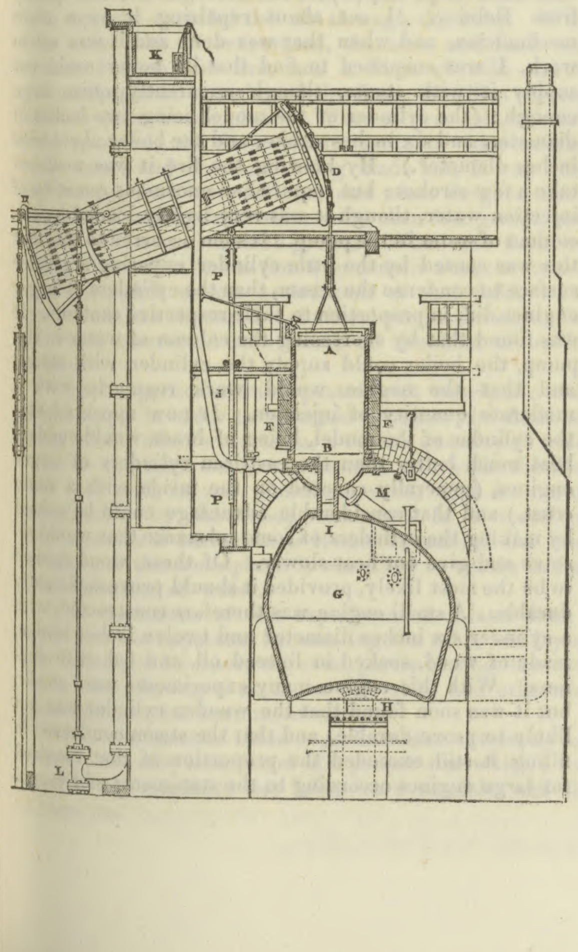
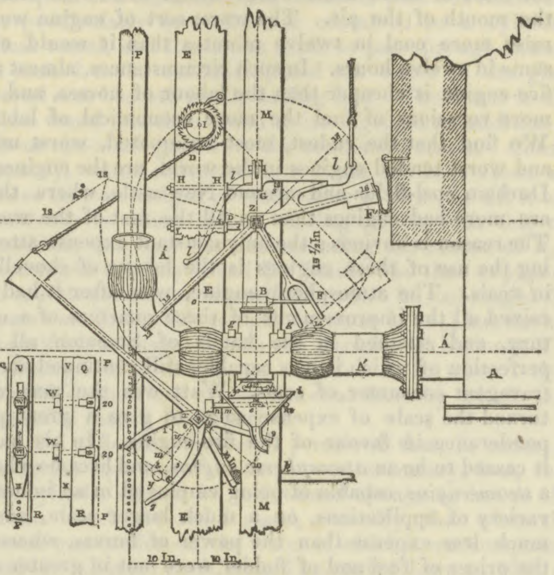


Fig. 33.



A is the lower corner of the cylinder, A′ A′ A′ the injection-pipe, B the injection-cock, B F its handle or spanner passing between the forks of the bent lever E Z F F′, called the F lever, by which the cock is opened and shut. The tail Z 12 of this F lever is, by the downward motion of the plug-tree P, forced from the position shown by the dotted line Z 18, into the position in which it is seen in the drawing, and it is there retained by the catch *l l l*. While the lever is in this position the injection-cock is shut, the steam from the boiler is flowing into the cylinder, and the piston is rising. When the piston has nearly reached the top of its course, an apparatus attached to the plug-frame P, draws up the catch *l l l*, and releases the F lever, which is forced into the position 18 Z, by the bob or weight 16, carried by its end F′, and the consequent movement of its fork F opens the injection-cock; T *x* 11, 9, is the Y lever or tumbler, which acts upon the stirrup-rod *k* attached to the spanner of the regulator, as in Beighton's gear, figs. 25, 27. The range of the tumbler's motion on each side of the perpendicular is regulated by its check-cord T I, which is passed round a roller I, furnished with a paul and ratchet, so that its length may be adjusted. The tumbler is moved by pins in the plug-frame P, acting upon its bent arms *x* 3, *x* 7.

In the left-hand corner at the bottom of the figure is seen a representation of a slider, which may be fixed upon the plug-tree instead of the pins, to work the lever. There is both a side and a front view of the slider. Q R shows a part of the plug-tree, N V the slider, and W 20 W 20 two screws for retaining the slider in its place. By this means the working-stroke may be adjusted much more surely than by the pins or plugs.

The working of the injection-cock by the forked end of the F lever was found to be defective, and Mr Smeaton, in the engines which he afterwards constructed, fixed a toothed sector on the end of the lever, which was made to act upon a toothed wheel, carried by the axis of the injection-cock, somewhat in the manner of the parts of Beighton's gear represented in figs. 25, 29.

Inventions of James Watt.

III. *The Era of Watt.*—Before the time of James Watt, the steam or atmospheric engine was a more costly power than horses, except where fuel was extremely cheap. At the mouth of a coal-pit almost any sort of steam-engine or fire-engine is better than horses, because it consumes the produce, and often the refuse of the pit, and is valuable for the purpose of volatilising the mass of small coals which would otherwise lumber the mouth of the pit. The worst sort of engine would raise more coal in twelve minutes than it would consume in twelve hours. In such circumstances, almost any fire-engine is cheaper than the labour of horses, and the more voracious of fuel the more economical of labour. We find that the rudest, most antiquated, worst made and worst tended engines in the world, are the engines of Durham coal-fields and around Newcastle, where there are more bad engines than in all the rest of the world. The reason is obvious; the only constant expense attending the use of these engines is the labour of shovelling in coals. The atmospheric engine, even after it had received all the improvements of three quarters of a century, and attained in the hands of Smeaton all the perfection of which it was capable, still continued an extravagant consumer of coals. Watt was the man who turned the scale of expense so as to give a great preponderance in favour of the fire-engine. In his hands it ceased to be an *atmospheric engine*, and became wholly a *steam-engine*, capable of being employed in an immense variety of applications, on a much larger scale, and at much less expense than the power of horses, wherever the prices of fuel and of fodder were not in greater disparity than in this country.

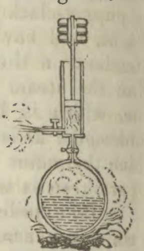
We have seen that hitherto the fire-engine, even in Smeaton's hands, was an engine that wasted a large quantity of fuel and of steam in doing what was useless, namely, heating the cylinder, which was cooled alternately in each stroke by the cold water injected into it. In Long Benton colliery engine, out of sixty-three cubic feet of steam thirty-two feet were thus wasted, and the remaining thirty-one feet alone performed useful work. There remained, therefore, one-half of the power of the steam and expense of the fuel to be saved by future improvements, provided the useless heating and cooling of the cylinder could be superseded. The vacuum formed below the cylinder was also far from being perfect. Watt found the atmospheric fire-engine in the hands of Smeaton, produced from it the pure steam-engine, and left it to us in its present state of high improvement. This portion of the history of the steam-engine has been contributed as a commentary upon the original article of this Encyclopædia by the person of all others best qualified to do it justice, Watt himself. For the purpose of further illustration, we have added some figures, as well as some remarks.

Watt's History of his own Improvements.

1759.

"My attention was first directed in the year 1759 to the subject of steam-engines by the late Dr. Robison, himself then a student in the University of Glasgow, and nearly of my own age. He at that time threw out an idea of applying the power of the steam-engine to the moving of wheel carriages, and to other purposes, but the scheme was not matured, and was soon abandoned on his going abroad.

Fig. 34.



"About the year 1761 or 1762, I tried some experiments on the force of steam, in a Papin's digester, and formed a species of steam-engine by fixing upon it a syringe one-third of an inch in diameter, with a solid piston, and furnished also with a cock to admit the steam from the digester, or shut it off at pleasure, as well as to open a communication from the inside of the syringe to the open air, by which the steam contained in the syringe might escape. When the communication between the digester and syringe was opened, the steam entered the syringe, and by its action upon the piston raised a considerable weight (fifteen lbs.) with which it was loaded. When this was raised as high as was thought proper, the communication with the digester was shut, and that with the atmosphere opened; the steam then made its escape, and the weight descended. The operations were repeated, and though in this experiment the cock was turned by hand, it was easy to see how it could be done by the machine itself, and to make it work with perfect regularity. But I soon relinquished the idea of constructing an engine upon this principle, from being sensible it would be liable to some of the objections against Savary's engine, viz. the danger of bursting the boiler, and the difficulty of making the joints tight, and also that a great part of the power of the steam would be lost, because no vacuum was formed to assist the descent of the piston.

"The attention necessary to the avocations of business prevented me from then prosecuting the subject further; but in the winter of 1763-4, having occasion to repair a model of Newcomen's engine belonging to the Natural Philosophy Class of the University of Glasgow, my mind was again directed to it. At that period, my knowledge was derived principally from Desaguliers, and partly from Belidor. I set about repairing it as a mere mechanician, and when that was done and it was set to work, I was surprised to find that its boiler could not supply it with steam, though apparently quite large enough; (the cylinder of the model being two inches in diameter, and six inches stroke, and the boiler about nine inches diameter.) By blowing the fire it was made to take a few strokes; but required an enormous quantity of injection water, though it was very lightly loaded by the column of water in the pump. It soon occurred to me, that this was caused by the little cylinder exposing a greater surface to condense the steam, than the cylinders of larger engines did, in proportion to their respective contents. It was found that by shortening the column of water in the pump, the boiler could supply the cylinder with steam, and that the engine would work regularly with a moderate quantity of injection. It now appeared that the cylinder of the model, being of brass, would conduct heat much better than the cast-iron cylinders of larger engines, (generally covered on the inside with a stony crust,) and that considerable advantage could be gained by making the cylinders of some substance that would receive and give out heat slowly. Of these, wood seemed to be the most likely, provided it should prove sufficiently durable. A small engine was therefore constructed, with a cylinder six inches diameter and twelve inches stroke, made of wood, soaked in linseed oil, and baked to dryness. With this engine many experiments were made; but it was soon found that the wooden cylinder was not likely to prove durable, and that the steam condensed in filling it still exceeded the proportion of that required for large engines according to the statements of Desagu-

Watt's History of his own Improvements.

liers. It was also found, that all attempts to produce a better exhaustion by throwing in more injection, caused a disproportionate waste of steam. On reflection, the cause of this seemed to be the boiling of water in vacuo at low heats, a discovery lately made by Dr Cullen and some other philosophers, (below 100, as I was then informed,) and consequently, at greater heats, the water in the cylinder would produce a steam which would, in part, resist the pressure of the atmosphere.

"By experiments which I then tried upon the heats at which water boils under several pressures greater than that of the atmosphere, it appeared that when the heats proceeded in an arithmetical, the elasticities proceeded in some geometrical ratio; and by laying down a curve from my data, I ascertained the particular one near enough for my purpose. It also appeared that any approach to a vacuum could only be obtained by throwing in large quantities of injection, which would cool the cylinder so much as to require quantities of steam to heat it again, out of proportion to the power gained by the more perfect vacuum; and that the old engineers had acted wisely in contenting themselves with loading the engine with only six or seven pounds on each square inch of the area of the piston. It being evident that there was a great error in Dr Desaguliers' calculations of Mr Beighton's experiments on the bulk of steam, a Florence flask, capable of containing about a pound of water, had about one ounce of distilled water put into it; a glass tube was fitted into its mouth, and the joining made tight by lapping that part of the tube with packthread covered with glaziers' putty. When the flask was set upright, the tube reached down near to the surface of the water, and in that position the whole was placed in a tin reflecting oven before a fire, until the water was wholly evaporated, which happened in about an hour, and might have been done sooner, had I not wished the heat not much to exceed that of boiling water. As the air in the flask was heavier than the steam, the latter ascended to the top, and expelled the air through the tube. When the water was all evaporated, the oven and flask were removed from the fire, and a blast of cold air was directed against one side of the flask, to collect the condensed steam in one place. When all was cold, the tube was removed, the flask and its contents were weighed with care; and the flask being made hot, it was dried by blowing into it by bellows, and when weighed again, was found to have lost rather more than four grains, estimated at four and a third grains. When the flask was filled with water, it was found to contain about seventeen and one-eighth ounces avoirdupois of that fluid, which gave about one thousand eight hundred for the expansion of water converted into steam of the heat of boiling water.

"This experiment was repeated with nearly the same result; and in order to ascertain whether the flask had been wholly filled with steam, a similar quantity of water was, for the third time, evaporated; and, while the flask was still cold, it was placed inverted, with its mouth (contracted by the tube) immersed in a vessel of water, which it sucked in as it cooled, until in the temperature of the atmosphere it was filled to within half an ounce measure of water.

"In repetitions of this experiment at a later date, I simplified the apparatus by omitting the tube, and laying the flask upon its side in the oven, partly closing its mouth by a cork, having a notch on one side, and otherwise proceeding as has been mentioned.

"I do not consider these experiments as extremely accurate; the only scale-beam of a proper size which I had then at my command not being very sensible, and the bulk of the steam being liable to be influenced by the heat to which it was exposed, which, in the way described, is not easily regulated or ascertained; but, from my experience in actual practice, I esteem the expansion to be rather more than I have computed.

"A boiler was constructed, which showed by inspection the quantity of water evaporated in any given time, and thereby ascertained the quantity of steam used in every stroke by the engine, which I found to be several times the full of the cylinder. Astonished at the quantity of water required for the injection, and the great heat it had acquired from the small quantity of water in the form of steam which had been used in filling the cylinder, and thinking I had made some mistake, the following experiment was tried:—A glass tube was bent at right angles, one end was inserted horizontally into the spout of a tea-kettle, and the other part was immersed perpendicularly in well water contained in a cylindric glass vessel, and steam was made to pass through it until it ceased to be condensed, and the water in the glass vessel was become nearly boiling hot. The water in the glass vessel was then found to have gained an addition of about one-sixth part from the condensed steam. Consequently, water converted into steam can heat about six times its own weight of well-water to 212°, or till it can condense no more steam. Being struck with this remarkable fact, and not understanding the reason of it, I mentioned it to my friend Dr Black, who then explained to me his doctrine of latent heat, which he had taught for some time before this period, (summer 1764;) but having myself been occupied with the pursuits of business, if I had heard of it, I had not attended to it, when I thus stumbled upon one of the material facts by which that beautiful theory is supported.

"On reflecting further, I perceived that, in order to make the best use of steam, it was necessary, first, that the cylinder should be maintained always as hot as the steam which entered it; and, secondly, that when the steam was condensed, the water of which it was composed, and the injection itself, should be cooled down to 100°, or lower, where that was possible. The means of accomplishing these points did not immediately present themselves; but *early in 1765 it occurred to me, that if a communication were opened between a cylinder containing steam, and another vessel which was exhausted of air and other fluids, the steam, as an elastic fluid, would immediately rush into the empty vessel, and continue so to do until it had established an equilibrium*; and if that vessel were kept very cool by an injection, or otherwise, more steam would continue to enter, until the whole was condensed. But both the vessels being exhausted, or nearly so, how was the injection-water, the air which would enter with it, and the condensed steam, to be got out? This I proposed, in my own mind, to perform in two ways. One was by adapting to the second vessel a pipe reaching downwards more than thirty-four feet, by which the water would descend, (a column of that length overbalancing the atmosphere,) and by *extracting the air by means of a pump.*

"The second method was *by employing a pump, or pumps, to extract both the air and the water,* which would be applicable in all places, and essential in those cases where there was no well or pit.

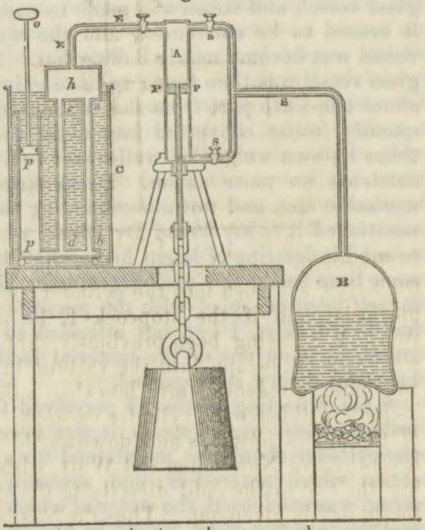
"This latter method was the one I then preferred, and is the only one I afterwards continued to use.

"In Newcomen's engine, the piston is kept tight by water, which could not be applicable in this new method, as, if any of it entered into a partially exhausted and hot cylinder, it would boil and prevent the production of a vacuum, and would also cool the cylinder by its evapora-

Watt's History of his own Improvements.

tion during the descent of the piston. I proposed to remedy this defect by *employing wax, tallow, or other grease, to lubricate and keep the piston tight.* It next occurred to me that the mouth of the cylinder being open, the air which entered to act on the piston would cool the cylinder, and condense some steam on again filling it; I therefore proposed *to put an air-tight cover upon the cylinder, with a hole and stuffing-box for the piston-rod to slide through,* and to admit steam above the piston to act upon it instead of the atmosphere. There still remained another source of the destruction of steam, the cooling of the cylinder by the external air, which would produce an internal condensation whenever steam entered it, and which would be repeated every stroke; this I proposed to remedy by *an external cylinder containing steam, surrounded by another of wood, or of some other substance which would conduct heat slowly.*

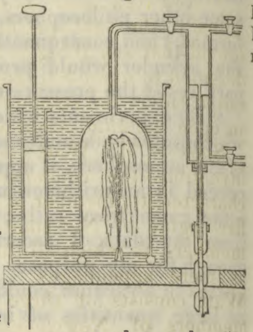
Fig. 35.



"When once the idea of the *separate condensation* was started, all these improvements followed as corollaries in quick succession, so that in the course of one or two days, the invention was thus far complete in my mind, and I immediately set about an experiment to verify it practically. I took a large brass syringe A, one and three-fourth inches diameter, and ten inches long, made a cover and bottom to it of tin-plate, with a pipe S to convey steam to both ends of the cylinder from the boiler; another pipe E to convey steam from the upper end to the condenser (for, to save apparatus, I inverted the cylinder.) I drilled a hole longitudinally through the axis of the stem of P the piston, and fixed a valve at its lower end, to permit the water which was produced by the condensed steam, on first filling the cylinder, to issue. The condenser used upon this occasion consisted of two pipes *a b*, *c d* of thin tin-plate, ten or twelve inches long, and about one-sixth inch diameter, standing perpendicular, and communicating at top with a short horizontal pipe *h* of large diameter, having an aperture on its upper side which was shut by a valve opening upwards. These pipes were joined at bottom to another perpendicular pipe *p* of about an inch diameter, which served for the air and water pump; and both the condensing pipes and the air-pump were placed in a small cistern C filled with cold water.

"The steam-pipe was adjusted to a small boiler B. When steam was produced, it was admitted into the cylinder, and soon issued through the perforation of the rod, and at the valve of the condenser. When it was judged that the air was expelled, the steam-cock was shut, and the air-pump piston-rod was drawn up, which leaving the small pipes of the condenser in a state of vacuum, the steam entered them and was condensed. The piston of the cylinder immediately rose and lifted a weight of about eighteen pounds, which was hung to the lower end of the piston-rod. The exhaustion-cock was shut, the steam was re-admitted into the cylinder, and the operation was repeated; the quantity of steam consumed, and the weights it could raise were observed; and, excepting the non-application of the steam-case and external covering, the invention was complete, in so far as regarded the savings of steam and fuel. A large model, with an outer cylinder and wooden case, was immediately constructed, and the experiments made with it served to verify the expectations I had formed, and to place the advantage of the invention beyond the reach of doubt. It was found convenient afterwards to change the pipe-condenser for an empty vessel, generally of a cylindrical form, into which an injection played, as in fig. 36, and in consequence of there being more water and air to extract, to enlarge the air-pump.

Fig. 36.



"The change was made, because, in order to procure a surface sufficiently extensive to condense the steam of a large engine, the pipe-condenser would require to be very voluminous, and because the bad water with which engines are frequently supplied, would crust over the thin plates, and prevent their conveying the heat sufficiently quick. The cylinders were also placed with their mouths upwards, and furnished with a working-beam, and other apparatus, as was usual in the ancient engines; the inversion of the cylinder or rather of the piston-rod, in the model, being only an expedient to try more easily the new invention, and being subject to many objections in large engines.

"In 1768 I applied for letters patent for my 'Methods of Lessening the consumption of Steam, and consequently of Fuel, in Fire-Engines,' which passed the Seals in January 1769; and my specification was enrolled in Chancery in April following, and was as follows:—

"My method of lessening the consumption of steam, and consequently fuel, in fire-engines, consists of the following principles:—

"First, That vessel in which the powers of steam are to be employed to work the engine, which is called the cylinder in common fire-engines, and which I call the steam-vessel, must, during the whole time the engine is at work, be kept as hot as the steam that enters it; first, by enclosing it in a case of wood, or any other materials that transmit heat slowly; secondly, by surrounding it with steam or other heated bodies; and, thirdly, by suffering neither water or any other substance colder than the steam, to enter or touch it during that time.

"Secondly, In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam-vessels or cylinders, although occasionally communicating with them; these vessels I call condensers; and, whilst the engines are working, these condensers ought at least to be kept as cold as the air in the neighbourhood of the engines, by application of water, or other cold bodies.

"Thirdly, Whatever air or other elastic vapour is not condensed by the cold of the condenser, and may impede the working of the engine, is to be drawn out of the steam-vessels or condensers by means of pumps, wrought by the engines themselves, or otherwise.

"Fourthly, I intend, in many cases, to employ the expansive force of steam to press on the pistons, or whatever may be used instead of them, in the same manner as the pressure of the atmosphere is now employed in common fire-engines. In cases where cold water cannot be had in plenty, the engines may be wrought by this force of steam only, by discharging the steam into the open air after it has done its office.

"Lastly, Instead of using water to render the piston or other parts of the engines air and steam tight, I employ oils, wax, resinous bodies, fat of animals, quicksilver, and other metals, in their fluid state.

"And the said James Watt, by a memorandum added to the said specification, declared, that he did not intend that any thing in the fourth article should be understood to extend to any engine where the water to be raised enters the steam-vessel itself, or any vessel having an open communication with it."

Such is Mr Watt's simple account of his beautiful invention—the condenser or refrigerator, which is the characteristic member of the modern steam-engine. The fire-engine of Newcomen possessed only two principal members, to which all the other parts may be considered as mere appendages. The modern steam-engine of Watt consists of three principal members. The two members of Newcomen's engine are the generating apparatus, by which the steam is produced from the water and conveyed to the second member, or the apparatus of application, where the elastic force of the steam is brought in contact with the piston in the cylinder, so as to produce the motion required for the mechanical effect of the machine, and thus directly applied to the work to be done. The third member, added by Watt, is a refrigerator or condensing apparatus, perfectly separate from and independent of the other two, for reconverting the steam, after it has done its duty in filling the cylinder, into the liquid from which it had been originally formed. We have, then, the boiler or generator with its appendages, the cylinder or applicator with its appendages, and the refrigerator or condenser with its appendages,—the function to be discharged by the first of these being altogether the reverse of the last; the first producing steam by heat from water, the last producing water from steam by cooling.

The progress of improvement in the steam-engine may be very well illustrated by comparison with an early project of Dr Papin, who, although he contributed no part towards the production of the modern steam-engine, nevertheless exercised his ingenuity curiously, though fruitlessly, upon the project of deriving mechanical power from the motion of a piston in a cylinder, first of all by gunpowder, and afterwards by steam. In Papin's project, fig. 37, he takes a cylinder, A B C D, containing a piston P, below which he places a fire, so as to generate steam from a little water in the bottom of the cylinder. This steam raises the piston, and it is evident that on the fire being removed, steam will be condensed, and the piston will again be carried to the bottom. Comparing this rude project, in which the steam is alternately produced and recondensed in the cylinder itself, which is alternately warmed and chilled, with the engine of Newcomen, fig. 38, we observe the following important change. The calefaction of the water and generation of steam are carried on in a boiler, W now removed to a considerable distance from and totally unconnected with the cylinder, except by a pipe of communication opened and shut alternately. Still, however, we have the process of cooling and condensation wholly carried on in the cylinder itself, by means of a jet of cold water playing therein. But let us now make a third step, and we arrive at the model of a machine acting on the principle of Mr Watt's, fig. 39. As we have already, in the machine of Newcomen, a separate heating apparatus, W, conducting the steam in a highly rarefied state to the cylinder, so now let us have a vessel, C. placed on the other side, and let this vessel have first been rendered empty or perfectly vacuous by expelling and pumping out the air; and let us also, for the sake of experiment, put a few lumps of ice and salt in the inside and on the outside of this vessel, surrounding it on every side; and we shall have a refrigerator as a counterpart to the boiler, and a type of the improvement of Watt.

Fig. 37.

Papin's Apparatus

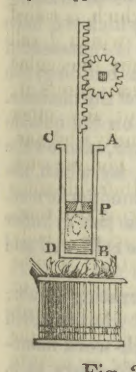


Fig. 38.

Newcomen's Apparatus.

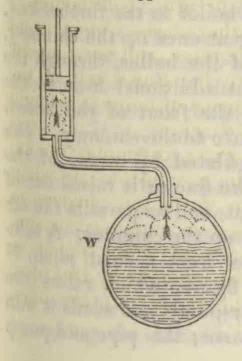
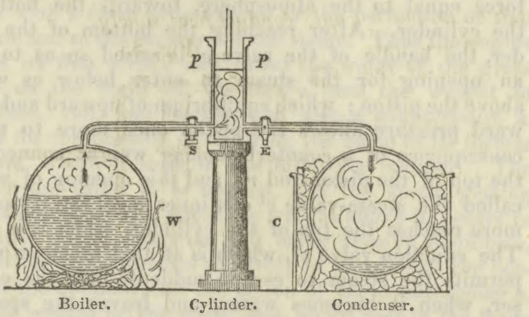


Fig. 39.



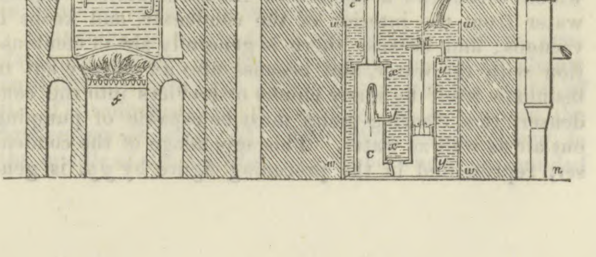
Boiler. Cylinder. Condenser.

If we now open the stopcock S, the steam generated in the boiler will rush into the cylinder, pressing the piston upwards; and if the stopcock E be next opened, the stopcock S having been previously shut, the steam in E will instantly escape into the vacuum in the refrigerator, and being condensed into less than a thousandth part of its bulk, will leave the cylinder vacuous. Thus the motion of the piston upwards and downwards is effected by the inventions of Newcomen and Watt, without either applying the fire or the cold directly to the cylinder in which the power is given out. Thus the loss of more than fifty per cent is remedied by the separate condenser of Watt. Papin's scheme was possible but not practicable; Newcomen's was practicable but wasteful. Watt's engine is practical, economical, and complete, both in theory and in practice, as it renders available all the power of heat which the steam contains, with the exception only of the very small part consumed in giving motion to the machine itself.

Details of Watt's Improved Steam Engine.

The following figure (40) approaches very closely to the form of Mr Watt's first engines. Their details are as follows. In the diagram, A represents the cylinder of his earlier engine, B the boiler, and C the condenser, each with its various appendages. The appendages of the boiler B, are of course, *f*, the furnace in which the

Fig. 40.



Details of Watt's improved Steam Engine.

fuel is burned; *g g*, small pipes for showing the height of the water in the boiler; *h*, a pipe for supplying the boiler with water as its contents pass off in the form of steam; *s s*, a steam-pipe for the purpose of conveying the steam to the top of the cylinder. The appendages of the cylinder are, *p* the piston, fitting accurately the inside of the cylinder, surrounded with hemp packing, soaked with tallow and oil, so as to be steam-tight; the casing, *c c c c*, which excludes the cold air of the atmosphere from entering into the cylinder to cool it down at the expense of afterwards heating it by the steam; and, instead of allowing it to enter at the top of the cylinder at A, and press down the piston, as in Newcomen's engine, the hot steam is substituted, which, being of an elasticity equal to the atmosphere, presses it, with a force equal to the atmosphere, towards the bottom of the cylinder. After reaching the bottom of the cylinder, the handle of the valve v^1 is raised so as to make an opening for the steam to enter below as well as above the piston; which equilibrium of upward and downward pressure allows the piston once more to rise, in consequence of a counterbalancing weight connected to the top of the piston-rod *r*; and this opening of what is called the steam-valve v^1 continues until the piston once more reaches the top of the cylinder, when it is closed. The eduction valve v^2, which is at that moment opened, permits the steam to escape suddenly into the condenser, when it becomes water, and leaves the space below the cylinder vacuous, so as to give free space for the piston to be carried down into the cylinder by the pressure of the steam resting always on the top of the piston. These, the casing, piston, piston-rod, steam-valve, eduction-valve, and communicating passages, are appendages of the second great member of the machine, the cylinder, by which the power of the steam is applied to give the required motion to whatever solid machinery may be placed in connexion with the piston-rod. The appendages of the condenser C of Mr Watt are as follows. First of all, a large cistern, *w w w w*, of cold water is provided, and furnished continually with fresh supplies of cold water either from a running stream or by means of a pump *m n*, wrought by the engine itself. In this is placed the condensing chamber C *x x*, wholly surrounded by the cold water, but perfectly empty, excepting that a small jet of cold water from the exterior is admitted through a regulated aperture to play in the inside, by which injection it has always been observed that the condensation of the steam is more efficient than when a casing of metal intervenes between the cold water and the steam. The eduction-pipe *e e e*, conducts the steam out of the cylinder by the valve v^2 into the condenser *x x*, where it is reduced back into the water from which it had been originally generated. Now, it must be obvious on a little consideration, that the water which is injected into the condenser must rapidly accumulate there, becoming at the same time warmed by contact with the steam, so as to impede the process of condensation, and ultimately filling up the interior of the condensing chamber, which should be kept vacuous; and further, that the steam itself, becoming reconverted into water, would in a short period of time accumulate in the condenser and choke it up. Hence a principal and essential appendage of the condenser is a large pump called the condenser-pump, which is essential to its long-continued efficient action, and which withdraws a portion of the accumulated warmed water from the interior of the condenser, and keeps it vacuous; and because there is generally air in combination with the water, and because also air is very apt to insinuate itself by many chinks or crevices into the condenser, this clearing-pump must be capable of pumping out air as well as water. This appendage of the condenser, represented in the preceding figure by *y y*, is generally termed the "air-pump;" a name which imperfectly expresses the functions of the said condenser-pump.

Fire being placed under the boiler, its heat, communicated to the water, rapidly expands that water, and rarefies it into steam, by the addition of six times more than its usual supply of heat. This combination of heat and water, forming the steam, rushes along the steam-pipe into the cylinder casing, and is admitted into the interior of the machine, filling all its chambers and pipes with steam; but that portion of the steam which is in communication with the condenser being instantly chilled by the jet of cold water and the cold sides of the vessels in the cold well, is condensed, and then the valve v^2 being closed so as to admit no more steam into the condenser, and the valve v^1 closed so as to admit no more steam into the lower part of the cylinder below the piston, there remains the elastic force of the steam above, pressing it towards the bottom of the cylinder with a force proportioned to the pressure of the steam and the extent of the cylinder. Thus a moving power is generated in the cylinder by the steam, which may be conveyed through the piston-rod *r*, and applied through various mechanism of application to the performance of the required work. The steam which has thus pressed down the piston is now admitted below to neutralize the force of that which remains; and having thus done its duty, is once more annihilated by the opening of the communication into the condenser, into which it rushes, and being almost instantly deprived of the caloric which gave it power and magnitude, there remains nothing except the few spoonfuls of water from which all that volume of steam had arisen, now lying inert at the bottom of the cylinder. This dead water is not yet cold. It is evident that in the primary generation of steam in the boiler, the supply of water must be rapidly diminished by this boiling off, and that this water must somehow be supplied. Now here lies an improvement: this waste, instead of being supplied by cold water, may be better replenished with the water of the condenser, which is highly heated in condensing the steam from the cylinder.

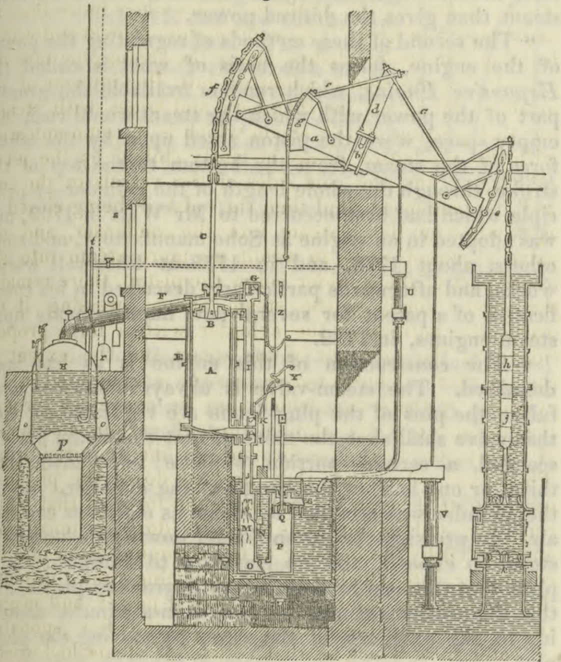
Mr Watt's Engine was first used as a substitute for the engine of Newcomen in pumping up water or draining mines: in 1788 it had attained the form which we have given in the following figure. The engine is represented in fig 41 as contained within the walls of a building, the anterior portion of which is removed to show the machine. The boiler stands on the left of the figure, on the outside of the building; and on the right of the figure, also on the outside of the house, are the large pumps, by which the water is raised, and the work of the engine performed. Nearly in the centre of the building stands the cylinder with its appendages, and below these are the cold well and condensing apparatus.

Beginning with the apparatus for generating steam; on the left of the figure, H is the boiler, of what is called the waggon shape, set in a furnace of brick-work immediately over the fire, which rests on the fire-bars at *p*, leaving a very deep ash-pit below; the flame passes away under the concave bottom of the boiler to the further end, and there, instead of proceeding at once up the chimney, returns by *o* on the left side of the boiler, through the brick channel or flue, giving out additional heat to the water, and after passing across the front of the boiler, proceeds along the right-hand flue *o* to the chimney. The draught of the chimney is regulated by means of the damper *r*, which descends into the flue or is raised out of it in any degree by the attendant, and so permits the air to rush with greater or less ease up the chimney. A tube *t*, regulated by a stopcock, comes from a small pump U on the right-hand side of the figure, which raises the warm water discharged by the air-pump, and sends it into the boiler so as to replenish its waste; this pipe and pump

Mr Watt's Pumping-Engine of 1768.

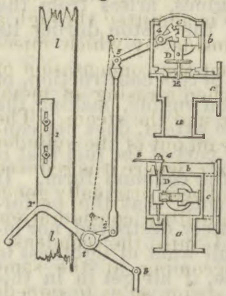
being generally named the feed-pipe and tube. The two little tubes proceeding from the water in the boiler, are slender pipes open at both ends, and have external stopcocks, which are always shut except when the attendant wishes to ascertain the height of the water in the boiler, when he opens these gauge-cocks and observing whether water or steam issues from them, forms his judgment accordingly. F is the steam-pipe, which carries the steam away from the boiler to be applied to its useful effect in the second great member of the engine.

Fig. 41.



The second great member of the machine is placed in the engine-house. A is the working cylinder, in which is contained the moving piston B, which communicates the force impressed on it by the steam, through the piston-rod *c*, and the chain *f*, to the end of the great lever or working-beam, *f a e*, which is forced up and down around the fixed centre or iron gudgeon *b*, and so raises or depresses the other end of the lever on the right-hand side of the figure, and thus gives the required motion to *h, j*, the piston and rods in the barrel of the great pump, in which the work of raising water to a height or from a mine is the useful labour or duty to be performed by the engine. Returning to the cylinder at A, we have now to examine the mechanism by means of which the steam is admitted alternately above and below the piston, through the openings or ports which may be observed on the right-hand side of the cylinder at top and bottom. F is the steam-pipe which brings steam from the boiler to the top of the valve passages, and the pipe I conducts it down to the bottom valves and port at K, and the pipe J forming the eduction-pipe, conducts the steam into the refrigerating apparatus, where it is finally condensed. In commencing to work the machine, the duty of the attendant is to allow the steam to pass freely into all the pipes, passages, and ports, F G I J, &c. filling the cylinder A, the condenser M, and passing out at an aperture O, closed by a valve called the blow-off valve; by means of which operation, the whole of the parts being filled with steam, are rendered vacuous from air, and this preparatory process is called blowing through. At G it is to be observed that there is a steam-nozzle and valve or regulator, which allows the steam to enter the cylinder at the upper part whenever it is opened, by raising the metallic cover or valve from the opening of the nozzle immediately below, which it exactly fits. At K is a similar nozzle and valve called the equilibrium-valve and nozzle, which admits steam through the pipe I into the bottom part of the cylinder; and the third or exhaustion-valve and nozzle or aperture, allows the final egress of the steam into the condenser. After the engine has been wholly filled with steam, the piston B, being at the top of the cylinder, the injection-cock N is suddenly opened, and the cold *jet d'eau* playing amongst the steam condenses it instantaneously, forming a vacuum into which the steam from the cylinder instantly rushes, and is in like manner annihilated, leaving the cylinder below the piston equally vacuous; and of course the steam from the boiler, on being admitted by the valve G to the upper side of the piston, instantly presses it down into the vacuum below with a force proportional to the perfection of that vacuum and to the pressure of the steam. Thus the engine makes its first stroke and raises the water of the great pump on the right of the figure, and the weight of the chain, rod, and bucket, and also a counterpoise *h*, added for the purpose of restoring the beam to its former position, which it does in the following manner. The equilibrium-valve K is opened, and the steam getting admission below the piston, as well as above it, ceases to urge it in either direction, and being thus in equilibrio, the piston would remain passively in its place at the bottom of the cylinder, but the action of the counterpoise *h*, and the weight of the water and pump-rods in the large pump on the outside, draw down the outer end of the great lever or working-beam *f a e*, and so raise the interior end *f*, and the piston B to the top of the cylinder. The equilibrium-valve is then closed at K, and the eduction-valve L is opened, so as to allow the steam below the piston to rush down into the condenser and leave a vacuum under the piston, into which it is immediately forced down by the pressure of the steam above A as at first, and raising water at the other end of the beam through a second stroke; and, thus by the continual opening and shutting of the valves by the attendant, the engine performs its work. But we have still to consider the mechanism by which the valves are shut and opened, and the machine is made to shut and open its own valves. For this purpose we have given a separate and enlarged drawing of one of the valves and its working gear:—*l i l* is a part of the air-pump rod, formed of wood, called the plug-frame or plug-tree, on which are two projecting plugs of wood to work the upper and lower valves; one of these plugs is seen at *i*. As the plug-tree moves up and down, the plugs strike the handles or working gear of the valves, and open or shut them at the proper instant. The valves D E are called conical valves, because the small cover D which closes the opening of each nozzle under the valve is slightly tapered downwards so as the more readily to fit its seat, and each is lifted from its seat by a small toothed rack and pinion *c* moved by a spindle from without, communicating by rods with the valve gear at *r*, or at Z and Y in figure 41. When the plug-frame *l i l* descends, the valve *d* is closed by the plug *i*, and the valve K is shut, and the valve L in figure 41 opened by the plug Y.

Fig. 42.



Returning to figure 41, it will be seen that the condensing apparatus and its appendages are placed almost immediately under the cylinder, and to the right of it. The eduction-pipe J conducts the steam into the condensing chamber M. This chamber is placed in the middle of the cold well, so as to be wholly surrounded

Description of Mr Watt's Engine of 1788.

by cold water; and through the regulated aperture N a jet of cold water is allowed to play in the inside of it amongst the steam. P the air-pump is also placed in the cold well surrounded by water; Q the piston or bucket of the air-pump is worked up and down by the piston-rod Q Y Z *g* from the great lever. The valve R closes when the piston descends, and opens on its ascent, allowing water and air to pass into the air-pump, but preventing its return; and the upper valve of the air-pump S allows the escape of water and air outwards, but prevents its return; this valve S leads to the hot well T, from which the feed-pump U draws off a supply of water for the boiler.

Robison's Description of Watt's Engine.

" The great advantage of Mr Watt's form is the almost total annihilation of the waste of steam by condensation in the cylinder. The cylinder is always hot, and therefore perfectly dry. This must be evident to any person who understands the subject. By the time that Mr Watt had completed these improvements, his experiments on the production of steam had given him a pretty accurate knowledge of its density: and he found himself authorized to say, that the quantity of steam employed did not much exceed what would fill the cylinder, so that very little was unavoidably wasted. But before he could bring the engine to this degree of perfection, he had many difficulties to overcome. He inclosed the cylinder in another containing steam, and that in a wooden case at a small distance from it, which effectually prevents all condensation in the inner cylinder from external influence; and the condensation by the outer cylinder itself, which was very small, had no other bad consequence than the loss of so much steam as formed the condensed water.

" The greatest difficulty was to make the great piston tight. The old and effectual method, by water lying on it, was inadmissible. He was therefore obliged to have his cylinders most nicely bored, perfectly cylindrical, and finely polished; and he made numberless trials of different soft substances for packing his piston, which should be tight without enormous friction, and which should long remain so, in a situation perfectly dry and very hot.

" After all that Mr Watt has done in this respect, he thinks that the greatest part of the waste of steam which he still perceives in his engines, arises from the unavoidable escape by the sides of the piston during its descent.

" But the fact is, that an engine of this construction, of the same dimensions with a common engine, making the same number of strokes of the same extent, does not consume above one-fourth *or one-third* part of the fuel that is consumed by the best engines of the common form. It is also a very fortunate circumstance, that the performance of the engine is not immediately destroyed, nor indeed sensibly diminished, by a small want of tightness in the piston. In the common engine, if air get in in this way, it immediately puts a stop to the work; but although even a considerable quantity of steam get past the piston during its descent, the rapidity of condensation is such, that hardly any diminution of pressure can be observed.

" When Newcomen's engines are working under loads inferior to their whole power, they are regulated to prevent shocks which would be prejudicial, by lessening the quantity of injection, or by shutting the injection-cock sooner. These new engines may, in some degree, be regulated in the same manner; but it is done more effectually and economically, first, by limiting the opening of the regulating-valve which admits the steam above the piston, and letting it continue so far open during the whole length of the stroke; secondly, by letting it open fully at first, and shutting it completely when the piston has proceeded downwards only part of its stroke; or, lastly, by the use of a throttle-valve, which, acting in the same manner as the floodgate of a mill, admits no more steam than gives the desired power.

" The second of these methods of regulating the power of the engine, forms the basis of what is called the *Expansive Engine*, which renders available the greater part of the power with which the steam would rush into empty space, were the piston acted upon by the whole force of the steam, from the bottom to the top of the stroke, through the whole length of the cylinder—a principle which had first occurred to Mr Watt in 1769, and was adopted in an engine at Soho manufactory, and some others, about 1776, and in 1778 at Shadwell water-works, and afterwards particularly described in his specification of a patent for several new improvements upon steam-engines, in 1782.

" The construction of this engine is as has been described. The steam-valve is always allowed to open fully; the pins of the plug-frame are regulated so, that that valve shall shut the moment that the piston has descended a certain portion, suppose one-fourth, one-third, or one-half, of the length of the cylinder. So far the cylinder was occupied by steam as elastic as common air. In pressing the piston farther down, it behoved the steam to expand, and its elasticity to diminish. It is plain that this can be done in any degree we please, and that the adjustment can be varied in a minute, according to the exigency of the case, by moving the plug-pins.

" In the mean time, it must be observed, that the pressure on the piston is continually changing, and consequently the accelerating force: The motion, therefore, will no longer be uniformly accelerated. It will approach much faster to uniformity; nay, it may be retarded, because although the pressure on the piston at the beginning of the stroke may exceed the resistance of the load, yet when the piston is near the bottom, the resistance may exceed the pressure. Whatever may be the law by which the pressure on the piston varies, an ingenious mechanic may contrive the connecting machinery in such a way that the chains or rods at the outer end of the beam shall continually exert the same pressure, or shall vary their pressure according to any law he finds most convenient. It is in this manner that the watchmaker, by the form of the fuzee, produces an equal pressure on the wheel-work by means of a very unequal action of the main-spring. In like manner, by making the outer arch-heads portions of a proper spiral instead of a circle, we can regulate the force of the beam at pleasure.

" Thus we see how much more manageable an engine is in this form than Newcomen's was, and also more easily investigated in respect of its power in its various positions. The knowledge of this last circumstance was of mighty consequence, and without it no notion could be formed of what it could perform, which may be called a discovery of great importance in the theory of the engine. We shall give here Mr. Watt's theory of the expansive engine which we have just described.

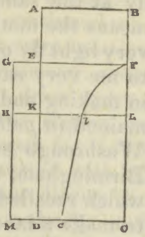
" Let ABCD (Fig. 43.) represent a section of the cylinder of a steam-engine, and EF the surface of its piston. Let us suppose that the steam was admitted while EF was in contact with AB, and that as soon as it had pressed it down to the situation EF, the steam-cock is shut. The steam will continue to press it down, and as the steam expands, its pressure diminishes. We may express its pressure (exerted all the while the piston moves from the situation AB to the situation EF) by the line EF. If we suppose the elasticity of the steam

Steam-Engine.

Mr Watt's Expansive Engine.

proportional to its density, as is nearly the case with air, we may express the pressure on the piston in any other position, such as KL or DC, by K *l* and D *c*, the ordinates of a rectangular hyperbola F *l c*, of which AE AB are the asymptotes, and A the centre. The accumulated pressure during the motion of the piston from EF to DC, will be expressed by the area EF *c* DE, and the pressure during the whole motion by the area ABF *c* DA.

Fig. 43.



"Now it is well known that the area EF *c* DE is equal to ABFE multiplied by the hyperbolic logarithm of $\frac{AD}{AE}$, $= L.\frac{AD}{AE}$, and the whole area ABF *c* DA is $= ABFE \times \left(1+L.\frac{AD}{AE}\right)$.

"Thus let the diameter of the piston be 24 inches, and the pressure of the atmosphere on a square inch be 14 pounds; the pressure on the piston is 6333 pounds. Let the whole stroke be 6 feet, and let the steam be stopped when the piston has descended 18 inches, or 1.5 feet. The hyperbolic logarithm of $\frac{6}{1.5}$ is 1.3862943. Therefore the accumulated pressure ABF *c* DA is $= 6333 \times 2.3862943, = 15112$ pounds.

"As few professional engineers are possessed of a table of hyperbolic logarithms, while tables of common logarithms are, or should be, in the hands of every person who is much engaged in mechanical calculations, let the following method be practised. Take the common logarithm of $\frac{AD}{AE}$, and multiply it by 2.3026; the product is the hyperbolic logarithm of $\frac{AD}{AE}$.

"The accumulated pressure while the piston moves from AB to EF is 6333×1, or simply 6333 pounds. Therefore the steam while it expands into the whole cylinder adds a pressure of 8781 pounds.

"Suppose that the steam had got free admission during the whole descent of the piston, the accumulated pressure would have been 6333×4, or 25332 pounds.

"Here Mr Watt observed a remarkable result. The steam expended in this case would have been four times greater than when it was stopped at one-fourth, and yet the accumulated pressure is not twice as great, being nearly five-thirds. One-fourth of the steam performs nearly three-fifths of the work, and an equal quantity performs more than twice as much work when thus admitted during one-fourth of the motion.

"This is curious and important information, and the advantage of this method of working a steam-engine increases in proportion as the steam is sooner stopped; but the increase is not great after the steam is rarefied four times. The curve approaches near to the axis, and small additions are made to the area. The expense of such great cylinders is considerable, and may sometimes compensate this advantage.*

"It is very pleasing to observe so many unlooked-for advantages resulting from an improvement made with the sole view of lessening the waste of steam by condensation. While this purpose is gained, we learn how to husband the steam which is not thus wasted. The engine becomes more manageable, and is more easily adapted to every variation in its task, and all its powers are more easily computed.

Let the steam be stopped at	Its performance is mult.
$\frac{1}{2}$	1.7
$\frac{1}{3}$	2.1
$\frac{1}{4}$	2.4
$\frac{1}{5}$	2.6
$\frac{1}{6}$	2.8
$\frac{1}{7}$	3.
$\frac{1}{8}$	3.2
&c.	&c.

"The active mind of its ingenious inventor did not stop here. It had always been matter of regret that one-half of the motion was unaccompanied by any work. It was a very obvious thing to Mr Watt, that as the steam admitted above the piston pressed it down, so steam admitted below the piston would press it up with the same force, provided that a vacuum were made on its upper side. This was easily done, by connecting the lower end of the cylinder with the boiler and the upper end with the condenser."

Mr Watt's Engine of Revolution.

Hitherto we have considered the condensing steam-engine of Watt in its application to the purpose of working the large pumps used to draw water from mines or to supply réservoirs from a lower level. This, indeed, was the most obvious and immediate application of the steam-engine, which was at first introduced as a substitute for the atmospheric pumping engine of Watt.

The steam-engine of revolution of Mr Watt was an invention subsequent to the mining steam-engine or "water-commanding machine." Previous to the time of Watt, indeed, there had been a few attempts made to produce a revolving motion by means of steam, such as the case where the engines of Savary and Newcomen drew up water, which, falling upon the buckets of a wheel, produced its revolution. There had also been many attempts to apply the atmospheric pumping-engine directly to this purpose—Jonathan Hall, Kean, Fitzgerald, Mr Oxley, John Stewart, and Matthew Wasbrough, had all contrived some means of producing a revolving motion from the reciprocation of the great beam of the pumping-engine; but Watt's engine alone had the power of being rendered an efficient and economical motive power.

We shall take the present opportunity of describing Mr Watt's method of communicating the force of the steam-engine to any machine of the rotatory kind.

"VV, fig. 44, represents the rim and arms of a very large and heavy metalline fly. On its axis is the concentric-toothed wheel U. There is attached to the end of the great beam a strong and stiff rod T, to the lower end of which a toothed wheel W is firmly fixed by two bolts, so that it cannot turn round. This wheel is of the same size and in the same vertical plane with the wheel U; and an iron link or strap (which cannot be seen here, because it is on the other side of the two wheels) connects the centres of the two wheels, so that the one cannot quit the other. The engine being in the position represented in the figure, suppose the fly to be turned once round by any external force in the direction of the darts. It is plain, that since the toothed wheels cannot quit each other, being kept together by the link, the inner half (that is, the half next the cylinder) of the wheel U will work on the outer half of the wheel W, so that at the end of the revolution of the fly the wheel W must have got to the top of the wheel U, and the outer end of the beam must be raised to its highest position. The next revolution of the fly will bring the wheel W and the beam connected with it to their first positions; and thus every two revolutions of the fly will make a complete period of the beam's reciprocating movements. Now, instead of supposing the fly to drive the beam, let the beam drive the fly. The

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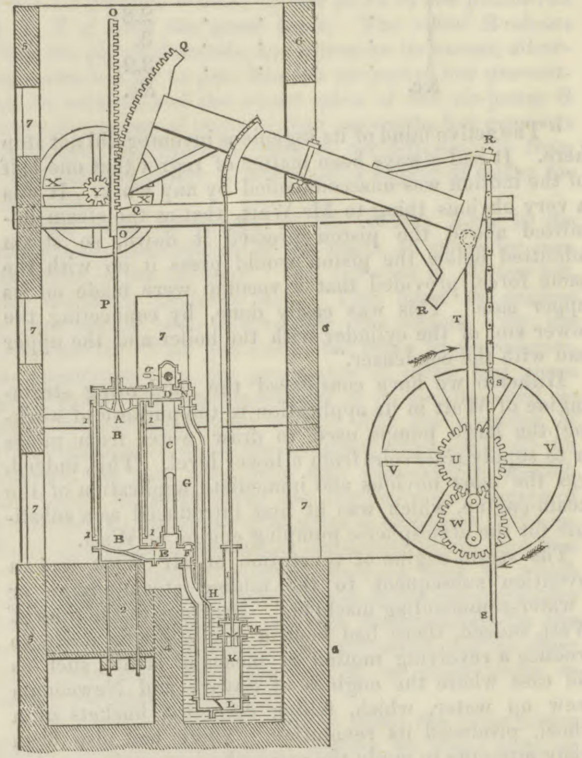
* All these calculations, however, proceed upon the supposition that *steam* contracts and expands by variations of *pressure*, in the same ratios that *air* would do.

Fig. 44.



motions must be perfectly the same, and the ascent or descent of the piston will produce one revolution of the fly.

Mr Watt's Account of his Engine of Revolution.

"It is proper here to give the history of this invention I had very early turned my mind to the producing continued motions round an axis, and it will be seen by reference to my first specification in 1769, that I there described a steam-wheel, moved by the force of steam acting in a circular channel against a valve on one side, and against a column of mercury or some other fluid metal on the other side. This was executed upon a scale of about six feet diameter at Soho, and worked repeatedly, but was given up, as several practical objections were found to operate against it. Similar objections lay against other rotative engines which had been contrived by myself and others, as well as to the engines producing rotatory motions by means of ratchet-wheels. Having made my reciprocating engines very regular in their movements, I considered how to produce rotative motions from them in the best manner; and amongst various schemes which were subjected to trial, or which passed through my mind, none appeared so likely to answer the purpose as the application of the crank in the manner of the common turning lathe, (an invention of great merit, of which the humble inventor, and even its era, are unknown.) But, as the rotative motion is produced in that machine by the impulse given to the crank in the descent of the foot only, and behoves to be continued in its ascent by the momentum of the wheel, which acts as a fly, and being unwilling to load my engine with a fly heavy enough to continue the motion during the ascent of the piston, (and even were a counter-weight employed to act during that ascent of a fly heavy enough to equalize the motion,) I proposed to employ two engines acting upon two cranks fixed on the same axis at an angle of one hundred and twenty degrees to one another, and a weight placed upon the circumference of the fly at the same angle to each of the cranks, by which means the motion might be rendered nearly equal, and a very light fly only would be requisite. This had occurred to me very early, but my attention being fully employed in making and erecting engines for raising water, it remained *in petto* until about the year 1778 or 9, when Mr Wasbrough erected one of his ratchet-wheel engines at Birmingham, the frequent breakages and irregularities of which recalled the subject to my mind, and I proceeded to make a model of my method, which answered my expectations; but having neglected to take out a patent, the invention was communicated by a workman employed to make the model to some of the people about Mr Wasbrough's engine, and a patent was taken out by them for the application of the crank to steam-engines. This fact the said workman confessed, and the engineer who directed the works acknowledged it, but said, nevertheless, the same idea had occurred to him prior to his hearing of mine, and that he had even made a model of it before that time, which might be a fact, as the application to a single crank was sufficiently obvious. In these circumstances I thought it better to endeavour to accomplish the same end by other means, than to enter into litigation, and, if successful, by demolishing the patent, to lay the matter open to every body. Accordingly, in 1781, I invented and took out a patent for several methods of producing rotative motions from reciprocating ones, amongst which was the method of the sun and planet wheels described in the text.

"This contrivance was applied to many engines, and possesses the great advantage of giving a double velocity to the fly; but is perhaps more subject to wear, and to be broken under great strains, than the crank, which is now more commonly used, although it requires a fly-wheel of four times the weight, if fixed upon the first axis. My application of the double engine to these rotative machines rendered unnecessary the counter-weight, and produced a more regular motion; *so that, in most of our great manufactories, these engines now supply the place of water, wind, and horse mills; and instead of carrying the work to the power, the prime agent is placed wherever it is most convenient to the manufacturer.*"

"Let us now trace the operation of this machine through all its steps. Let us suppose that the lower part of the cylinder BB, fig. 44, is exhausted of all elastic fluids; that the upper steam-valve D and the lower eduction valve F are open, and that the lower steam-valve E and upper eduction-valve N are shut. It is evident that the piston must be pressed toward the bottom of the cylinder, and must pull down the end of the working-beam by means of the toothed rack OO and sector QQ, causing the other end of the beam to urge forward the machinery with which it is connected. When the piston arrives at the bottom of the cylinder, the valves D and F are shut by the plug-frame, and E and N are opened. By this last passage the steam gets into the eduction-pipe, where it meets with the injection water, and is rapidly condensed. The steam from the boiler enters at the same time by E, and pressing on the lower side of the piston, forces it upwards, and by means of the toothed rack OO and toothed sector QQ forces up that end of the working-beam, and causes the other end to urge forward the machinery with which it is connected; and in this manner the operation of the engine may be continued for ever.

"The injection water is continually running into the eduction-pipe, because condensation is continually going on, and therefore there is a continual atmospheric pressure to produce a jet. The air which is disengaged from the water, or enters by leaks, is evacuated only during the rise of the piston of the air-pump K.

"It is evident that this form of the engine, by maintaining an almost constant and uninterrupted impulsion, is much fitter for driving any machinery of continued motion than any of the former engines, which were inactive during half of their motion. It does not, however, seem to have this superiority when employed to draw water; but it is also fitted for this task. Let the engine be loaded with twice as much as would be proper for it if a single stroke engine, and let a fly be connected with it. Then it is plain that the power of the engine during the rise of the steam-piston will be accumulated in the fly; and this, in conjunction with the power of the engine during the descent of the steam-piston, will be equal to the whole load of water.

"The engraving here referred to is copied from the drawing of the double engine in the above patent of 1782, and is that of an experimental engine, no others having ever been made exactly similar. I have now added engravings of one of the Albion mill engines, fig. 45, 46, being one of the earliest double engines erected for sale. I do not exactly recollect the date of the invention of the double engine, but a drawing of it is still in my possession, which was produced in the House of Commons when I was soliciting the act of Parliament for the prolongation of my patent in 1774–5. Having encountered much difficulty in teaching others the construction and use of the single engine, and in overcoming prejudices, I proceeded no farther in it at that time, nor until, finding myself beset with a host of plagiaries and pirates in 1782, I thought it proper to insert it, and some other things, in the patent above-mentioned.

"Fig. 45 is a vertical and fig. 46 an horizontal section of one of the Albion Mill Engines.

"The steam-pipe F conveys steam from the boiler *n* to the cross-pipe, or upper steam-nozzle G, and by the perpendicular steam-pipe I, to the lower steam-nozzle K. In the nozzle G is a valve, which, when open, admits steam into the cylinder *above* the piston B, (fig. 48,) through the horizontal square pipe at its top; and in the *lower* steam-nozzle K there is another valve, which, when open, admits steam into the cylinder *below* the piston. In the upper exhaustion-nozzle H is a valve, which, when open, admits steam to pass from the cylinder *above* the piston into the exhaustion-pipe J, which conveys it to the condensing-vessel M, where it meets the jet of the injection from the cock N, and is reduced to water; and, in the *lower* exhaustion-nozzle L, there is also a valve, which, when open, admits steam to pass out of the cylinder *below* the piston, by the eduction-pipe, into the condenser M.

"The piston being at the top of its stroke, the valves G and L are to be opened, and the fly-wheel *m* turned by hand about one-eighth of a revolution, or more, in the direction in which it is intended to move; the steam which is then in the cylinder will pass by L into the condenser, when, meeting the jet of water from the injection-cock, it will be converted into water, and the cylinder thus becoming exhausted, the steam, entering the cylinder by the valve G, will press upon the piston and cause it to descend, while, by its action upon the working-beam through the piston-rod, &c., it pulls down the cylinder-end of the beam, and raises up the outer-end and the connecting rod *h*, which causes the planet-wheel *i* to tend to revolve round the sun-wheel *j*; but the former of these wheels, being fixed upon the connecting-rod so that it cannot turn upon its own axis, and its teeth being engaged in those of the sun-wheel, the latter, and the fly-wheel, upon whose axle or shaft it is fixed, are made to revolve in the desired direction, and give motion to the mill-work.

Steam-Engine

Mr Watt's Engine of Revolution.

"As the piston descends, the plug-tree Z also descends, and a clamp, or slider *q*, fixed upon the side of the plug-tree, presses upon the handle 1 of the upper Y-shaft, or axis, and thereby shuts the valves G and L; and the same operation, by disengaging a detent, permits a weight suspended to the arm of the lower Y-shaft to turn the shaft upon its axis, and thereby to open the valves K and H. The moment previous to the opening these valves, the piston had reached the lowest part of its stroke, and the cylinder *above* the piston was filled with steam; but as soon as H is opened, that steam rushes by the eduction-pipe J, into the condenser, and the cylinder *above* the piston becomes exhausted. The steam from the boiler entering by I and K, acts upon the *lower* side of the

Fig. 45.

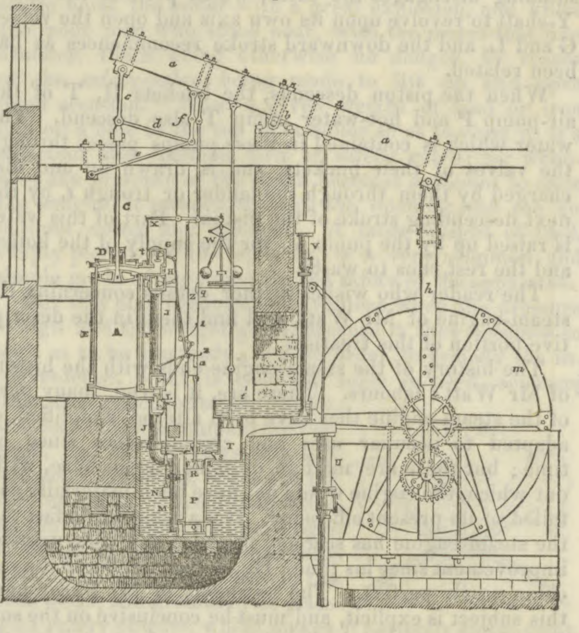
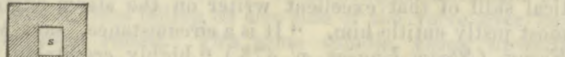


Fig. 46.



Watt's Engine of Revolution.

piston, and forces it to return to the top of the cylinder. When the piston is very near the upper termination of its stroke, another slider *a* raises the handle 2, and in so doing disengages the catch, which permits the upper Y-shaft to revolve upon its own axis and open the valves G and L, and the downward stroke recommences as has been related.

When the piston descends, the buckets R, T of the air-pump P and hot-water pump T also descend. The water which is contained in these pumps passes through the valves of their buckets, and is drawn up and discharged by them through the lander or trough *t*, by the next descending stroke of the piston. Part of this water is raised up by the pump V, for the supply of the boiler, and the rest runs to waste.

The reader who wishes further details concerning the steam-engine of Mr Watt, will find them in the descriptive portion of this treatise.

Conclusion of the History.

The history of the steam-engine ends with the history of Mr Watt's labours. There are, it is true, many parts of the steam-engine that have been altered, simplified, or adapted to peculiar uses and circumstances since his time; but these are matters of minor importance, without which, the engine would not have been materially curtailed of its present efficiency. It is a remarkable fact that the steam-engine has scarcely received any very valuable improvement since his time. He, in fact, rendered it a machine nearly perfect. The testimony of Mr Farey upon this subject is explicit, and must be conclusive on the subject with every one who has the means of ascertaining the very high estimation to which the knowledge and practical skill of that excellent writer on the steam-engine most justly entitle him. "It is a circumstance," says Mr Farey, (*Steam-Engine, p.* 473,) "highly creditable to Mr Watt's character, both as an original inventor and as a practical engineer, that his first double-revolving engine, which he made in 1787 at the Albion Mills, performed quite as well as any engine which has since been constructed to employ steam on the same principles. Some important improvements have been made in the construction of modern engines by substituting cast-iron and stone-work in the place of wood, and by putting the parts together in more substantial modes; but all those essential forms and proportions which affect the performance of the machine, were so ascertained by the first inventor, that no improvement has been since made in them, and every departure from those forms and proportions has impaired the performance in a greater or less degree."

Thus have we taken a rapid survey of the history of the steam-engine. We have omitted the names of many individuals who have distinguished themselves by ingenuity directed to this subject. We have omitted the labours of Gebert, Alberti, Cardan, Decaus, Branca, Morland, Papin, Amonton, Leupold, Meyer, Bosfrand, Gessanne, and a hundred others who have, all in different degrees, expended ingenuity upon the application of steam to the production of mechanical power; and these we have omitted not because we consider their labours either undeserving of notice or uninteresting to the general reader, but because they have not contributed towards the production of the modern steam-engine, and because an account of their works would rather serve to illustrate the possible varieties of the machine and the fertility of the human mind in mechanical devices, than either to conduct the reader along the stream of historical succession, or render him better acquainted with the nature and mechanical peculiarities of the steam-engine itself.

Part II.—Description of the Modern Steam-Engine.

The Mode- Steam Engin Two cies.

Of modern steam-engines there are two distinct species —the high-pressure and low-pressure engines. The former is simple, light, and of few parts, generally used for locomotive engines, steam-carriages, steam-vessels of a light and rapid construction, and such other purposes as require portability or cheapness. The latter is more complex, but more effective; more expensive in original construction, but more durable and more economical in consumption of fuel. The first is more commonly in use in America, the latter in this country. The high-pressure engine is sometimes also called the non-condensing steam-engine, to distinguish it from the low-pressure engine, which is also called the condensing steam-engine; but there is sometimes a combination effected of some of the parts and principles of both these species, in what is called a high-pressure condensing engine, by which, for certain purposes, the peculiar merits of both species are combined in the same machine.

Of these two sorts of steam-engine it is remarkable that the more elementary and simple—that which is the more easily conceived and understood—was not invented and brought into practical use until long after the other kind had been very extensively used and made known by its inventor, James Watt. It appears to us, that we are to consider Oliver Evans of Philadelphia as the inventor of the modern high-pressure engine. Before 1786 he had contrived and made experiments upon a high-pressure engine, which seems to have been in all essential respects similar to our own. Indeed, it appears that the Americans have taken the form and arrangements of their engines from Evans, as implicitly as in this country we have adopted those of Watt. The history of Evans consists almost entirely of the romance of real life. Sanguine and energetic, he continually encountered difficulties only to overcome them, and to encounter renewed disaster and disappointment, till he at length died of a broken heart. To him we attribute the rapid advancement of America, at the commencement of the present century, in all that relates to the introduction of the steam-engine in its multifarious applications, and especially in steam navigation. He had awakened in that nation a lively sense of the advantages which they were likely to derive from the introduction of the power of steam, and placed in their hands an instrument well fitted for their use, and which they were not slow to adopt and apply.

The high-pressure or non-condensing engine consists of *two* principal members, *generator* or *boiler* and working *cylinder*, each with sundry appendages. The low-pressure or condensing steam-engine consists of *three* principal members, *generator*, *cylinder*, and *refrigerator* or *condenser*, each with sundry appendages.

The generator and working cylinder, with their appendages, are nearly the same in both kinds of steam-engine, the presence of a condenser or refrigerator forming the principal and almost only distinction of the second species. By this second species the steam is returned into its first state of water, thereby effecting a saving of heat and of mechanical power; whereas, in the first form of engine, the steam, after performing a certain portion of its labour, is discharged into the open air as useless; a process which can only be advisable in circumstances where the labour and apparatus for condensing would cost more money, and cause more inconvenience than would countervail the loss of fuel and heat and power.

As, therefore, the high-pressure non-condensing steam-engine is simpler in its action and construction than the low-pressure condensing engine, it is convenient to con-

S n-E ne. sider, in the first instance, its mechanism and management, and afterwards, how far it may require to be modified in order to acquire the advantage of condensation.

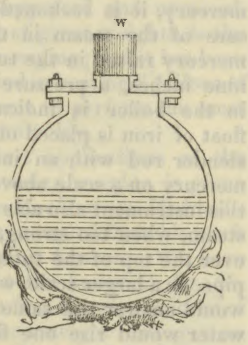
The High-Pressure Non-Condensing Steam-Engine.

The elastic force of steam is a phenomenon with which we become acquainted very early in life. We see that when water boils furiously in a kettle or caldron which is closely fitted by a lid or cover, it has a tendency to raise it up or drive it off with considerable force; and that the steam, collecting in the upper part of the vessel, rushes with considerable velocity out of any crevice or pipe which communicates with the open air.

The force of the steam which is thus issuing from the spout of a kettle or crevice in the cover of a caldron is comparatively slight; and the steam which thus rises from boiling water is called low-pressure steam. But if we stop up the spout and close the cover with accuracy, so as to confine the steam within the kettle or boiler, the water will become hotter and hotter, and the steam stronger and stronger, until it will either force up the cover with violence, or altogether burst asunder the sides of the boiler. In this confined and heated state the steam acquires, from its properties, the descriptive appellation of high-pressure steam.

Pre re of S am. Engineers are in the habit of reckoning the force of high-pressure steam by a very simple expedient. They place a weight such as W (Fig. 47,) upon a hole on the top of the boiler. This hole being square, and an inch in length and breadth, and the weight being equal to one pound, when the steam is strong enough just to blow the weight off the hole, they call that *steam of an elastic force equal to one pound on the square inch.* They then place a weight of two pounds upon this hole of a square inch, and continue the heat until the steam just blows it off, and that is called *steam of the pressure of two pounds on the square inch.* And, in like manner, when steam is confined and heated until it acquire force enough to blow weights of three, four, five, fifteen, or fifty pounds off an aperture of not more than a square inch in extent, that is technically called *steam of the elastic pressure of three, four, five, fifteen, and fifty pounds on the square inch.* It is difficult to say whether there be any limit to the elastic force which steam may acquire from continued heat and confinement: it is known to be even as powerfully elastic as gunpowder, and pressures of one thousand pounds an inch have been produced.

Fig. 47.



The pressures generally adopted for high-pressure engines are from fifteen to one hundred and twenty pounds on the inch. Of course, when there is a given pressure on any one inch of the surface of a boiler, there will be the same on every other inch of surface; and if the aperture under the weight be any number of times greater than one inch, it will just require so much the more weight to keep it closed. The standard by which the pressure is reckoned and calculated is, however, always the square whose side is one inch.

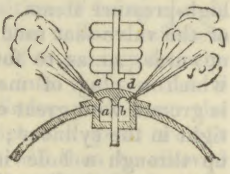
Safet valve By placing a movable weight upon an aperture of given size in this manner, the engineer not only ascertains the amount of the elastic force of the steam tending to burst the boiler, but he also constructs a *safety-valve* by which to avert the danger of an explosion of the boiler. Dr Desaguliers relates a circumstance which happened very early in the history of the steam-engine, when, for want of proper precautions of this nature, "the steam burst the boiler with a great explosion, and killed the poor man who stood near, with the pieces that flew asunder, there being otherwise no danger, by reason of the safety-valve being made to lift up and open upon occasion." Now, a given weight of lead or iron laid on a hole in the top of a boiler so as to close it, is a sufficient and common form of safety valve; for whenever the pressure of the steam becomes sufficient to raise the weight, it escapes through the opening into the air without doing any mischief. A large weight of lead, simply placed on the opening, is a very common and simple mode of providing for the safety of the apparatus.

Steam-Engine.

Safety-valve.

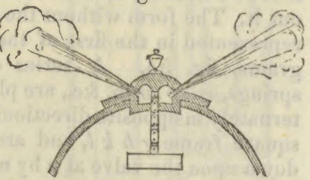
But this plan becomes inconvenient when the pressure is high and the weight great, because it then becomes so high as to be unsteady; and, in order to remedy the inconvenience, what is called a *valve* is used, separate from, and in addition to, the weight, as shown in the accompanying diagram, fig. 48. A valve-seat *a b*, formed of cast brass, is fixed in the aperture, and is accurately fitted by the valve itself *c d*, the edges of which, at *c* and *d*, are carefully turned and tapered, so as to fit the neck of *a b*, and ground in its place with emery powder, which makes it perfectly steam-tight. A spindle protrudes downwards from the valve through a guide which keeps it in a straight line, and prevents it from falling on one side of the valve after having been raised. This same spindle, rising upwards, carries upon a crossbar a series of large cylindrical weights which may be increased or diminished in number as the case may require.

Fig. 48.



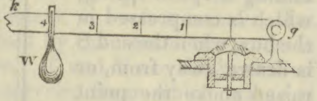
It is a practical fault of this valve that the tall erect spindle may easily become bent or injured by accident, and also that the weight upon it may too easily be handled, so as wantonly to be increased; hence, a safety valve, with an internal weight, has been contrived in the following shape. A conical valve is placed in its seat in every respect as formerly, only the spindle does not rise up but hangs down among the steam, terminating in a chain and weight.

Fig. 49.



In all of these modifications the weight on the safety-valve becomes large and cumbrous when the pressure is high; and a contrivance was devised very early in the history of steam to obviate the inconvenience of this plan, under the name of the lever safety-valve. Instead of placing a great series of weights on the valve itself, a single weight is hung on the end of the longer arm of a lever so as to produce an effect proportional to its distance, and this lever being graduated, shows the amount of the effect which is thus produced. In the figure, the valve, valve-rod, and spindle are all arranged as formerly: but a lever *g k* rests on the top of a small hemispherical button on the valve; and the one end *g* being a fulcrum, the weight W is suspended by a ring from any point of the lever. When, at the point 4, as in the figure, its effect on the valve is four times as great as if directly upon it. The effect of the lever's own weight will, in this case, be

Fig. 50.



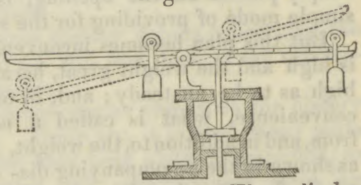
Steam-Engine.

Safety-valve.

also equivalent to a certain number of pounds on the valve, which, being properly estimated, the lever safety-valve may be used to indicate with accuracy the pressure of the steam.

Another form of valve has been proposed, as indicating still more correctly the point at which the pressure of the steam is equal to the pressure on the valve. It is a cylinder or flat valve, acted on by a lever and weight; and there are weights on opposite sides of the lever, which has also equal arms. These weights rest on light rollers so as to run down from their places and release the steam entirely, whenever its pressure reaches the prescribed limit. This is the valve of the French Academy and Franklin Institute.

Fig. 51.



Another form of valve, also cylindrical, was used by Mr Southern for his delicate experiments on high-pressure steam. (See Art. Steam.) The cylinder of the valve-seat used in the former figures is prolonged upwards, so as to form a vertical cylinder or tube, in which a plug of metal is exactly fitted. This plug is ground with great care, so as to move freely but steam-tight in the cylinder; and a rod from the cylinder passes up through a hole in the top, and is kept down by a lever and weight. A hole in the cylinder allows the steam to escape whenever the pressure on the valve upwards exceeds the pressure of the lever and weights in the opposite direction. The indications of this instrument are found to be very precise.

Fig. 52.

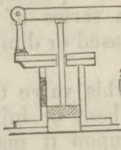
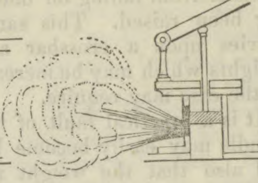
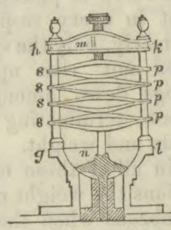


Fig. 53.



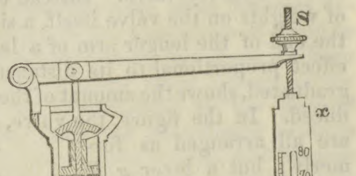
Another species of safety-valve has of late years come into use, called the spring-valve. It is of two kinds, with a lever and without it. The form without the lever is represented in the first of these diagrams, fig. 54. A series of bent springs, *sp sp sp sp*, &c., are placed alternately in opposite directions, in the square frame *g h k l*, and are forced down upon the valve at *n* by means of a cross-bar *k h* acting at *m*—a small screw at *m* adjusting the pressure by compressing or releasing the spring.

Fig. 54.



The other form of spring safety-valve interposes a lever between the safety-valve and the spring. S T, fig. 55, is what is commonly called a Salter's spring balance, the box *x y*, containing a spiral-spring, which is compressed in the box, when the end S is drawn away from, or raised above the point S. The finger-screw S, adjusts the degree of tension on the end of the lever. The two last species of safety-valve are used in locomotive steam-engines.

Fig. 55.



Stea
Engi

Elasti
force
Steam

Fig. 56.

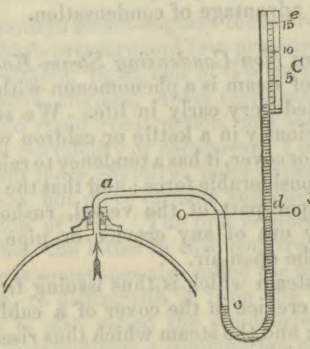
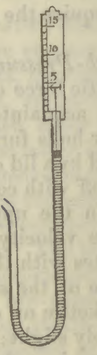


Fig. 57.



A totally different method of indicating the pressure of steam in a boiler, is by means of what is called a *mercurial gauge*, communicating with the boiler. Mercury is poured into a bent tube, one end of which springs from the boiler, and the other end is exposed to the air, so that the steam by its pressure raises the mercury in the straight limb of the tube to a height above the level proportioned to that pressure. In the figure *a c d e*, is the bent tube, communicating with the boiler at *a*, and open at the end *e*, the steam presses on the end *c* of the mercury, and raises the other extremity of the fluid to the height C. From calculating the weight of mercury, it is reckoned, that for every pound of pressure of the steam in the boiler, there is an inch of mercury raised in the tube; so that, if the space *d c* be nine inches, a pressure of nine lbs. on the square inch in the boiler is indicated. Sometimes also a small float of iron is placed on the mercury, which, carrying a slender rod with an index, points the elevation of the mercury on a scale above the gauge. It is evident that this instrument also acts as a safety-valve, inasmuch as the steam, when too strong, must force the mercury entirely over the top of the tube, and make its escape. A double pipe, on a larger scale, with water in it instead of mercury, would answer the same purpose equally well; only the water would rise one foot and an inch for every pound of pressure of steam in the leg of the double tube, and twice that quantity if the tube were single; which would give a scale of 16½ feet in a double tube, or 33 feet in a single tube, as the column of water raised above the level by a pressure of 15 lbs. on the square inch.

It is convenient to reckon the pressure of steam in larger numbers than pounds, and the quantity that has been fixed is a weight of 15 lbs., or a stone weight, per square inch; and to this weight the name of an atmosphere of pressure has been given, simply because the common atmosphere of air presses on all bodies with a weight of 15 lbs. on the square inch, (see Art. Pneumatics.) Thus steam having a pressure of 15 lbs. on the square inch, is called high-pressure steam of the elastic force or strength of one atmosphere. High-pressure steam having a pressure of 30 lbs., is said to have an elastic force of two atmospheres, 45 lbs. of three atmospheres, &c. Sometimes, however, a nomenclature rather different is adopted, and the common steam of boiling water, which exerts no further pressure than merely to balance the atmosphere, is called steam of one atmosphere; and in this case the elastic steam which has been called one atmosphere would be considered as two atmospheres. This nomenclature will be rendered evident by the consideration of the following table:—

High-Pressure Steam of

0 lbs. on the square inch is called	0 atmos. or	1 atmos.
15	1	2
30	2	3

45 lbs. on the square inch is called	3 atmos. or	4 atmos.
60	4	5
75	5	6
90	6	7
105	7	8
&c.	&c.	&c.

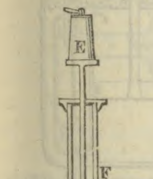
Owing to this degree of ambiguity in these technical measures of pressure, it is always necessary to observe and to specify whether the pressure spoken of is pressure total, or excess above the atmosphere of air. If, for example, four atmospheres be specified, it must be considered whether four atmospheres above the pressure of the atmosphere be meant, as in the first column of the table, or four atmospheres including the atmospheric air pressure, in which case the number in the second column is meant; for, in the former case, high-pressure steam of 60 lbs. on the square inch is meant, and in the latter high-pressure steam of only 45 lbs. above the atmosphere.

Such are some of the various methods by which the elastic force of high-pressure steam in a boiler may be estimated and shown. We have next to consider the manner in which that force may be applied to the useful purpose of forming a high-pressure steam-engine.

We have already seen how the force of steam, confined in a close boiler and heated until it acquires great elastic force or high pressure, acts upon every point of the surface in which it is enclosed, tending to press it asunder; and how, by sufficiently confining and heating it, weights of five, fifteen, or fifty pounds, resting on only a single square inch of surface, may be supported and upraised. To apply this force to the raising of great weights, is the object of the high-pressure steam-engine; and it has been calculated that 6 lbs. of coal, applied in heating 6 gallons of water into steam, has sufficient force to perform the most arduous labour of a man, for a whole day.

One of the simplest and earliest applications of the force of high-pressure steam to raising weights, is given by Jacob Leupold, in his *Theatrum Machinarum Hydraulicarum*, Leipzig, 1725. This we have copied from his work in the accompanying figures. We have already seen that the boiler C, fig. 58, being placed on a fire, the elastic force of the steam will raise a weight resting on an aperture. Now, if we conduct the steam in a pipe into any other vessel, such as the cylindrical tube F, in which there is a piston or movable plug D, on the top of which rests the weight E, by a metallic rod E B, connected with the piston, and passing freely through a hole in the top of the cylinder, it is manifest that when the steam becomes strong enough to overcome the pressure of the weight, it will raise up the piston to any required height. If the weight be 15 lbs., and the size of the surface of the piston one square inch, and if the pressure of the steam be equal to any thing more than one atmosphere of elastic force, it will overcome the weight and raise it. If the surface of the piston were double the size, or two square inches in extent, then each inch would be acted on by a force of 15 lbs., and the same elastic force acting on two inches would raise double the weight, or 30 lbs., and so on for any number of square inches; so that, if the piston were a circle of four inches in diameter, which would have a surface of about 12 square inches, on each and all of which a pressure of 15 lbs. was sustained, there might be a total weight of 12 times 16 lbs., or 180 lbs., sustained and raised to the top of the cylinder. The boiler being removed from the fire and allowed to cool down again, the piston might again descend, and this operation be repeated as often as necessary.

Fig. 58.

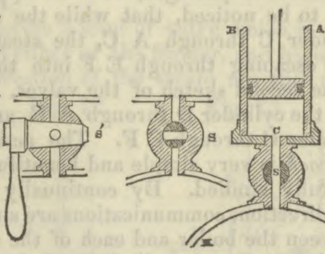


Steam-Engine.

Leupold's High Pressure apparatus.

But a more convenient form of this apparatus is that which Leupold gives in the next figure,—in which it is unnecessary to remove the fire. The boiler G H, fig. 59, having a constant fire placed under it, the communication with the cylinder A B C takes place through a passage capable of regulation by a stopcock S, which is shown at S as shut by turning the handle T. This stopcock is similar to that commonly used for regulating the flow of liquors in vessels of any kind; a small conical plug S′ stops up the passage entirely, but being perforated in one direction, allows the communication to take place whenever that perforation is turned round into such a position as to form a continuation of the channel. By this means it is provided that this stopcock shall remain in the position, S¹ being closed, until the steam has collected in the boiler a sufficient elastic force, after which it is allowed to pass up into the cylinder, by turning the stopcock into the position S when the steam entering the cylinder pushes up the piston and the piston-rod by which the great weight E is raised as before. The piston will then be allowed to descend to the bottom, by allowing the cylinder gradually to cool, when the weight may again be raised as at first; and so on for any number of operations.

Fig. 59.



But the most perfect of Leupold's machines is that represented in the following figures, 60, 61. It is a true water-pumping high-pressure steam-engine; a machine which might be efficiently used without any alteration at the present day, only the modern machines are calculated to do the work with a smaller expenditure of fuel. Two pumps for raising water are directly worked by steam, by connecting the handles of the pumps with the pistons of two high-pressure cylinders, in such a manner, that when the pistons are raised by the steam the water is forced up in the pump-pipe. T and V are the barrels of two pumps placed in a reservoir, from which water is raised through the joint-pipe K; G and H are the handles or levers by which the pumps are worked. The pistons of the steam cylinders C and D are attached to the ends of the levers. In figure 60, at A C the steam is shown in the act of entering into the eylinder C, and pushing up the end of the lever G, so as to force the water; and

Leupold's Engine.

Fig. 60.

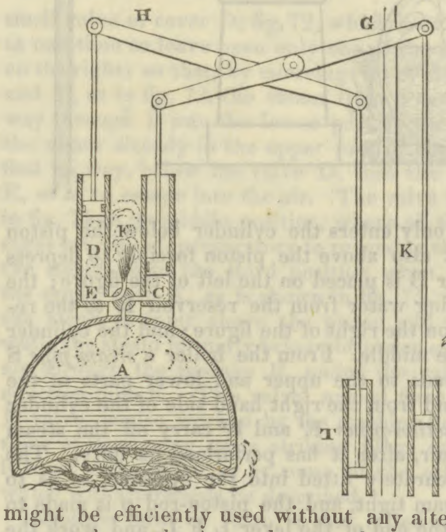
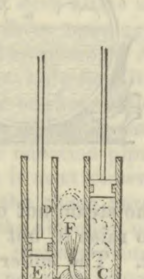


Fig. 61.



Steam-Engine.

Modern High Pressure Steam-Engine.

in figure 61 the steam is shown entering into the cylinder D to work it. This change is effected by turning round the disc A F into the position R S, which reverses the passages, as will appear on examination. It is to be noticed, that while the steam is entering the cylinder C through A C, the steam from the cylinder D is escaping through E F into the open air; and that in the second sketch of the valves, the steam is passing into the cylinder D through A E, and passing out of the cylinder C through C F. The action of this *four-way stopcock* is very simple and beautiful, and deserves to be carefully studied. By continually turning it round in one direction, communications are simultaneously effected between the boiler and each of the cylinders alternately, and between each cylinder and the open air. We shall afterwards revert to this mechanism.

The modern steam-engine of high pressure is in many respects analogous to the machine of Leupold. It will be readily understood by the study of the few following illustrations. The engine is called double acting, because the steam not only enters the cylinder below the piston to raise it, but also above the piston forcibly to depress it. The boiler B is placed on the left of the figure; the pump, for raising water from the reservoir R to the reservoir R^2, is on the right of the figure; and the cylinder is placed in the middle. From the boiler a *steam-pipe* S S S^1 S^2 proceeds to the upper and lower parts of the cylinder C; and from the right hand side of the cylinder two short *eduction-pipes* E^1 and E^2 carry off the steam into the open air, after it has performed its duty. The piston P is accurately fitted into the cylinder, so as to be air and steam tight, and the piston-rod *p* is made to carry with it the end of the lever L F L, and work the pump W W. Perhaps the only difficulty that is felt in understanding the mechanism of the double-acting steam-engine, lies in the construction and operation of the valves. S^1 S^2 E^1 E^2 are four plugs, each capable of exactly filling up the passage in which it is placed, like S^2 E^1, or of being withdrawn from it, like S^1 E^2. Therefore it is evident that in figure 62, the steam has free access through the upper port S^1, into the cylinder above the piston, so as to press it down. In fig. 63, the case is shown reversed; the valve S^1 is shut down, allowing steam to enter only by S^2, the lower-valve, so as to enter at the bottom of the cylinder and force the piston up.

Fig. 62.

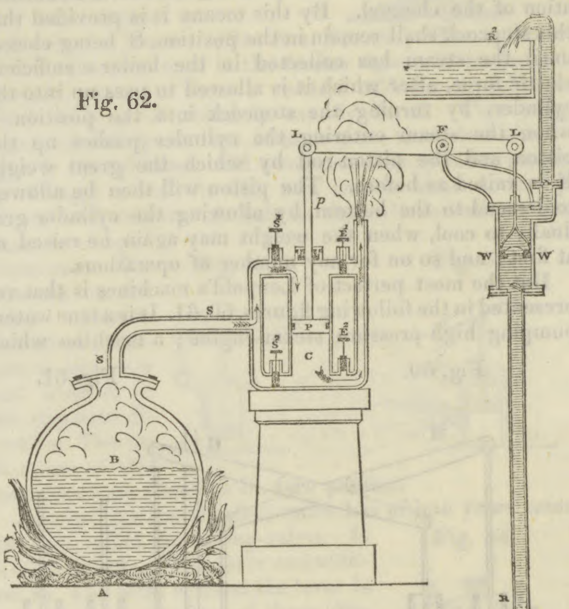
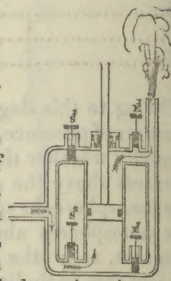


Fig. 63.



The arrangement of the eduction-valves E^1 and E^2 is also to be observed. In fig. 62, where S^1 is open and S^2 is shut, E^2 is also open, and E^1 is shut; so that, while steam enters freely by S^1 on the upper side of the piston, pressing it down, there is a free passage for escape of steam from the under side of the piston, by the bottom passage, through E^2 to the open air; and when the whole is reversed, as in fig. 63, the steam-valve S^2 at the bottom being opened for ingress of steam below the piston, E^1 gives free egress to what was formerly admitted above, so that it may now pass along the passage E^1 into the open air. Thus then, by opening and shutting alternately each of the two pairs of valves, first the under steam-valve and upper eduction-valve, and then the upper steam-valve and under eduction-valve, so as first to allow steam to enter above and escape below, and then to get in below and out above, the one pair being always shut when the others are open, the whole effect is accomplished.

It is an object of great importance to the precision of a machine's operation, that it should be automatic; that is to say, that it should not require for its successful action the continual attention and unvarying assistance of an attendant. In the machine which we have just described, the valves are opened and shut by the attendant. With the following simple mechanism the valves are opened and shut by the machine itself:—

Fig. 64.

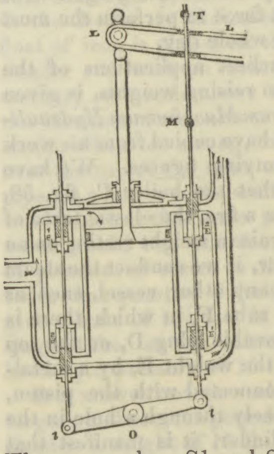
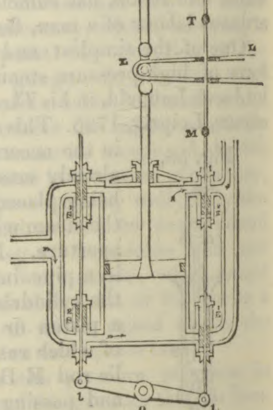


Fig. 65.



The two valves S^1 and S^2 are connected together by a straight rod, and the two eduction-valves E^1 E^2 by another straight rod; these valve-rods are made to rest on opposite ends of a lever *l l*, which turns on a centre O. By this simple arrangement it is brought about that the pair of valves S^1 S^2 being depressed, as in fig. 64, the other pair E^1 E^2 are raised; but when, as in fig. 65, S^1 S^2 are raised, E^1 and E^2 are depressed, while at the intermediate position both are situated similarly to each other. In the next place it is to be noticed that the rod E^1 E^2 is prolonged to T upwards, and that it carries two projections fixed to it at M and T. These projections are struck by the lever L L as it rises and falls. When in fig. 64, the lever is making its downward stroke, it comes on the plug M; and pushes it down, first into the middle position, and then into the position of fig. 65. The steam then entering below, raises up the piston to the top of the cylinder, and with it raises also the lever, which striking on the upper plug T, carries it upwards, raising the eduction valves E^1 E^2, and allowing the opposite valves

Slide Valves.

S^1S^2 to descend into the position of fig. 64, as at first. This operation being repeated, so that at the end of each upward and downward stroke, the descent and ascent of the piston and lever prepare the valves for producing the inverse effect, and giving the next succeeding stroke, the machine becomes independent and automatic. It is rather curious that these simple valves, now described, are the latest improvements that have been introduced in the steam-engine.

Considerable ingenuity has been expended on the valves and passages of the steam-engine, for the purpose of forming all these communications by means of a couple of passages, instead of four. The following diagrams are designed to explain the manner in which this has been effected, by means of a four-way cock, similar to that introduced by Leupold into his high-pressure engine. For this purpose the steam-pipe S, the eduction-pipe E, and the pipes of the upper and lower ends of the cylinder, communicating with it above A and below B the piston, are all brought to the circumference of a single circle, so as to form a St George's cross, as in fig 66. A metallic circular disc O P O B, with two curved channels communicating at successive quadrants of a circle, as shown in fig. 67, is inserted in this circle, so as to fit it exactly, and to be moved round by a protruding handle H. In fig. 68, this valve is represented *in situ*, a communication being formed from S to A, and the other from B to E; and, in fig. 69, the handle being pushed down, a communication is made betwixt S and B, and between A and E. The means of effecting this communication is given in fig. 70. A vertical rod T T^2 being suspended from the end of the great lever, with two plugs T T^2, by means of which the handle H of the valve is raised, in that position the steam enters at S and passes up through the superior passage into the top of the cylinder, forcing the piston down, while the steam already below the piston finds free egress, along the inferior passage B, through the valve, and escapes at the eduction-pipe E into the open air. Just before the piston gets to the bottom of its stroke, the plug T strikes the handle H into the position H^2. The steam before let in above the piston suddenly escapes by the port A through the valve into the eduction-pipe E, while by the same motion a connexion has been effected between S and B, so that the steam now enters below the piston, again to raise it up until the plug T^2 strikes the handle H^2 upwards once more into the position H as at first, when the piston once more descends; and this process is repeated to the end.

Fig. 66.

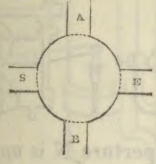


Fig 67.

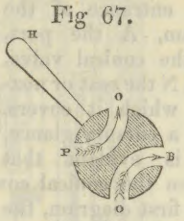


Fig. 68.

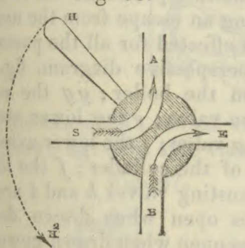


Fig. 69.

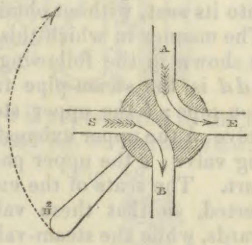
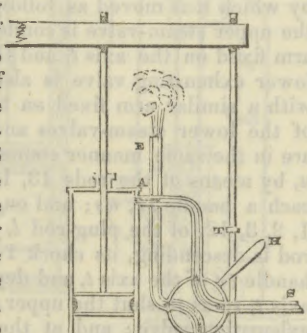


Fig. 70.



We shall next describe a kind of valve which is more commonly in use than either of the former, and by which the changes in the direction of the steam are still more simply effected. In this case all the four passages are united in a square box called a valve-box, or valve-chest, as in fig. 71; S E A B being the steam, eduction, upper, and lower passages. Into this box is introduced a small valve or cover D, fig. 72, which is of such a size as at one time to leave open only one of the three openings on the right; so that, by covering two of the openings, A and E, as in fig. 73, the steam from S can only find its way through B into the lower part of the engine, while the steam already in the upper part of the cylinder can find its way, below the valve D, into the eduction-pipe E, so as to escape into the air. The valve is next shown in fig. 74 in its middle position, where all the three passages are closed, preparatory to reversing the direction of the steam, as in the third position when it slides from the upper part A, as is shown in fig. 75, so as to allow the steam to enter above the piston and press it down, while the steam formerly below the piston escapes into the air through the passage B, under the valve D, by the eduction-pipe E. This valve, named from its figure the D-valve, is also worked by the machine itself, either by some of its moving parts striking plugs on a rod which is fixed to the valve, or by some of the other apparatus which will afterwards be described.

Fig. 71.

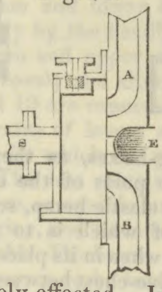


Fig. 72.

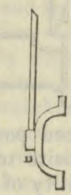


Fig. 73.

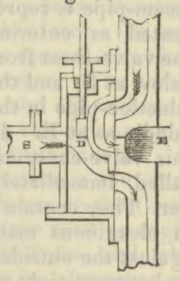


Fig. 74

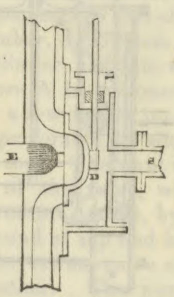
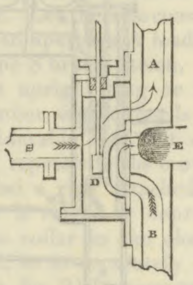


Fig. 75.



Another form of valve is that called the long slide or long D-valve, the invention of Mr Murdoch, which gives the advantage of shutting off the steam, close to its ingress into the cylinder; and so saving what in the common short D-slide is lost in the passages from A and B to the ends of the cylinder. It is formed thus. The valve chest extends along the side of the cylinder. It is shown in fig. 76, without the valve. In figure 77 the long D-slide valve is shown separately. It is a pipe extending along the whole length of the cylinder. Towards the ends, this pipe is almost semicircular, its flat side which forms the diameter of the circle, being a narrow flat plate capable of covering the opening or port of the cylinder. This pipe is left open, and perfectly clear from one end to the other, so that steam

Slide Valves.

may traverse it freely length-wise. The semicircular ends are polished, and rendered truly cylindrical, that the packing in the valve chest may embrace them perfectly. The steam-pipe is represented as entering the valve-chest from below at S, and the eduction-pipe in the middle as at E. In this valve-chest are placed packing-boxes, as they are called, immediately opposite to the ports of the cylinder. They contain a quantity of soft elastic hemp, soaked in oleaginous matter, the object of which is to press against the outside of the slide-valve when in its place, and make steam-tight partitions in the valve-chest between the middle and ends of the valve, so that no communication of steam can take place between the middle and the two ends.

Fig. 76.

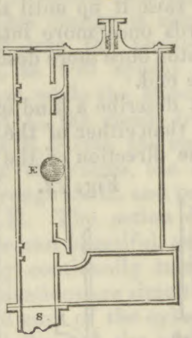


Fig 77.

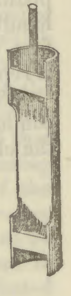


Fig. 78.

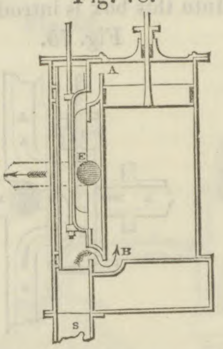
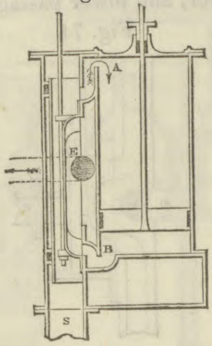


Fig 79.



In the figures 78 and 79, the valve is shown *in situ*. In figure 79, the steam from S rises up along the centre of the slide, and enters the upper part A, while the steam in the under part of the cylinder has free egress through B to the eduction-pipe E. In figure 78, the steam has free access to the lower part B, while the steam already above the piston has free egress through the port A, through the eduction-pipe E. In this species of slide, there is scarcely any loss of steam in the passages, as it is cut off close to the cylinder.

Instead of the long D-slide, which is very heavy on a large scale, two short slides, similar to its two ends, and connected together by bars, have been used in the following form. Fig. 80 is a section of the slide, fig. 81, a face view; and fig. 82, a section of the cylinder with the valves in their place.

Fig. 80.

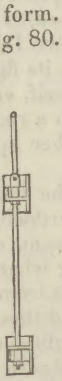


Fig. 81.

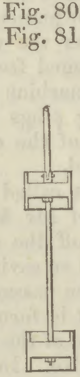
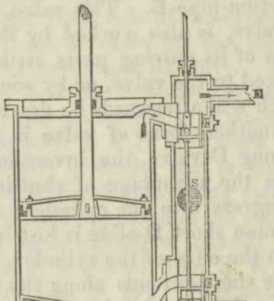


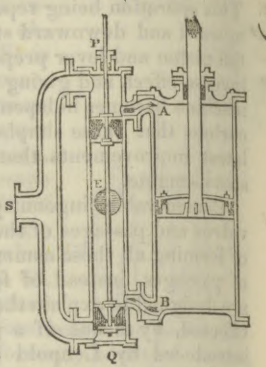
Fig. 82.



In this case, however, there are two eduction-pipes E E instead of one, as formerly, and the steam-pipe enters between the valves.

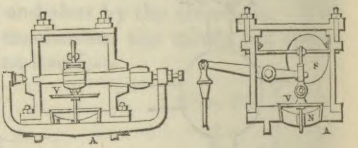
A cylindrical slide-valve of the following form is in use in a considerable number of engines, and works well in those cases which we have had an opportunity of examining. The valve-chest is an upright cylindrical pipe P Q, the inside of which is bored truly cylindrical, and is exactly fitted by two metallic cylindrical plugs, which are ground so smooth in their places as to be steam-tight. It will be apparent from the figure that these two plugs being raised and depressed by the valve-rod which connects them, will effect the same purpose as the former valve.

Fig. 83.



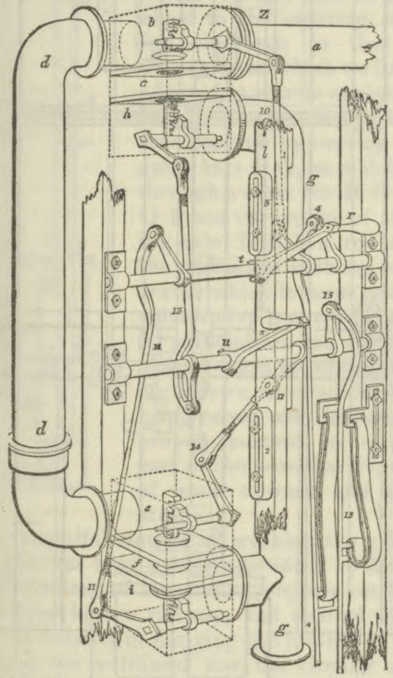
The conical valve is a species of valve introduced by Mr Watt, and improved by his assistant Mr Murdoch, from whom the steam-engine of Watt has received many valuable appendages, and much of its practical perfection. It has been applied in two forms. Mr Watt's own form, the earlier one, is given in the following figures. For a single engine four valves are required. One of them is represented separately in figures 84, 85, which are vertical sections through the valve, at right angles to each other. The valve is shown open in fig. 84, and shut in 85. S is the entrance of the steam, A the port, V the conical valve, and N the seat or nozzle which it covers. On a cursory glance, it is evident that when the conical cover V of the aperture N is up, as in the first diagram, the steam has free entrance; and when it is closed, the steam will merely press the valve down into its seat, without obtaining an escape from the nozzle. The manner in which this is effected for all the passages, is shown in the following perspective diagram, fig. 86. *add* is the steam-pipe from the boiler; *gg* the eduction-pipe; *b* the upper steam-valve; *e* the lower steam-valve; *h* the upper exhausting valve; *i* the lower exhausting valve; *c* the upper part of the cylinder; *f* the lower part. The seats of the exhausting valves *h* and *i* are inverted, so that these valves open when drawn downwards, while the steam-valves open when drawn upwards. Each valve has a toothed rack attached to it, which is acted on by a toothed sector, fixed on an axis, whose end passes through the valve-box, and carries an arm or handle by which it is moved as follows:—the arm or handle of the upper steam-valve is connected by the rod 10 with an arm fixed on the axis *t*, and the arm on the axis of the lower exhausting valve is also connected by the rod 11 with a similar arm fixed on the same axis *t*. The arms of the lower steam-valves and upper exhausting valves are in the same manner connected with arms on the axis *u*, by means of the rods 13, 14. These axes *t*, *u*, carry each a handle *tr*, *us*; and on these the plugs or chocks 1, 2, 3, 12, of the plug-rod *l*, 12, act. When the plug-rod is descending, its chock 1 comes in contact with the handle *tr* of the axis *t*, and depressing it, turns round the axis *t*, so as to shut the upper steam-valve and the lower exhausting valve; and at the same instant its chock 3 comes in contact with the handle *us* of the lower axis *u*, and depressing it, opens the lower steam-valve and the upper exhausting valve. In the upward motion of the plug-tree, the position of the handles are reversed by the chocks 12, 2. The axis *t* carries a short lever 4, to the end of which there is a weight hung through the rod 4 4. When the valves connected with the axis *t* are opened, this weight keeps them open; but is prevented from open-

Figs. 84 and 85.



ing them too far by the strap attached to the rod, as seen in the figure. The lower axis *u* has a similar apparatus, 15, 15, for the same purpose. It remains to notice how the exhausting valves are prevented from being opened by the pressure of the steam. The rods which connect the arms on the axes of the valves with the arms on the axes *t u*, it will be observed, are bent at one extremity in such a manner as that when the valves are shut, the connecting rods and the arms on the axes *t* and *u* fall into the same straight line, as is seen in the case of the upper exhausting valve in the figure. In this condition the arms of the axes *t* and *u* cannot act as levers in turning these axes round, and the valves are thus effectually locked until released by the action of the chocks upon the handles *r s*.

Fig. 86.



Mr Murdoch's conical valve is represented in the next figures: fig. 87 a side view, and fig. 88 a front view.

Fig. 87.

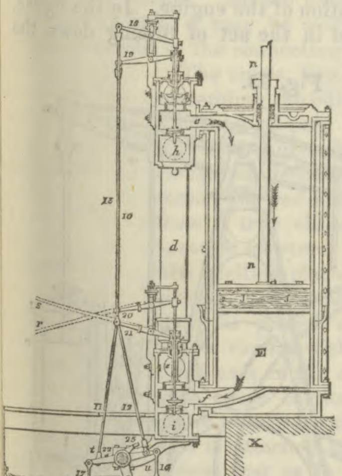
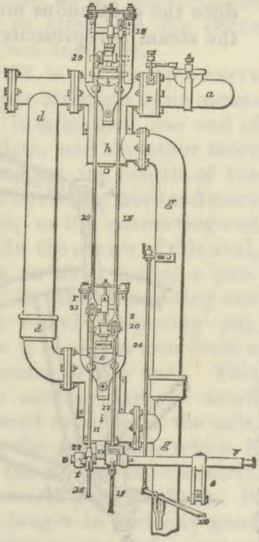


Fig. 88.



a d d are steam-pipes, and *g g g* eduction-pipes as formerly; *c* being the upper port of the cylinder, and *f* the bottom port; *b* and *e* the top and bottom steam-valves, *h* and *i* the top and bottom eduction-valves. The steam-valves *b* and *e* are raised or lowered by hollow rods or tubes, through which the spindles or rods of the eduction valves *h i* work freely without interference. A rod 10 joins the short levers 19, 20 of the valves *b e* together, and another rod 13 joins the levers of the valves 18 and 21 together; so that by inserting into sockets, formed on the ends of the levers 20 21, the bars *r s*, shown by dotted lines, and by using them as lever handles, the upper steam and lower eduction-valves are opened simultaneously by the handle *r*, and by the other lever *s* the lower steam and upper eduction-valves are opened also simultaneously and alternately with the former. The rods 10 and 13 are connected by the rods 11 and 12, with an apparatus of levers and weights, acting through an axis at 22, by which the valves are retained in their seats.

Equilibrium Valve.

The last valve which we shall describe is the crown-valve, or equilibrium-valve, which is in use on the Cornish engine, and has also been introduced into rotative engines by Mr Fairbairn, and Messrs Caird & Co., and which deserves to be better known than it is. Its value consists in effecting a large opening, and requiring little force to work it, while large valves of the common sort are heavy, or are so much pressed in one direction by the steam as to require great force to work them. The valve has been called the crown-valve, from the resemblance of its appearance to that of a diadem. Let there be conceived a chamber, fig. 89, out of which an aperture A leads into the cylinder, and into which a pipe S brings steam. The aperture A is surrounded by an upright ring or collar rising a few inches into the chamber, which ring is on all sides perforated by slits of considerable size, but closed at the top. The next figure, 90, represents the crown or cover of this valve, which is also a ring attached to a steel rod or spindle, by which it is raised or depressed. All round at top and bottom, the collar in the chamber and the crown-valve are ground, so as accurately to fit each other. The next diagram, fig. 91, represents the valve on its seat, and closed on all sides, so that no steam can find admittance; and fig. 92 represents it open or raised up from its seat, with steam entering freely on every side.

Fig. 89.

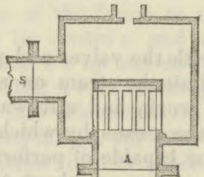


Fig 90.

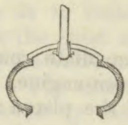


Fig.91.

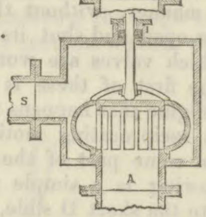
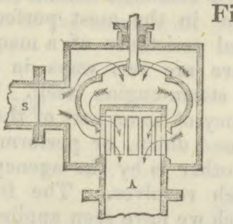


Fig.92.



These valves are arranged in a manner similar to the common conical valves, and work in the same way, four of them being used in a single engine, instead of four conical valves as in fig. 86. The following diagram shows the valves and valve-gear of a Cornish steam-engine, with the gear for working the valves either by the hand or with the pump-rod of the steam-engine. It is very perfect, and deserves the study of the intelligent engineer. The valves are equilibrium valves, such as we have already described. Although we cannot here enter into a detailed description of the mechanism, the engineer will at once understand it from the drawing.

Fig. 93.

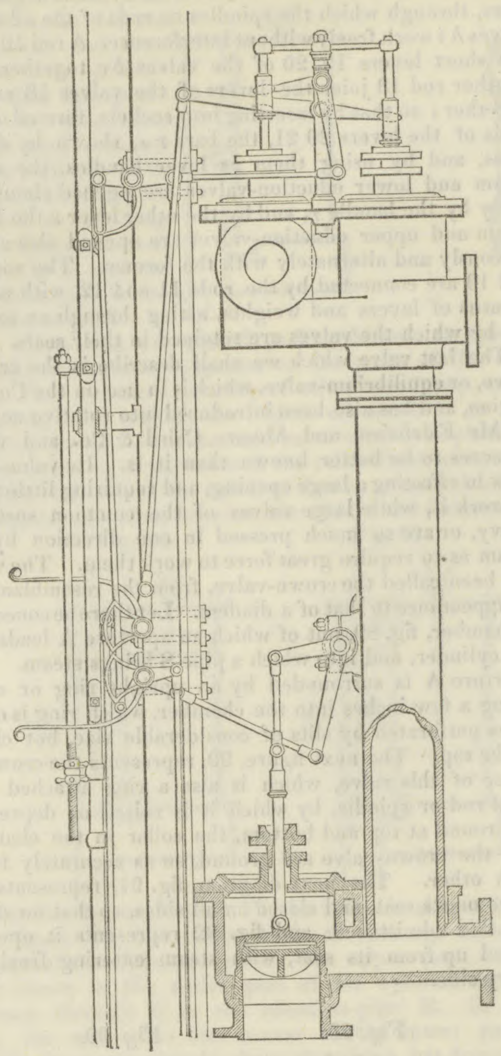
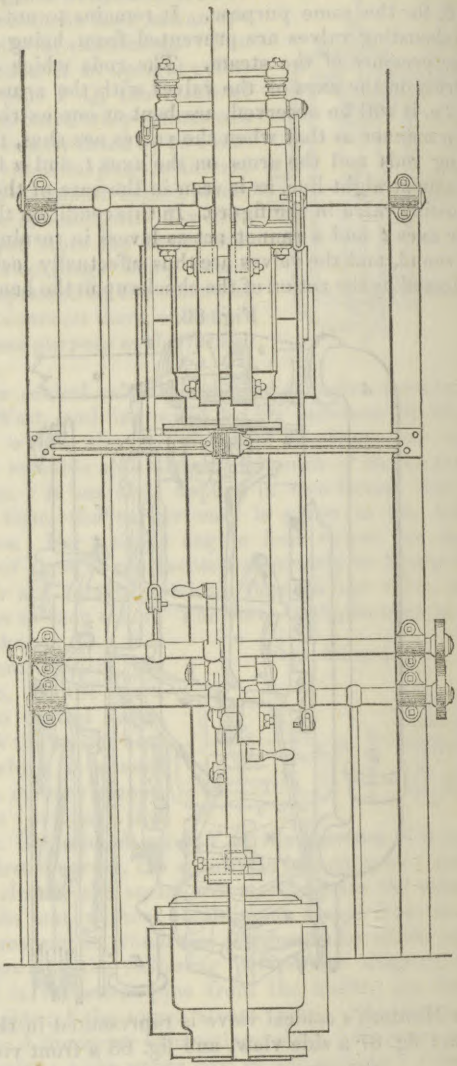


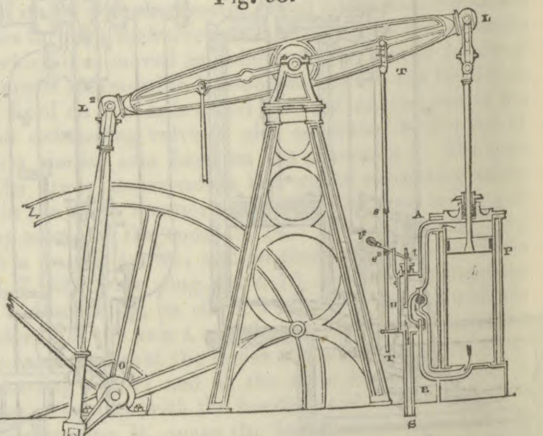
Fig. 94.



Valve gear.

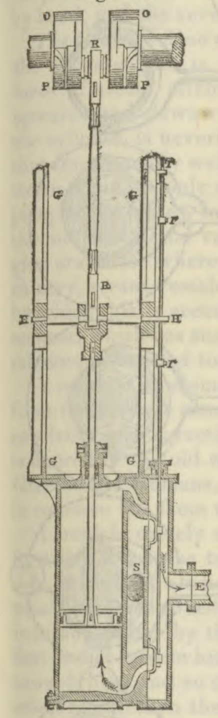
In immediate connexion with the valves and passages of a steam-engine, which admit the steam on alternate sides of the piston to do its work, and afterwards discharge it, we may consider the means by which the engine is rendered automatic, or capable of performing its labour in the most perfect manner, without the continual assistance of a man to open and shut its valves. There are two ways in which valves are worked by the steam-engine itself. The first of these is by the agency of some part of the engine that happens to move up and down, or perform a reciprocating motion, and the other is by the agency of some part of the engine which revolves. The following is a simple method, which we have seen applied to the short D slide, already described. In figure 95, A B P is the cylinder, P the piston, acting on the end L, of a great lever L L^2, raising and depressing it alternately, while the other end L^2, united by a connecting rod L^2 R to the handle or crank of a large wheel, turns it round. The manner in which the steam-valves are moved is by the long vertical bar T T, suspended from the lever L L^2, so as to move up and down with it. This bar T T carries two projecting plugs of wood *s* *s*^{2} upon it, which strike alternately up and down the handle *l* *l*^{2} at the bottom and top of the stroke, and so produce the reciprocating motion of the slide valve D, and by admitting the steam on alternate sides of the piston, and discharging it at the opposite ports, produce the continuous motion of the engine. In the figure, the steam is represented in the act of forcing down the piston; but when the piston gets near the bottom, the plug *s* will have come in contact with the valve-rod *l* *l*^{2}, and will have forced it and the slide valve D into the opposite position, and so permitted the steam, formerly above the piston, to pass into the open air, while the steam on the

Fig. 95.



other side presses up the piston, so as to bring the plug s^2, in contact with the lever, pressing it up, and the valve D down into its first position, and so on alternately.

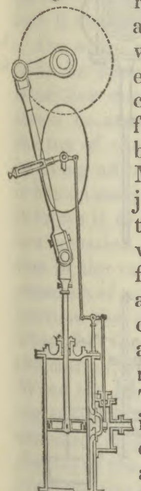
Fig. 96.



This first plan of moving the valves by means of a plug-frame, rising and falling with the alternate strokes of the piston, has been principally adopted for pumping engines that have no revolving motion. We have, however, seen it adopted with advantage even in marine engines. It is noisy, as the sudden strokes of the prime mover produce an instant jerk, but it is effective, in so far as it at once opens the ports to their fullest extent, and so allows full effect to the entering steam, and full clearance to that escaping. The form in which we have seen it adopted in marine engines is as follows. The piston was kept in its true position by moving along two guide bars G G, on which it rested, through a cross bar H H; O P and O P are the cranks of the revolving axis; R R is a rod connecting the piston-rod with the ends of the cranks which it turns round. The valve-rod *r r* is extended upwards as far as the piston-rod works, and two plugs *r r* are so placed by adjusting screws, as to admit of the rod being raised and depressed at the proper moment by a projecting part of the cross-bar H, at the end of each upward and downward stroke.

A very beautiful method of working the valves of the steam-engine has been recently invented by Mr. Melling, the superintendent of locomotive engines on the Liverpool and Manchester railway, and applied with perfect success. It consists in deriving the motion of the valves neither from the rectilineal nor the circular motions of the machine, but from the connecting-rod, one end of which rod moves round in the circle of the crank, while the other end performs a rectilineal, or a circular reciprocating motion. Before entering on the consideration of this motion, it may be well to attend to the curve which a point in the connecting-rod describes.

Fig. 97.



The curve, Fig. 97, is manifestly a curve resembling the ellipse, although by no means a correct ellipse. It is an oval, one end of which is more oblate, and the other more elongated, depending on the length of the connecting-rod, and deviating more and more from a true ellipse, as the connecting-rod becomes shorter. In the centre of this oval, Mr. Melling places an axis, having a projecting arm, and in the connecting-rod there is placed a round projecting pin, which carries with it a radius arm from a fixed axis in the centre of the oval. This axis again carries another arm, or small crank, which is turned round with the axis, and is attached to the valve-rod, which it moves just as in the case of the eccentric. This motion has several good qualities. It is said to continue longer in perfectly good order than the common eccentric motion, and it is said to save steam. This last fact we are disposed to question. The motion exaggerates the properties of the eccentric.

Steam-Engine.

Valve apparatus.

One of the commonest of the many applications of the steam-engine is to produce the revolving motion of an axle and wheel, and in the second system of valve apparatus, by which the steam-engine is rendered automatic, the reciprocating motion of the steam valves is derived from the continuous revolving motion of one of the shafts or wheels. Of the various methods in which this has been done, the following are some examples.

Fig. 98.

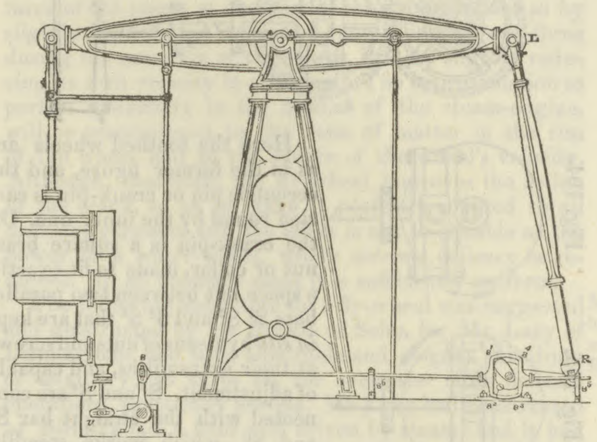


Fig. 99.

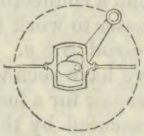


Fig. 100.

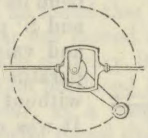
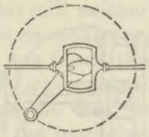


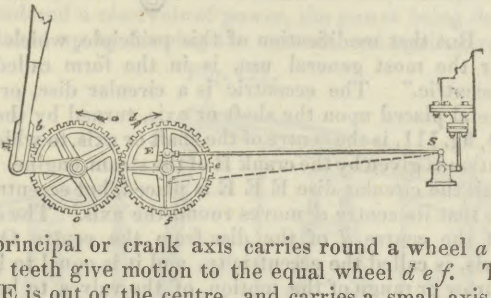
Fig. 101.



On the axis O, fig. 98, which is turned round by the rod LR so as to make one complete revolution during each alternate ascent and descent of the piston, and at the centre O, is placed a smaller axis, carrying round a cam or projection with it. A square frame s^1 s^2 s^3 s^4 encloses this cam. As the axis turns round, the cam comes into such positions as to bear upon the bars s^1 s^2 and s^3 s^4 successively, and so pushes the frame towards the right and left alternately. *s e v* is a small crank, to which the motion of the frame is applied so as to make it move round its centre *e*, and so to raise the point *v*, and the valve rod *v v* up and down, giving the valve to which it is attached a reciprocating motion. The different positions into which the frame is forced by the cam are sketched in figs. 99, 100, 101.

Another form in which this motion has been given, is by connecting the large axle of the crank with a smaller one by toothed wheels, thus:—

Fig. 102.



The principal or crank axis carries round a wheel *a b c* whose teeth give motion to the equal wheel *d e f*. The point E is out of the centre, and carries a small axis E, to which the crank is connected by the rod E *s*, so as to raise and depress the valve-rod. It is manifest, that during the revolution of the wheels *a b c* and *d e f*, the point E will be carried round a circle, and communicate alternate motion to the rod E *s*, equal in extent to the diameter

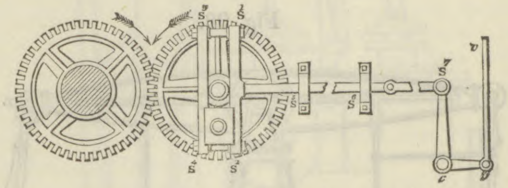
Steam-Engine.

of that circle. This circle must, therefore, be chosen of a diameter equal to the required motion or throw of the steam valves attached to the cylinder.

Valve apparatus.

This motion has been modified into a very excellent and durable arrangement in the following form.

Fig. 103.



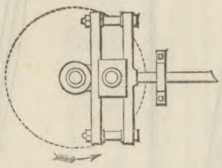


Fig. 104.

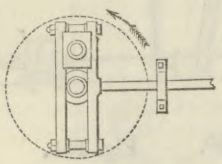


Fig. 105.

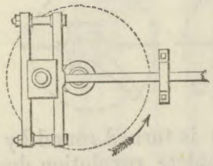


Fig. 106.

Here the toothed wheels are as in the former figure, and the eccentric pin or crank-pin is carried round by the inner one. On the crank-pin is a square brass nut or collar, made to fit exactly a space left between two parallel bars S^1 S^2 and S^3 S^4 that are kept *in situ* by means of nuts and screws at their extremities, and capable of adjustment. S^3 and S^4 are connected with the straight bar S^5 and S^6, which works steadily through the collars S^5 and S^6, and from its end a connecting link S^6 and S^7 passes to work the crank and valve-rod S *c v*. This apparatus we have seen work well without repair for a long period. It was executed by the Messrs Carmichael of Dundee. Figs. 104, 105, 106, show the apparatus in three other positions.

Another mode of producing the motion of the valves is by a projection in the great axis of the engine itself. A rigid circular hoop S encloses the axle as in figs. 107, 108, 109, 110. It is evident that if the projection E be just equal to the radius of the hoop the axle will revolve without producing motion in the hoop; but, if on the contrary, the axle and its projection be equal to the diameter of the hoop, as in the figs. 107, 108, 109, 110, it is apparent that the projection or cam, in passing round, must push the hoop in alternate directions.

Fig. 107.

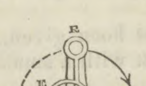


Fig. 108.

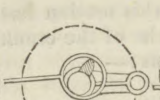


Fig. 109.

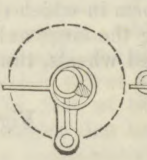
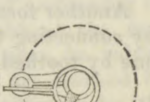


Fig. 110.



But that modification of this principle, which is in by far the most general use, is in the form called "the eccentric." The eccentric is a circular disc, or ring of metal placed upon the shaft or axis, turned by the crank. O, fig. 111, is the centre of the shaft or axis, to which revolution is given by the crank R of the steam-engine. On this axis the circular disc E E E is placed, but eccentric to it, so that its centre *d* moves round the axis. The distance of the centre *d* of the disc from the centre O of the axis, is called the eccentricity, and it is equal to half the throw or range of the motion of the valves to be moved by the eccentric. The rod, fig. 112, is called the eccentric rod, and is attached to a hoop or circle that exactly fits the eccentric disc. The various positions which the eccentric will take during the revolution of the engine, is shown in the succeeding figures.

Fig. 111.

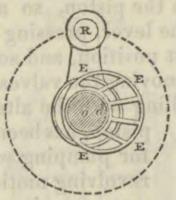


Fig. 112.

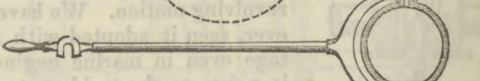


Fig. 113.

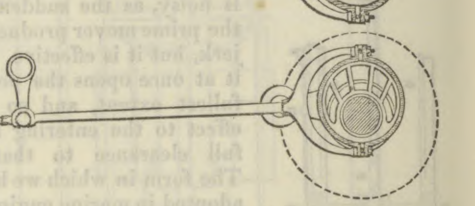


Fig. 114.

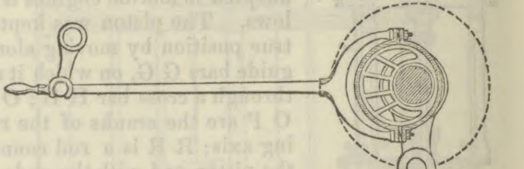


Fig. 115.

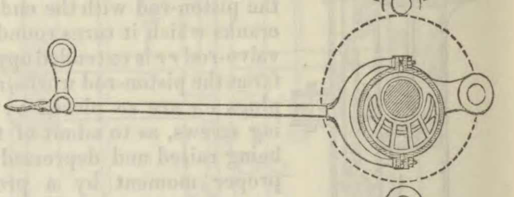
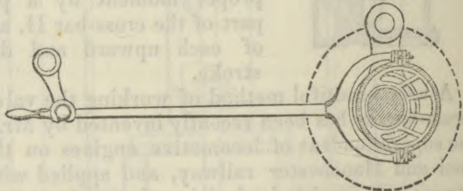


Fig. 116.



We have used the common eccentric in a much simpler form than that generally adopted, by placing it immediately over the valve which it moves. In engines which require compactness and simplicity, this way is useful, and is valuable where the axis of rotation is immediately over the valves, thus:—

Fig. 117.

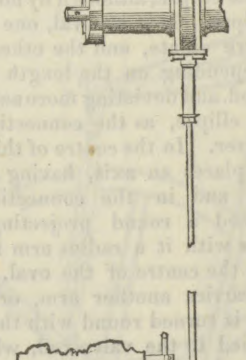
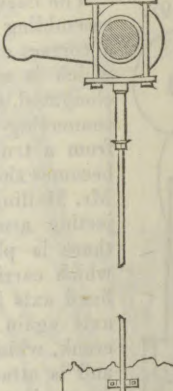


Fig. 118.

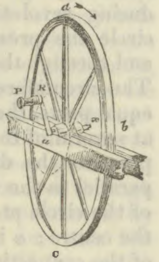


The valve-rod, figs. 117. 118., branches out into four portions; a flat brass plate is inserted at their separation, another at the summit unites them. The eccentric disc works between the side forks of the rod, and bears against its top and bottom plates, as seen in fig. 117. The other forks of the rod are made, in width, equal to the diameter of the axle, which thus prevents the rod from deviating from the vertical position as seen in fig. 118; a handle is added to work by hand, and the reversing process is performed as usual.

The Crank.—One of the most important appendages of the steam-engine is the crank, by means of which the force of steam, although at first producing motion only upwards and downwards in the right line of the axis of the cylinder, is nevertheless rendered capable of exerting that force equally well in a circular direction. When the steam-engine is only employed for some such purpose as pumping up water, no crank is necessary, but as some of the most usual and valuable applications of the steam-engine are those where it turns wheels of mills, cotton machinery, steam-vessels, or locomotive engines, the crank, by which this is accomplished in an admirable and simple manner, which has superseded every other plan of transmission, is entitled to very minute consideration.

A crank is an elementary machine which has been used from the earliest times for the purpose of converting a revolving into a rectilineal motion, or the reverse. It is figured in the old machines of the Egyptians, Chinese, Greeks, and Romans, and in water machinery it has been in common use from the time of Ctesebius.

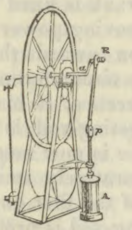
Fig. 119.



A crank is merely a handle to a wheel, by which it may be turned round. Let *a x* be an axis of a wheel *b c d*, *a* R P the usual bent (or crooked) handle, by which it is turned round by the man, whose arm first pushes it from him, and then draws it towards him, and so continually turns the wheel round, then the part *a* R radiating from the centre, is called the crank, the axis *a x* is called the crank-axle, and the straight part PR is called the crank-pin.

Now imagine, instead of a man's arm, a rigid metallic connecting-rod, and instead of the strength of his body, conceive the force of steam to be applied through a cylinder piston and piston-rod to the crank by means of the connecting-rod, and the steam will produce the revolution of the wheel by means of the crank, axle, and pin, as in the figure, A the cylinder, *p* the piston-rod, *p* R the connecting-rod, R the crank, and *a x* the axis.

Fig. 120.



On examining, in detail, the action of the crank, it is to be observed that the force exerted by the steam is neither continuous in direction nor in action. If the steam be admitted first below the piston, it forces it to the top of the cylinder; it is then cut off preparatory to its being admitted above the piston; and in the interval it has no motive action. When admitted above the piston, it forces it to the bottom of the cylinder; and again there is a cessation in its action during the change in the position of the valve. Now it is evident that this recurring cessation of action between the alternating impulses, would prevent the production of continuous revolution in the wheel, but for the power of the wheel itself of continuing the motion, by what is termed the momentum of its mass. When the steam, during a stroke of the machine, is acting most powerfully on the piston, part of its power is absorbed in giving motion to the wheel; and when, at the end of the stroke, it ceases for a time to act, the wheel gives out the power which it had absorbed, and continues its motion until the next stroke gives it a fresh accession of power. A wheel of this kind, when attached to an axle for the purpose of equalizing motion, is termed a fly-wheel; and to obtain the full benefit of its equalizing power, it is made of large diameter, that its rim may move rapidly, and it is made of great weight, being formed either of lead or iron, that it may acquire momentum to render the motion as uniform as possible.

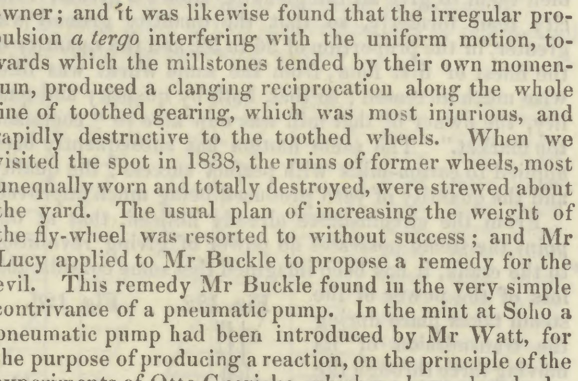
Equalization by the Fly-wheel not perfect.

Still, however, it must be remembered, that the equalization of the motion produced by the fly-wheel is partial, not perfect. Matter only takes up or gives out force when it changes from one velocity to a different one. If, therefore, the fly-wheel take up into itself the accession of force of the steam at one part of the stroke, it does so by slightly accelerating its motion; and if it give out force during the cessation of the stroke, it is by slightly reducing its own velocity in so doing. The approximation to perfect uniformity in the motion of the steam-engine, will be proportioned to the mass of matter in the rim of the wheel and to the square of the wheel's velocity. Although, therefore, the fly-wheel improves the action of the crank, so as to make it perfectly adapted to all ordinary purposes, still the effect is not so equable as the power of a water-wheel, where *extreme* delicacy is required. In all ordinary cases it is sufficiently uniform.

Mr Buckle's Pneumatic Equalizer.

The following substitute for a fly-wheel was suggested and constructed by Mr Buckle of Soho, for Mr Lucy of Birmingham, and is an admirable and elegant substitute or auxiliary; so as to be, for even the most delicate operations, practically perfect. Mr Lucy had constructed at Birmingham a flour mill driven by steam; and it had been his object to obtain perfection without any limitation of expense. He had got one of Bolton and Watt's best steam-engines, and yet he found that his mill neither produced such perfect flour nor moved so smoothly as mills driven by water. On the contrary, it was found that the irregularity of the motion produced a larger quantity of coarse than of fine flour, at a mercantile loss to the owner; and it was likewise found that the irregular propulsion *a tergo* interfering with the uniform motion, towards which the millstones tended by their own momentum, produced a clanging reciprocation along the whole line of toothed gearing, which was most injurious, and rapidly destructive to the toothed wheels. When we visited the spot in 1838, the ruins of former wheels, most unequally worn and totally destroyed, were strewed about the yard. The usual plan of increasing the weight of the fly-wheel was resorted to without success; and Mr Lucy applied to Mr Buckle to propose a remedy for the evil. This remedy Mr Buckle found in the very simple contrivance of a pneumatic pump. In the mint at Soho a pneumatic pump had been introduced by Mr Watt, for the purpose of producing a reaction, on the principle of the experiments of Otto Guericke, which we have already described. The force of the steam-engine was made to draw up a piston from the bottom of a cylinder, leaving a vacuum below it. Into this vacuum the piston was again carried down, after the action of the steam had ceased, by the whole force of the atmosphere, amounting to about 15 lbs. on every inch of its surface. Thus the atmosphere was rendered a reservoir of power, the power being first of all taken up by forming the vacuum, and again given

Fig. 121.



out by the atmosphere pressing the piston down into the vacuum.

Mr Buckle's Pneumatic Equalizer.

The following is the arrangement by which Mr Buckle accomplished the object which he had in view. P, fig. 121, being the usual piston and cylinder of the steam-engine, L L the usual lever, L R the connecting rod, R O the crank, and R W W W a toothed wheel carried round by the crank, as usual in the steam-engine: there is added *r w w* a smaller wheel of half the number of the teeth of the other, so that during a semi-revolution of the small wheel, the large one performs a quarter of a revolution; *l l* is a second lever to which there is attached a piston-rod L H, carrying a piston from top to bottom of an open cylinder H. When the piston is at the bottom of the cylinder H, the crank R is near the point 1 in the figure. While the crank passes from 1 to 2, it is raising the piston in the pump, and against the pressure of the atmosphere, the steam exerting its greatest force; but when the crank reaches point 2, the little wheel *w w r* is at the bottom of its circuit, the piston in the pump is at the top; and now the pressure of the atmosphere carries the piston down into H, turning the little wheel *r w w* along with it, and propelling the large wheel and crank from 2 to 3, through that part of the stroke where there is a cessation of the action of the steam: then again from 3 to 4 the excess of the power of the steam is employed in raising the pump piston; while from 4 to 1 the piston of the pump, carried down by atmospheric pressure, brings round the mechanism once more to the point 1.

So perfect was the action of this mechanism that the fly-wheel had been wholly removed, and the engine and the whole mill-work were moving in the most smooth and effective manner. It was found that the change enabled them to give all the grinding stones a greater velocity than formerly, so that the quantity ground was greater, in the proportion of 56 to 52, and the quantity of the finest or first flour, from the same wheat was likewise much increased; so that, both by quantity and quality, the owner of that mill was now able to "command the market." The same motion has subsequently been applied to cotton-mills with perfect success; the quality and the quantity of yarn produced being much improved.

Analysis of the action of the Crank.

From the circumstance already noticed, that at one point the steam possesses no power of giving revolution to the crank, it has been imagined that some considerable loss of the power of the steam takes place during the transmission of its moving force through the crank. This is a grave error, and it has produced other errors, which we shall consider in our chapter on rotatory steam-engines.

Fig. 122.

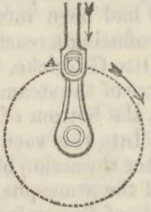


Fig. 123.

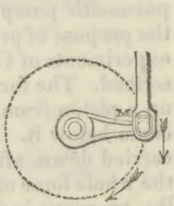


Fig. 124.

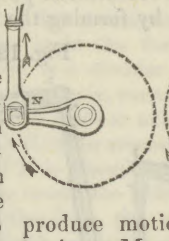
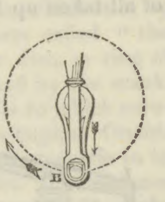


Fig. 125.



Figs. 122 to 125 represent the crank in different positions. In figs. 122, 125 the connecting-rod and crank are in the same straight line, technically called the position "on the centre," or passing the line of centres, in which the action of the crank neither tends to produce motion in the one direction nor the other. Again, at M and N, figs. 123, 124, where the crank is represented as acted upon at right angles by the connecting-rod, it is plain that the whole force transferred through the rod is acting to produce the effective motion of the crank; while in the intermediate positions there are two effects produced, one acting on the centre of the crank, and another acting to give it revolution. For the purpose of examining the proportion of these forces to each other, we may use the two following diagrams:

Figs. 126, 127.

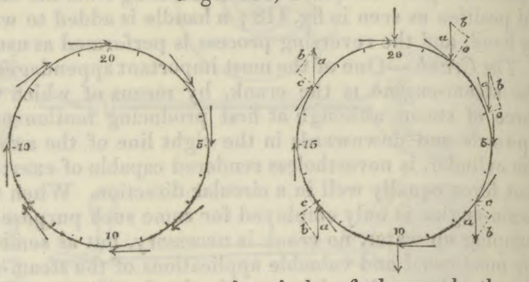


Fig. 126 represents the circle of the crank, the arrows showing the direction in which the crank-rod would require to act, in order that all its force should be undivided, and produce alone the single effect of causing revolution. Fig. 127 indicates the deviation which the actual motion of the crank exhibits from this hypothetical condition. The arrow *a* indicates the direction of the action of the connecting-rod, which at divisions 10 and 20 is acting only towards the centre of the circle with no effect in producing revolution. At divisions 5 and 15, the whole effect takes place in producing revolution only. Through the first half of the circle the pressure of the rod acts wholly downwards, and through the latter half of the stroke wholly upwards. The circumference of the circle being divided into 20 equal parts, the analysis of the force is given in the figure at several of these points. At the second division, *a* represents the direction of action of the crank-rod, *b* is parallel to the direction of the circumference (or tangent) of the circle at that point, while the line *c* is directed to the centre; *a* indicating the direction of the whole force of the connecting-rod, *b* representing the effect produced in the direction of the tangent to turn it round, and *c* the effect of the force of the connecting-rod acting to produce pressure on the centre of the crank; but as the centre of the crank is fixed and prevented from moving, none of the moving power of the crank is given out in producing motion towards the centre, but only in producing motion in the circumference. At the fourth division of the circumference, it may be observed, that the effect of the connecting-rod is differently distributed. The whole force *a* is now more nearly in the direction of *b*, and *c* is comparatively small; showing that as we approach the end of the first quarter revolution, the force of the connecting-rod is producing much less pressure in the centre of the crank, and pressing in a higher proportion in the direction of the revolving effect, until at last the connecting-rod being at right angles to the crank, its whole pressure acting to turn round the crank, none of it is directed towards the centre. After passing the quadranted point 5, the crank-rod still presses downwards, as shown by the arrow *a* at point 7; but, at its two effective pressures, one represented by *b* still acts in turning round the crank, while another represented by *c*, instead of acting towards the centre, as in the upper quadrant, now produces a pressure which would draw the crank away from the centre; but as the crank is fixed, none of the motive power is employed in producing any motion of the crank away from its centre. Similar alternating effects are produced through the other quadrants; so that, while the pressure of the steam, acting through the connecting-rod upon the extremity of the crank, is divided into two effects, one of these is prevented from expending the moving force of the engine by the fixedness of the crank centre, and the whole motive power is given out only at the circumference of the crank circle in turning it round, but in a proportion of pressure that is continually varying from 0 to a maximum, and from a maximum to 0, through every successive quadrant of the circle. The amount of the variation is shown in the following table:—

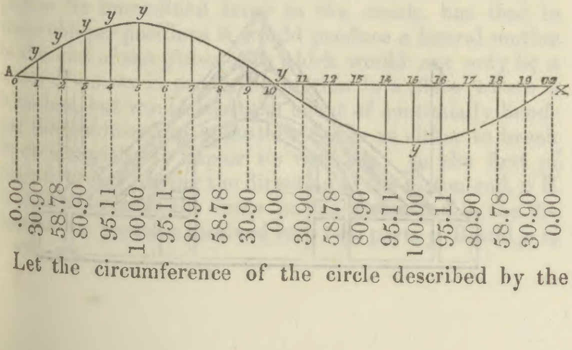
Points in the figure.	Pressure in direction of revolution.
0 and at 20	0.00
1 19	30.90
2 18	58.78
3 17	80.90
4 16	95.11
5 15	100.00
6 14	95.11
7 13	80.90
8 12	58.78
9 11	30.90
10 10	0.00
	Mean pressure 63.11

The mean pressure on the crank being in the table about 63 pounds, taken on an average of the whole circumference of the circle, the pressure varies from 36 pounds above the mean, to 63 pounds below it. The total pressure of the steam in the cylinder, forces the connecting-rod up and down through a space equal, each time, to the diameter of the circle, while the connecting-rod carries the crank through a space which is equal to the whole circumference; and as the circumference of a circle bears to twice its diameter an approximate ratio of 100 to 63, it follows, that the pressures on the crank and piston are inversely as the spaces through which they move; the motive power of steam in the cylinder being 100 lbs. moved through a space of 63, and the motive power given out in the crank, being a mean of about 63 lbs. moved through the circumference of a circle which is represented by 100, so that the motive power is in the one case 100 lbs. × 63 = 6300 lbs., and in the other case 63 lbs. × 100 = 6300 lbs.

The crank is merely one beautiful exemplification of the great dynamical principle, which includes in it the law of operation of all the elements of machinery, "that in uniform motions the quantities of motive power, or *vis viva*, may be transferred from one point to another, through every variety of direction, velocity, and intensity, by material mechanism, without being thereby altered in quantity, except in so far as friction and imperfect rigidity may diminish its amount by a certain percentage, which diminution it is the aim of all perfect construction and design, in the practical application of machinery, to reduce to the smallest possible amount." To render uniform the effective pressure given out by the crank, is the object of the fly-wheel, and of the pneumatic pump of Mr Buckle. For the same purpose many other expedients have been devised; and the following explanation is intended to facilitate the comprehension of the nature and value of these expedients.

The variation of pressure on the crank of a steam-engine, may be conveniently represented by curves.

Fig. 128.



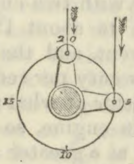
Let the circumference of the circle described by the crank be represented by the straight line A X, fig. 128, and divided into any number of equal parts; let straight lines y^1 y^2 y^3 &c., be drawn to represent the amount of pressure converted into the direction of the motion of the crank, according to the line b in fig. 127, being the amounts represented in the line of figures, then the curved line A y y y x passing through the summit of all these lines will represent the variation in the power of the crank at each instant of time, each ordinate y^1 y^2 y^3 being the pressure, and the area of the whole figure will represent the whole motive power, having a maximum of y^5 and y^{15}, and a point of change of direction from pressure one way to pressure the opposite way at y^{10}.

Analysis of the Crank's action.

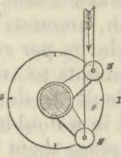
Combination of two Cranks at right angles.

Now one method of equalizing the rotative pressure on the crank has been proposed, and is very generally adopted, viz. to make two steam-engines act on the same axis by means of two cranks at right angles to each other, so that when the one ceases to exert force, the other may be at its point of greatest force.

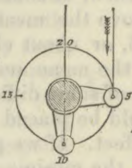
129.



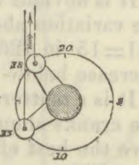
130.



131.



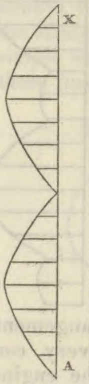
132.



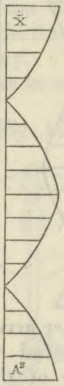
Thus in the figures 129 to 132 two cranks are represented as coming from two cylinders, and attached to the same axis, so that when the one of them is at 0, the other is at 5, when the first is at 5 the second is at 10, and so on; so that while either is on the line of cessation of force, the other is at the point of maximum.

The joint effect of two such cranks may be represented by curves in the following way:—

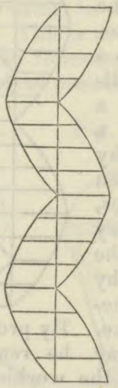
133.



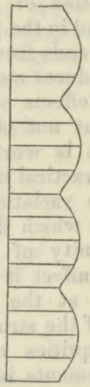
134.



135.



136.



First.	Second.	Sum.
00.000	100.000	100.000
38.268	92.388	131.656
70.710	70.710	141.420
92.388	38.268	131.656
100.000	00.000	100.000
92.388	38.268	131.656
70.710	70.710	141.420
38.268	92.388	131.656
00.000	100.000	100.000
38.268	92 388	131.656
70.710	70.710	141.420
92.388	38.268	131.656
100.000	00.000	100.000
92.388	38.268	131.656
70.710	70.710	141.420
38.268	92.388	131.656
00.000	100 000	100.000

Let the circumference of each crank circle be represented by the lines A X and A² X² as formerly, each semi-circumference being divided into eight parts, and let the pressure be calculated from a table of sines, where each will be found as the sine of the arch of the circumference to which it corresponds; the numbers thus obtained being arranged on the right of the figures, so as to obtain by the two curves the representation of the varying quantity of force, but without regarding the reversion of direction. If now we place these curves together, as in fig. 135, their whole ordinates taken across from the one curve to the other, will truly represent the amount of the sum of the forces and its variation; and if we place all these ordinates from a fourth axis, we shall have truly represented, by the new curve fig. 136, the variations of the sum of the forces of the two cranks. The figures in the third column represent the sums of the ordinates, in which it is shown that the maximum is 41 per cent greater than the minimum pressure, even when two cylinders are made to act on cranks at right angles to each other.

Analysis of the action of the Combined cranks.

The whole of this calculation is summed up in the following formula:

Let r be the radius of each crank,

x the effective leverage of one,

$\therefore \sqrt{r^2-x^2}$ is the effective leverage of the other,

and $x+\sqrt{r^2-x^2}$ the sum of the pressures,

from which we obtain, by differentiating

$x=\sqrt{r^2-x^2}$ in the case of a maximum,

and when $x=0$, the sum $x+\sqrt{r^2-x^2}$ becomes $=r$

or when $\sqrt{r^2-x^2}=0$, $x+\sqrt{r^2-x^2}$ becomes $=r$

and when $x=\sqrt{r^2-x^2}$, $x+\sqrt{r^2-x^2}$ becomes $=2r$

$$\sqrt{2}\,r.$$

$$=1.411.$$

Hence the point of greatest pressure is at 45° from the minimum, and the minimum sums at the termination of each quadrant, the maximum being to the minimum as the square root of 2 to unity.

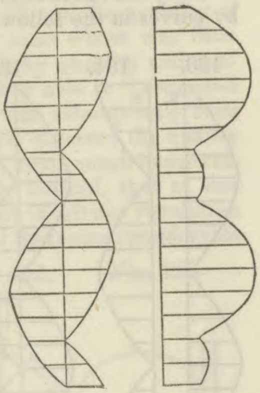
It is obvious then, in conclusion, that with two engines the variation above the mean, amounts to about 12,6—141=15 in 126, or about eleven per cent, and that the decrease below the mean amounts to twenty per cent.

It is a matter of some difficulty to decide at what angle the cranks should be placed in a double engine, so as to give the best effect. If we place them at a greater angle than 90° apart, the minima become small, and the maxima, however, are by no means sudden. If we place them at a less angle, the maxima become excessive; and although the minima be larger, the maxima are also larger. The following diagrams, 137, 138, show the effect of these two methods.

Effect of the crank-rod on the Crank's action.

When a lever intervenes between the crank-rod and the piston-rod, new irregularities are introduced. The variation in the direction of the connecting link, and in the position of the lever-ends from a straight line, introduces modifications of these effects of a serious nature, but not of a large amount. It is worthy the attention of practical men to consider these variations, and the manner in which they affect the uniformity of the pressure. They affect it by way of increase at the beginning and end of the stroke. By proper arrangements these very obliquities may be rendered very considerable improvements in the working of the engine. It should also be observed that the stroke of the piston and crank will not remain of the same length.

Figs. 137, 138.



The agency of the crank in transmitting a force parallel to the piston-rod has been represented by the curve of sines, as in fig. 139. But if we represent, in a similar way, the pressures produced by the obliquity of the crank-rod, we shall find the form become that given in the following figures.

139. 140. 141. 142.

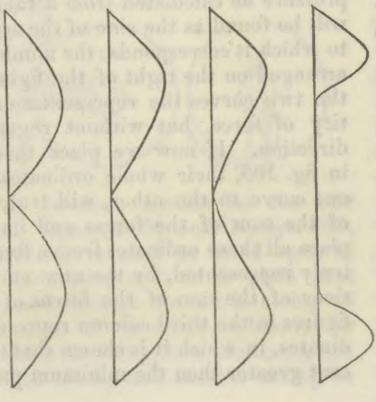
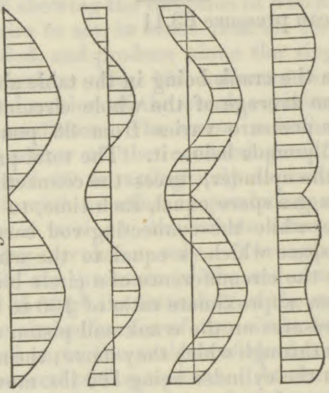


Fig. 140 represents the variation of pressure with a crank-rod of four times the length of the crank, fig. 141 with a crank-rod of double the length of the crank, and fig. 142 with a crank-rod equal to the length of the crank.

It is obvious, that with the shortening of the crank-rod, the irregularity of the motion becomes very great. Two maxima rapidly succeed each other, and these are wide apart from the next pair. Thus two violent pressures succeed at a short interval, and a long pause intervenes, when the force is very small.

By the same system of curves we may proceed to examine the pneumatic equalizer of Mr Buckle. Let the rotative pressure of the crank be again represented, as formerly, by the curve in fig. 143. And let the rotative pressure of the pneumatic crank of the equalizer be represented by the curve in fig. 144, lying on alternate sides of the axis, so as to show the alternate coincidence with, or opposition to, the action of the steam-crank. Then if we place the two axes as in fig. 145, the lines between the two curves will represent the sums of the pressures; and if we set off these intercepted parts in a third curve, we shall get the line representing the variation of the resulting force, corresponding to the sums and differences of the former ordinates. The values of these are given in columns of figures on the right through one quadrant. The mean value 63 is in this case exceeded by 19 per cent, and is receded from below by nearly 20 per cent. The deviation from the mean pressure is not, therefore, greater than 20 per cent, and the equalization produced by Mr Buckle's pneumatic equalizer is as sufficient as a pair of engines, and much less complicated and expensive.

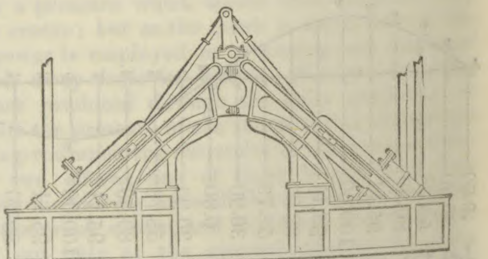
Figs. 143, 144, 145, 146.



0.000	50.000	50.000
19.509	46.194	55.703
38.268	35.345	73.623
55.555	19.134	74.686
70.710	00.000	70.710
83.147	19.134	64.013
92 388	35.355	57.033
98.078	46.194	51.864
100.000	50.000	50.000

Still, however, it is to be noticed, that as there is a variation of force amounting to about 20 per cent above or below the mean, with a pair of engines as well as with the pneumatic reservoir of power, it is obvious that the combination of a fly-wheel with either of these systems of arrangement, would be required to obtain the nearest possible approximation to uniformity in cases of delicacy.

Fig. 147.



Instead of using two cranks for the purpose of applying the force of two steam-engines to the same axis of revolution, two engines have been used with their cylinders laid at right angles to each other, and having their connecting-rods applied to the same crank. For an engine of this kind, fig. 147, Mr. Brunel obtained a patent; and we have seen his machine working in a satisfactory manner. An arrangement of a similar description has also been introduced in steam-boats by M. Cave of Paris.

Of the Connecting-rod and Parallel Motion.—In considering the agency of the crank in modifying the force and velocity of steam, so as to connect its direction and distribute its force in the manner required to produce a rotative motion in the machinery, from the original reciprocating motion of the piston in the cylinder, we have hitherto avoided the introduction of another important element, by which a further variation of force and of motion is produced. The connecting-rod is a rigid bar of metal which conveys the motion of the piston from the piston-rod to the crank either immediately or through the interposition of the lever or beam; and as the connecting-rod, in doing so, takes various directions different from those either of the piston-rod or of the crank, there is an obliquity of pressure produced at both extremities of the connecting-rod, which gives rise to a variation of force and of direction, which must be practically provided for, and carefully appreciated in quantity, in so far as it may affect the ultimate operation of the machine.

There are two ways in which the motion of the piston-rod is most commonly transferred to the crank; either immediately through the connecting-rod, as in fig. 148, or through the medium of the great lever, as in fig. 149; both ends of the great lever describing circles around its middle fulcrum as a centre, and the head of the piston-rod being connected with the one end of the lever by means of an iron strap or connecting link. From inspection of the figure, it becomes plain that the connecting rod or link, is never, except at two points, in the same straight line with the piston-rod, so as to propagate its unmodified force to the crank, but that in these oblique positions it would produce a lateral motion in the end of the piston-rod which would not only be a waste of power in producing motion in a place where it is useless, but would have the effect of continually bending the piston-rod in opposite sides so as either to break it, or materially to impair its working. In the first of these figures, P*p* being the direction of the piston-rod, *p* R that of the crank, the force in the piston-rod in the direction *p a* becomes resolved into two parts *p* R and *p c*, *p* R being effective in the direction of the crank-rod, and *p c* tending only to give lateral motion to the piston-rod, or else to bend it, or else break it across. And so also in the second figure there is a similar separation of pressure.

Fig. 148.

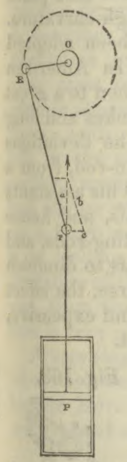
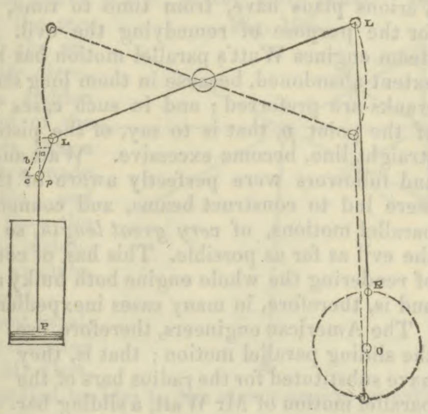


Fig. 149.



Steam-Engine.

Parallel motion of Watt.

To prevent these lateral pressures from wasting the power of the steam, by producing lateral, useless, or injurious motions, is the object of a series of contrivances called parallel motions, or parallel guides. The most notable of these we owe to Mr Watt.

Let it be supposed that we desire to prevent the top of the piston-rod *p*, fig. 150, from being moved by the obliquity of the connecting-rod *p* R, either towards the right or the left, then it is accomplished in the following way. A fixed support, *s*, is found on one side of the piston-rod, and another on the other s^2 at equal distances from it, and two parallel bars *g s* and g^1 s^1 are placed between the piston-rod and these points, so that it may be steadied between them. These parallel bars are made so as to revolve freely round the points *s* s^1 as centres, each of the ends *g* g^1 describing the circles *g* g^2 g^1 g^3, from which it is evident that if these rods were directly attached to the piston-rod at *g* and g^1, they should have the effect of keeping the point *p* in the straight line *o g* g^1 *p*. As these bars *s g* and *s* g^1 must describe circles round *s* and s^1, they would, in the positions *s* g^2 s^1 g^3, deviate altogether from the straight line of the piston-rod; but as the one will act nearly as much in the one direction as the other in the opposite, it occurred to Mr Watt that, by connecting their extremities with a link, *g* g^1, and attaching the piston-rod, not to the ends of the guide-bars, but to the middle of this link, the point *p* might be prevented from deviating to any appreciable extent from the straight line. This is accordingly produced in a very simple way. The following figures show the effect of these links in various positions.

Fig. 150.

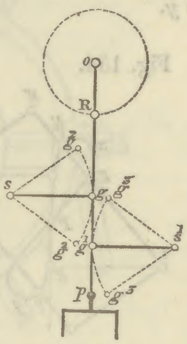


Fig. 151.

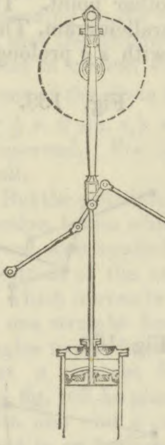


Fig. 152.

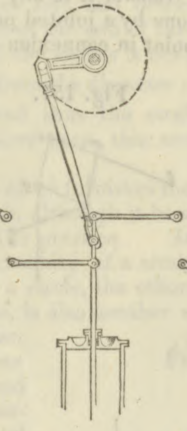
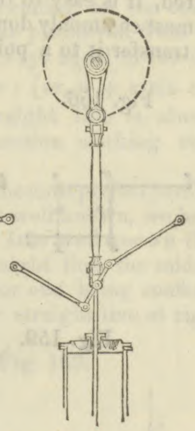


Fig. 153.



Watt's parallel motion not perfect.

This elegant and simple contrivance is not, however, absolutely perfect; and, in accurate workmanship, and on a larger scale, great allowance requires to be made for its errors, or it will produce very many serious derangements of the machinery to which it is applied. By this arrangement the point *p* is not kept perfectly in a straight line, but is, on the contrary, compelled to deviate from it

Watt's Parallel Motion.

so as to describe a looped curve. The nature of this deviation will become very evident if we suppose the parallel motion to be altogether detached from the piston-rod, and the motion of the parallel bar and link carried to its extreme, as in the following figures, 154, 155. A pencil being used to trace the motion of the middle point, *p* will describe, not a straight line, but the curve *p x y*. When we carry the rods up to the position represented in the first of the following figures, where the bar *g s* comes into the straight line with the link *g g*, the point *p* deviates from the straight line by a quantity equal to *p*', and this is reversed in the opposite extreme. In the next figure the deviation is much greater when the link *g g* comes into the same line with the other bar *g s*, and is also reversed in the position at the bottom of the figure. By the time the links have been returned to their primitive position, they have described the curve *x p y*.

Fig. 154.

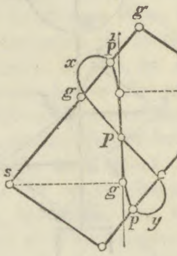
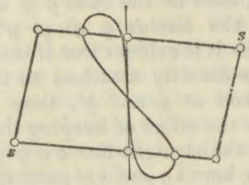


Fig. 155.



It is important to diminish the amount of this deviation, which increases more rapidly than the square of the length of the stroke. Having ascertained the amount of greatest deviation at the end of the stroke, and also the amount at $\frac{1}{8}$th part of the stroke from the middle, bring the centres *s* and *s* each nearer to the other by a quantity equal to the deviation at the said 8th part, and the amount of the greatest deviation will now be reduced to less than one quarter of its former amount: the curve will now become a line of the sixth (eighth?) order.

The parallel motion of one point having thus been secured, it is easy to transfer it to any other point. This is most commonly done by a jointed parallelogram. Thus, to transfer it to a point in connexion with *s g* prolonged

Fig. 156.

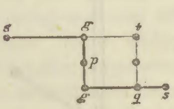


Fig. 157.

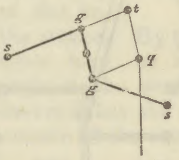


Fig. 158.

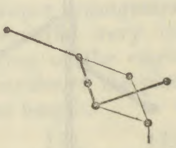


Fig. 159.

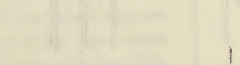
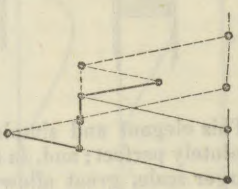


Fig. 160.



to *t*, (figs. 156 to 158) take a second link *t q*, equal to *g g*, and a second bar, called the parallel bar *g q*, equal to *g t*, the corner *q* of the parallelogram will give a motion *t q* similar to *p*. Figs. 159, 160, show the parallel motion transferred to a point still farther from the original point.

Another form of Mr Watt's invention consists in placing two bars in the same direction, with such a difference in their length, that the excess of the continuance of the one above the other may afford the means of compensation. Suppose that the point *p*, fig. 161, is to be guided to move in the straight line *p g g*'; *s s*' are points on the same side of the required direction of motion, and *s g s*' *g*' are the differential bars connected by a link *g*' *g*,

Fig. 161.

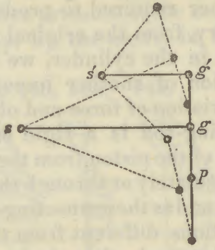
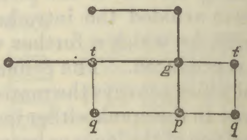


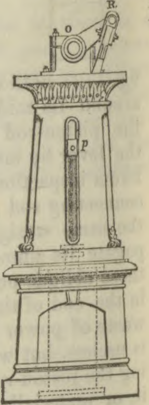
Fig. 162.



which is prolonged to *p*. The dotted lines of the figure show the bars in different positions. The line described by the point *p* is not a straight line, but a curve, like figs. 154, 155. The motion of the point *p* may be transferred to a distance, as in the former instance, by a jointed parallelogram *g p t q*, fig. 162. All these parallel motions may be inverted, and, indeed, generally are inverted in steam-boat engines. For practical examples of them, the reader may consult the plates.

All these motions are imperfect; that is to say, the motion of the end of the piston-rod does not take place in a perfectly straight line, but possesses high curvature. Various plans have, from time to time, been adopted for the purpose of remedying the evil. In American steam-engines Watt's parallel motion has been to a great extent abandoned, because in them long strokes and long cranks are preferred; and in such cases the deviations of the point *p*, that is to say, of the piston-rod, from a straight line, become excessive. Watt and his assistants and followers were perfectly aware of this, and hence were led to construct beams, and connecting-rods, and parallel motions, of *very great length*, so as to diminish the evil as far as possible. This has, of course, the effect of rendering the whole engine both bulky and expensive, and is, therefore, in many cases inexpedient.

Fig. 163.



The American engineers, therefore, use the sliding parallel motion; that is, they have substituted for the radius bars of the parallel motion of Mr Watt, a sliding bar or groove in which the top of the piston-rod is guided.

The head of the piston-rod *p*, figs. 163, 164, is enclosed between two flat surfaces, or between two parallel iron bars, which are kept in the vertical position by means of stiff-framing: on these it slides, or to diminish the friction a wheel may be added; but there are reasons why this wheel does not in practice work very well, and the plain slide is therefore preferred. In fig. 163 we have represented this motion as applied to an engine of the simplest form, and in fig. 164 to a beam engine.

Another species of parallel motion was, we think, first adopted in America, but it has also been used in this country. It is the engine with vibrating pillar.

Fig. 164.

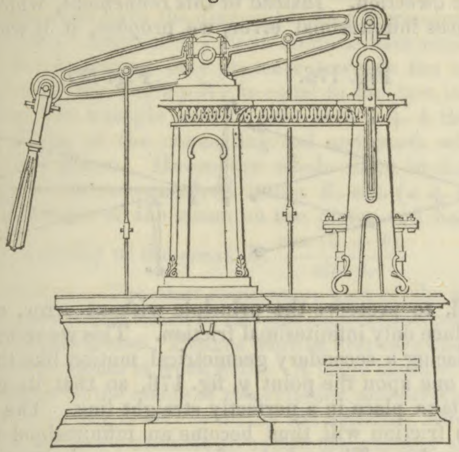
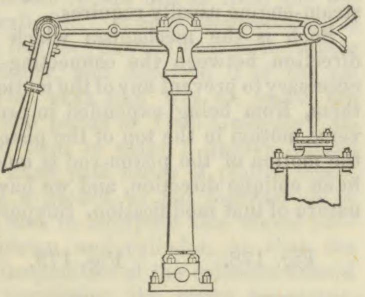
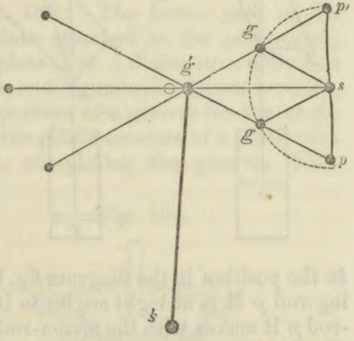


Fig. 165.



The pillar, which supports the beam or lever, instead of being fixed in an upright position, has a joint at the bottom, as will be seen in fig. 165, on which it and the beam and the crank-rod perform a joggling motion backwards and forwards during each stroke. The motion is of the following nature. The point *s*, fig. 166, is fixed; so is *s'*; *s g* and *s' g'* are moveable bars; *p g* is ½ of *p g'*. The point *g* describes a circle round *s*, and *g'* round *s'*: hence *p* describes the curve *p s p'*, of the sixth order. The oscillation of the moving mass of the engine in alternate directions, with a sudden jolt at the end of the stroke, renders this a bad engine when made on a large scale; and it is obvious that the deviation of the piston-rod from the straight line is very great.

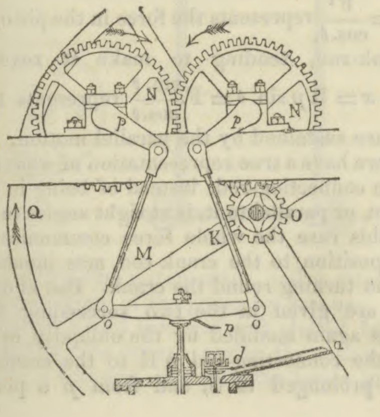
Fig. 166.



Parallel Motions.

A very elegant parallel motion was invented by the Rev. Mr Cartwright, and applied by him to the steam-engine so early as 1797. Two equal toothed wheels N N, fig. 167, work into each other, and from corresponding points of their circumference two connecting links unite at the extremity of a cross bar, to the middle of which the piston-rod is joined. These wheels and connecting-rods being always in similar positions on opposite sides of the piston-rod, the obliquity of their actions balances each other, and the rod describes a straight line. But it is difficult to make and to maintain the wheels of this machine in the state of accuracy and perfection necessary to its working well.

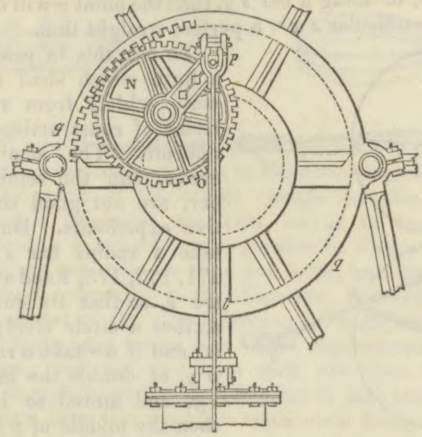
Fig. 167.



Cycloidal Parallel Motion.

The cycloidal parallel motion is one of high geometrical beauty. It was invented by Messrs Fenton, Murray, and Wood, and applied to the steam-engine in practice in 1802. It depends on this principle that an encycloidal curve, described by one circle rolling within another, approaches a straight line as the inner circle becomes more nearly equal in diameter to the radius of the outer one. For the purpose of applying this principle, a large wheel *q q*, fig. 168, with teeth on its inner circumference, is fixed on a frame concentric with the axis and circle of the crank O O. N O is a wheel with external teeth, which is fixed freely on the crank-pin, and *p* is the point of attachment of the piston-rod *p l*. By this arrangement the small wheel N O is compelled, by the pressure of the piston-rod upwards, to roll round the great circle, ascending on the one side, and descending on the other, so that the distance of the end of the piston-rod from the point of contact of the circles is always equal to the distance of the circle from the diameter; (or, $n \mp r.\sin.e = \pm \frac{1}{2} r. 2 \sin. e,$) and thus the straight line is always preserved. We have seen this motion working very well.

Fig. 168.

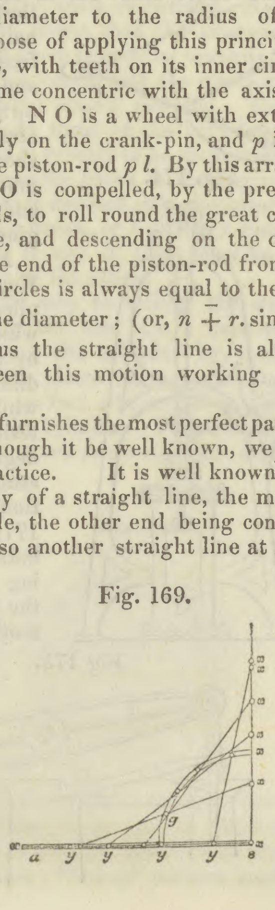


Perfect Parallel Motion.

But the principle which furnishes the most perfect parallel motion, is one which, although it be well known, we have never seen applied to practice. It is well known that the locus of the extremity of a straight line, the middle of which moves in a circle, the other end being confined to one straight line, is also another straight line at right angles to the former.

Let a straight bar *x y*, fig. 169, be placed with one end *y* confined in an horizontal groove *a s*, and let a pin in the middle *g* be allowed to slide in a circular groove *y g x*, then the end *x* will always describe a straight line *s x* perpendicular to the first.

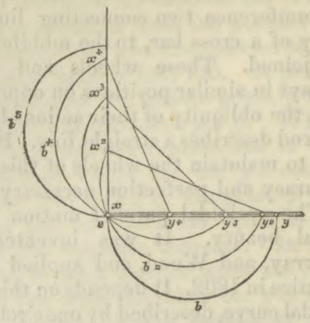
Fig. 169.



Steam-Engine.

Parallel Motions.

Fig. 170



Or it may be thus modified. If the arc of a semicircle have one of its extremities placed in a given straight line, while it moves along a given fixed point, the other extremity of the arc will describe another straight line at right angles to the former. Let a semicircular round bar *y b x*, fig. 170, be allowed to slide through a fixed centre at *s*, the one end *y* sliding in a groove, or along a bar *s y*, then the point *x* will describe the perpendicular $s\,x^4$, a perfect straight line.

Fig. 171.

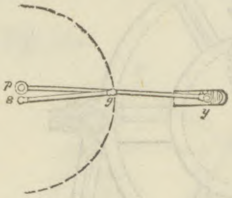


Fig. 172.

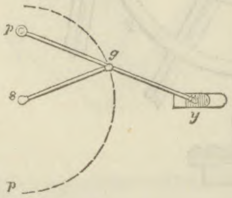
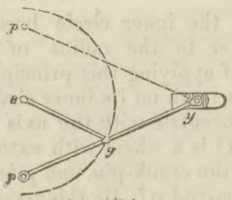


Fig. 173.



To put this in practice in a form which shall not deviate widely from received forms of construction, is not difficult. The semicircular grove, and the semicircular bar, are not good constructive expedients. But if we take a radius bar *s g*, figs. 171, 172, 173, fixed at a centre *s*, so that its end *g* describes a circle freely round it; and if we take a rigid bar *p y*, of double the length of *s g*, and united to it at *g*, then the middle of *p y* being thus constrained to move in the circle round *s*, we have only to permit *y* to slide freely in an horizontal groove, and the point *p* being carried up and down, will describe the straight line *p s p*. Fig. 174 shows the application of this motion to the simple engine, and fig. 175 to the beam engine.

Mr Oldham of the Bank of England has shown us an application of this principle, of which he has made a model: he adds a refinement which diminishes the friction at *y*, while it introduces an infinitesimal error of the second degree. To the end *y* he has attached Watt's parallel motion, as represented in fig. 177; *s g g s* being the radius bars, and *g y g* the connecting link on a small scale, the point *y* is by this parallel motion guided in the horizontal direction. Instead of this refinement, which only produces infinitesimal error, we propose, if it were required, to preserve the principle without error, and to introduce only infinitesimal friction. This we accomplish by placing a secondary geometrical motion like the primary one upon the point *y*, fig. 176, so that its motion may take place in a perfectly straight line. The effect of the friction will thus become an infinitesimal of the third order. These last refinements are, however, of a higher order than the degree of practical precision in the steam-engine usually requires.

Fig. 174.

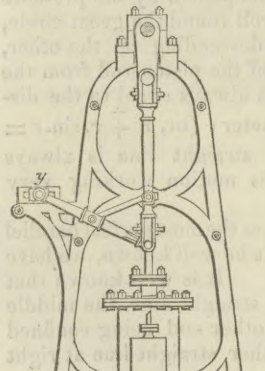


Fig 175.

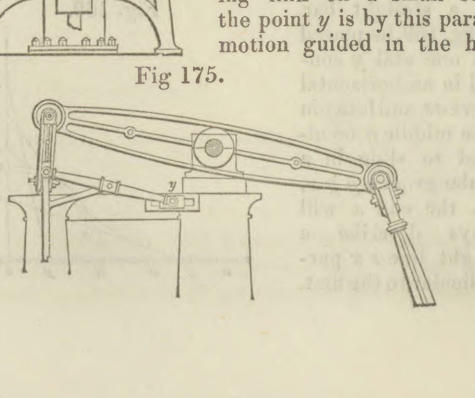


Fig. 176.

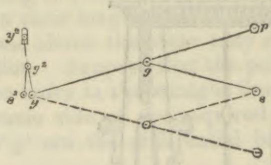
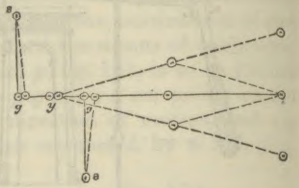


Fig. 177.



Effect of the o- necti- rod.

Such is the mechanism which the obliquity of the direction between the connecting-rod, or link, renders necessary to prevent any of the motion, propagated through them, from being expended in producing oblique transverse motion in the top of the piston-rod. Still, however, the motion of the piston-rod is modified by transference in an oblique direction, and we have now to consider the nature of that modification. Suppose the crank O R to be in the position in the diagram fig. 178, where the connecting-rod *p* R is at right angles to it, then the connecting-rod *p* R makes with the piston-rod P*p* an angle O *p* R or θ. The force F therefore, acting along the piston-rod P*p*, being represented by the length of *p x*, and *x y* and *p y* being drawn parallel to R *p* and R *x*, we see that the line *x y* or $p\,R = \frac{F^1}{\cos.\theta,}$ represents the force in the piston-rod along the crank-rod, tending to make it revolve, while $p\,y = R\,x = R\,p\sin.\theta = F.\frac{\sin.\theta}{\cos.\theta}$ represents the amount of pressure sustained by the parallel motion.

Fig. 178.

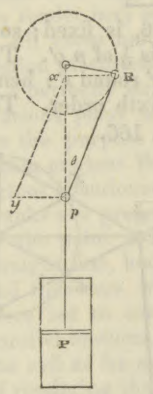


Fig. 179.

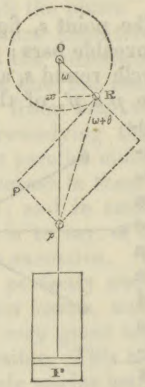
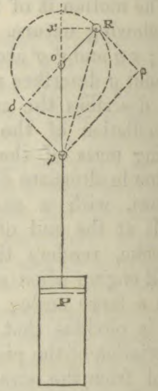


Fig. 180.



Thus we have a true representation of what takes place when the connecting-rod, instead of being in a line with the piston, or parallel to it, is at right angles to the crank; and in this case the whole force communicated in this oblique position to the crank-rod, acts immediately and entirely in turning round the crank. But at other points, such as are given in the two succeeding figures, the motion is again modified by the obliquity of the direction of the connecting-rod *p* R to the crank O R. If O R be prolonged to S, and from *p* a perpendicular dropped upon it, and the parallelogram R ρ p σ completed, we shall have the diagonal force p R resolved into R σ and R ρ; whereof R ρ alone tends to turn round the crank, R σ producing only pressure towards the centre. In this case the angle p R σ is equal to the two interior angles of the triangle p R O, that is to $\omega + \theta$, the sum of the angles of the connecting-rod and crank with the line of the piston. Hence the whole force in the connecting-rod becomes resolved into p R. cos. $(\omega + \theta)$ and the whole force of the steam on the piston-rod becomes on the extremity of the crank F. $\frac{\cos.(\omega + \theta).}{\sin.\ \theta.}$

The Piston.—The next elementary part of the steam-engine, upon which much of the efficiency of its operation depends, is the piston. Pistons were at first very rude implements for steam to work with. A large block of wood cut round to fit the inside of the cylinder, and driven very tight so as pretty nearly to fill up the cylinder, was considered a sufficient obstacle to resist the passage of the steam, until it had performed its duty, either of driving the piston from the bottom to the top, or from the top to the bottom of the cylinder. It next became usual to cover this piston with leather; but the heat of the steam soon dried up the leather, and deprived it of the requisite pliability. The next step was to make the piston of metal, like the piston of Otto Guericke's atmospheric engine, and then to make a groove around this piston, which was filled with bands of plaited hemp, now technically called a gaskin, so put together as to be spongy and elastic, and to interpose this elastic substance between the piston and cylinder, so that the hemp, yielding to the inequalities of the cylinder, should fill them up without permitting the steam to escape. This has been successfully used for a long period, and, where the cylinder is in good condition, used with advantage: and it is still very extensively employed. Instead of using a solid piston with a groove for the hempen packing, it was found better in practice to contruct the piston as shown in fig. 182. The lower part of the piston is formed of a plate attached to the piston-rod; the under edge of this plate is of a diameter a little less than that of the cylinder, and it gradually curves inwards, so as to form the lower portion of a groove for the packing. The upper part of the piston consists of a plate with a similarly curved rim, completing the groove. This upper plate is called the piston-cover, and is attached to the lower plate or body of the piston by screws. In the groove are carried round bands of soft plaited hemp or gaskin, which fill up the cavity; and as the gaskin wears, the upper plate is screwed closer to the lower one, and forces the packing against the sides of the cylinder. The piston is represented *in situ* in figure 184.

Fig. 182.

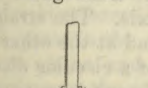


Fig. 184.

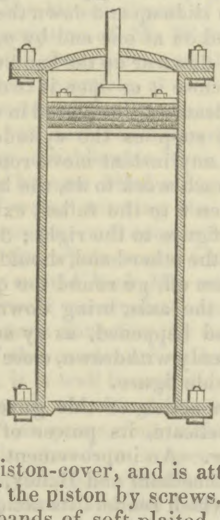
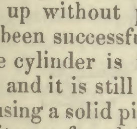


Fig. 183.



The Piston.

The only fault of this hempen packing is its liability to wear out, and become rigid and unelastic. A plan was next adopted of protecting this hemp, and still using its elasticity. Around the piston, in front of the packing and enveloping it, two brass hoops, fig. 186, with slits in them, were placed, to protect it from contact with the cylinder. These slits allowed the hoops to enlarge and contract their diameter, in correspondence with the inequalities of the cylinder; while by the elasticity of the hemp, they were kept continually pressed out in contact with the surface. This simple metallic packing is represented as applied to the piston in figure 185.

Metallic Packing.

Fig. 185.

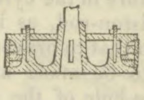
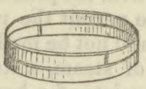


Fig. 186.



A still more independent metallic packing is produced in the following manner, so as to dispense altogether with the elastic action of the hemp. Large metallic belts of considerable thickness are cast, so as to form solid rings, about a hundredth part greater in diameter than the inside of the cylinder they are to fit, and turned on a lathe truly cylindrical to that diameter. A small portion is then cut out of the circumference of each ring, so as to make them open hoops like those represented in the last figure; and the two open ends are then forcibly brought together, until their diameter is just such as to admit them into the cylinder, their ends being now in contact so as to form complete rings, and they are again placed in the lathe and turned truly cylindrical. By this arrangement it is brought about, that the elasticity of the rings continually urges them outwards, towards their original diameter, and so dispenses with the elasticity of the hemp, forming a packing wholly metallic. This is employed on a large scale by some of the very best engineers in this country, and is greatly to be recommended for its simplicity. Of course the break in the ring would allow steam to pass; but this is avoided either by interposing a metallic tongue at the break, or by using a number of rings, so that the break in one of them may be opposite to the sound portion of the other.

Wedge Piston.

Another form of piston may be called the wedge metallic piston. The rings are cut into a number of parts, and are pressed upon the cylinder by wedges, which again are kept in their places by springs; and so it is supposed that a more perfect adaptation is gained of the parts of the ring to the cylinder. This is certainly the case; but the ring is much more complex than in the other form:—

Figs. 187.

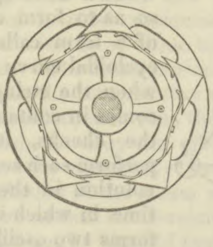
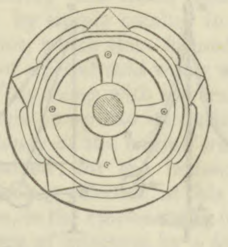


Fig. 188.



In fig. 187, wedges are shown to be inserted behind the rings, with springs behind them, forcing them outwards; and in the figure 188, a single elastic hoop is substituted for all those springs. Springs without wedges

Steam-Engine.

are also in very common use for metallic pistons with divided rings, double sets of rings being used, and the springs pressing directly on the segments of the metallic rings, as in figs. 189, 190.

Fig. 189.

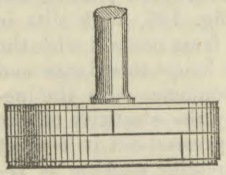
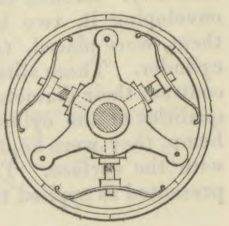


Fig. 190.



The Stuffing-box.

A stuffing-box is an apparatus used in immediate connexion with the piston. A simple aperture in the cylinder-cover to permit the passage of the piston-rod, as in fig. 191, could not be made steam-tight: so that to prevent the escape of steam, a stuffing-box has to be made use of. This consists of a box cast round the hole of the cylinder-cover, fig 192, in which is laid, around the piston-rod and in contact with it, a large quantity of hempen packing. This packing is lubricated with oleaginous matter, and the ring, fig. 193, is then placed on the top of this matter, and pressed hard down upon it by screws, so as to squeeze the stuffing into every crevice. Stuffing-boxes of this description are employed wherever it is necessary to pass a rod out of a vessel, or into it, without permitting the escape of the steam. Thus there is one at the entrance of each valve-rod into the steam-chest of the cylinder valves, and also, wherever a rod passes into the interior of a boiler.

Fig. 191,

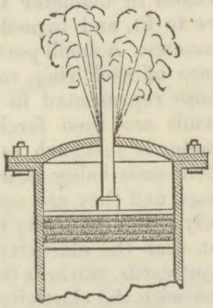


Fig. 192.

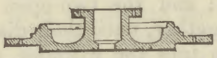


Fig. 193.

The Steam-Engine Governor.

The governor is an appendage to a steam-engine, of much value in all its applications to the production of uniform revolving motion. It is merely a modification of an apparatus similar to the pendulum, and by which Huyghens once attempted to make a time-keeper instead of the common pendulum. If we suppose the axis A *x*, fig. 194, to revolve on its centre, and the ball B hung by a thread from *x*, two pieces of iron, *x* C and *x* C, being bent so as to form cheeks of a form called the cycloidal curve; then when the string B *x* comes in contact with the cheeks, it will perform each semi-revolution in the same time in which it performs two oscillations as a common pendulum; that is, if it be 39.1 inches from the centre of B to *x*, the pendulum will revolve once in two seconds. If, however, the ball B be suspended from *x* by a straight bar, such as B *x* in the next figure, the line B *x* in deviating from A *x* will describe the circular arch A B, instead of a cycloid as formerly, and the time of oscillation will vary as the ball recedes from A, the revolutions being more rapid at *b* than at B. If in the position B, the line *x* C be 39.14 inches, then will the revolution be performed in two seconds, or at the rate of 30 revolutions per minute; while at *b* they will be performed in less time, and between B and A more slowly; and in general to find the height C *x* for any required number of revolutions, it is only necessary to find by the rules for calculating the rates of the pendulums of time-keepers, what length of pendulum will give double that number of beats per minute, and that is the desired height for C *x*. The rule for this purpose is easy. Divide the number 35226 by the square of the number of revolutious per minute, and the result is the height C *x*. Thus to find the length of A *x* for 30 revolutions per minute:—

30 squared = 30 × 30 = 900)35226(

required height = 39.14 inches.

The required regulation is effected in the following manner:—

Fig. 194.

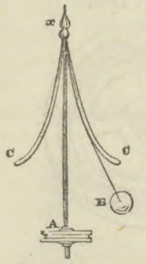


Fig. 195.

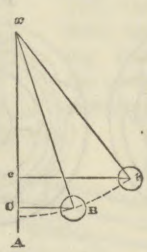
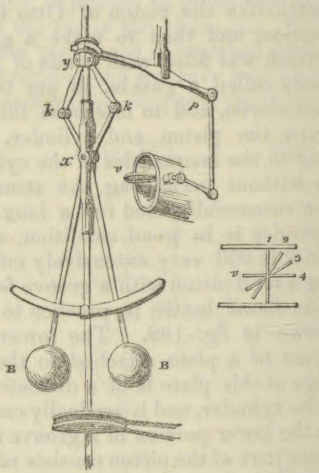


Fig. 196.



The balls B B, fig. 196, are suspended by rigid bars from the centre *x*, and are prolonged to *k k*. These bars are joined by links, *k y* and *k y*, to a moveable socket *y*, which can slide up and down the axis. The straight lever *y p* is acted on at one end by *y*, and at the other it draws or pushes down or up the handle of a circular disc *v*, so as either to close it or open it to different degrees; this disc is in the steam-engine placed in connexion with the steam-pipe that supplies the cylinder, so that if the engine should at any instant move round too slowly, from having too much work to do, the balls will collapse, raise up *y*, and open *v* to the fullest extent, as at 4, in the small sectional figure to the right; 3 being the mean position; while, on the other hand, should the engine, from its work being taken off, go round too quickly, the balls would fly off from the axis, bring down *y*, close the valve to 2; or if it had happened, as by an accident, that the load was suddenly withdrawn, close the valve altogether, as at 1 in the side figure.

But the action of this governor is not always sufficiently delicate, its power of adjustment being somewhat slow. An improvement has been made upon it by Messrs Cheetham and Bailey, of Staley Bridge, in Lancashire, which renders its action much more rapid. On the centre of the throttle-valve, as the disc *v* in the steam-pipe is called, there is placed an iron tube, like a gun barrel, partially filled with mercury. When this tube is held perfectly horizontal, an equal quantity of mercury lies in both ends; but, on the contrary, when the slightest inclination is given to either end, the mercury instantly preponderates to that lower end, and suddenly changes its inclination in either direction. In practice I have seen this work well.

Condensing Apparatus.

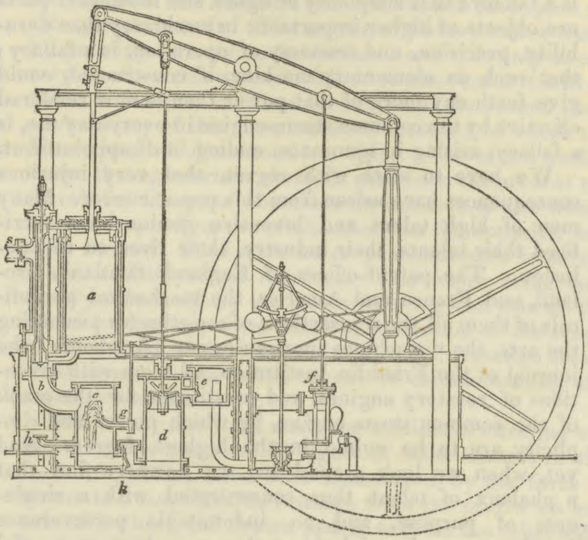
Of Condensing Apparatus.—The parts of the condensing steam-engine which we have hitherto examined, are in all respects identical with those of the high-pressure steam-engine. The characteristic difference consists in the manner in which the steam is disposed of after having produced its effect, and in the apparatus required for the purpose. In the high-pressure steam-engine, the steam is discharged from the cylinder simply by allowing the entering steam to press the piston upon the outgoing steam, and force it through the eduction-pipe into the open air. Now, it requires considerable force to effect this; we know that the atmosphere must be pushed away before the steam with a force equal at least to 15 lbs. on each square inch of the surface of the pipe; and, therefore, this amount of the force of the steam, which is a balance for the air, that is, an atmosphere of steam, is consumed or thrown away in this employment. In the condensing steam-engine this atmosphere is saved. The steam is annihilated almost instantaneously. A vacuum is formed on one side of the piston by this annihilation, and the steam is allowed to employ that part of its force, which formerly was spent in the useless labour of forcing the steam into the air, in forcing the piston through the performance of useful labour.

If, therefore, we take a high-pressure engine, such as we have already described, and if we desire to form it into a condensing steam-engine, we must add to it a large reservoir of cold water, named the cold well, such as is described in one of Watt's steam-engines, in the historical part of this article; and in this reservoir we must place a close vessel having an aperture or small pipe in it, from which a jet of water shall play and spread over the interior, so as to form a condenser, into which shall be conducted the eduction-pipe, by which the steam is led out of the cylinder. The quantity of cold water thrown into this vessel to cool it, will require to be six or eight times as much as is boiled off in the shape of steam. Attached to the condenser is a blow-through valve, opening outwardly, which allows the whole condenser, before starting the engine, to be filled with steam, so as to blow out at the valve all the air that may have previously got into it. The reader is referred to the historical part of this article for those parts in the description of Mr Watt's engine, and also to plates, and their descriptions of the parts of steam-engines at the end of the article.

It must already have occurred to the attentive reader, that such a condenser as has now been described could not act efficiently for any considerable time. On the contrary it would rapidly become filled with water; for it is plain that the jet of water entering the condenser will fill it up at last with water; and even were this not the case, it is plain that the whole steam which passes through the engine being turned back into water in the condenser, this water would accumulate and fill the condenser. This water must therefore by some expedient be removed out of the condenser without admitting the air. And again, it is well known that all water contains a large quantity of air mingled with it, and permanently retained in its pores, but which escapes from it the moment it is placed in a vacuum. Now this air would of itself accumulate rapidly, to such an extent as to fill up the vacuum of the condenser and render it inefficient. Air must therefore be removed out of the condenser, along with the accumulations of injection water, and the condensed water of the steam; and therefore an air-pump must be provided, capable of removing air and water from the condenser. This air-pump is placed beside the condenser in the cold well, communicating with it by a foot-valve, which permits the air and water to go out and prevents their return, and delivering that air and water which it removes into another smaller reservoir, named the hot well, from the circumstance that the water withdrawn from the engine has been made warm by contact with the hot steam which it has condensed, and which it does not generally cool to a lower temperature than 80° or 90°.

These appendages of the condenser, the cold well, the injection-pipe, the air-pump, the hot well, the blow-through valve, the foot-valve, the delivering valve, &c., are represented in the following diagram, in a usual arrangement.

Fig. 181.



a is the cylinder, *b* the eduction-pipe, *c* the condenser, *h* the blow-through valve, *g* the injection cock and pipe, *k* the foot-valve, *d* the air-pump, *e* the hot well, *f* the cold-water pump.

The reader will find other arrangements of these parts in the plates and their descriptions. The air-pump is generally worked by the great beam of the steam-engine, as in the figure, and is about half the area and half the stroke of the cylinder of the engine.

The cold well requires a continual supply of water, either from a running stream, or to be forced up by a pump like that marked cold-water pump in the figure.

Dry condensation is a subject which has attracted much attention from machinists; that is to say, it has been considered very desirable to condense the steam without injecting water amongst it. Mr Watt originally condensed in this manner. He merely placed upright pipes among cold water, and letting the steam into them, allowed it to be condensed by simply coming in contact with the inside of these tubes, which thus formed a condenser. The introduction of a jet of cold water was thus avoided, the introduction of air along with the water was also avoided, and thus the air-pump had its duties much diminished. But the efficiency of the engine was found to be very materially impaired; for the instantaneous annihilation of the steam was not effected, in this process of mere surface condensation, in the efficient way in which it had been by the old system of injection by a *jet d'eau.*

ON THE ROTATORY STEAM-ENGINE.

The steam-engine being now most generally used in our workshops, our manufactories, our steam-ships, and our locomotive engines, for the purpose of *turning round* certain axles or wheels with a continuous whirling or revolving motion, it has appeared to many the simplest, the most elementary, and the most appropriate manner of applying the moving power, that the steam should itself follow the wheel which it turns, round the circumference of its circle of gyration, and so it is supposed, by acting immediately and directly on the wheel to be turned round, produce the most powerful effect. In this way the action of the steam would be made to resemble the turning of a mill-wheel by the action of the water on the buckets of its rim; and the arrangements by which such an elementary mode of action might be brought about, form what is called a ROTATORY STEAM-ENGINE.

Fallacies of the Rotatory Steam-Engine.

That simplicity of form and of outline are essential to simplicity of action, and excellence of mechanical action, is a fallacy; that simplicity of figure and fewness of parts are objects of higher importance in machinery than durability, precision, and economy of operation, is a fallacy; that such an elementary machine, if constructed, could give forth any more of that power than is now rendered effective by the common steam-engine in every-day use, is a fallacy, arising in ignorance, ending in disappointment.

We have to state with regret, that very injurious consequences have arisen from this popular error. Many men of high talent and inventive genius have sacrificed their talents, their industry, their lives, to this delusion. The patent-offices of England, Scotland, Ireland, and France and America, the mechanical periodicals of them all, the transactions of societies for promoting the arts, the "machines approuvées par l'Académie," the journal of the Franklin Institution, all teem with inventions of rotatory engines, and substitutes for the crank of the common steam-engine, by which power and simplicity are to be united in the highest degree. And yet, when we look around us, we nowhere find that a phalanx of talent thus concentrated with a singleness of purpose, and an indomitable perseverance worthy a more hopeful object, has ever been successful in producing one form of mechanism to stand in competition with the common every-day reciprocating engine, with its crank and its fly-wheel and all its much condemned appendages. In this country alone a crowd of inventors have not only proceeded so far as to expend their ingenuity, labour, and money, in inventing and constructing machines of this class, and making them the subject of experiment, but more than a hundred of them have actually laid out in succession four or five hundred pounds a-piece in procuring the royal grant of monopoly for their valuable contrivances. We feel it, therefore, to be our duty to give a full and uncompromising exposure of the fallacies of the rotatory engine. We regard such a fallacy as a grievous obstruction to the advancement of the arts and the industry of Great Britain. It is to the prevalence of ignorance on this subject, that much of the misdirection of mechanical talent, in so far as it has been applied to the improvement of our prime movers, is to be attributed. Again and again, year after year, do we find the same machine invented and re-invented, and the same experiments repeated and the identical failures encountered. Of these failures, however, there is only a small number comparatively which comes before the public. Those alone which obtain patents are dragged into light; and of these we are only left to infer the subsequent failure, from the circumstance of discovering that their existence is recognised nowhere except in the parchments of the Patent-Office. It is indeed a matter of general regret, not limited to the subject of rotatory engines, that false pride should prevent men from publishing the results of such experiments as may not be perfectly successful in accomplishing the objects originally intended. It should be recollected, that, as evidence of the truth or falsehood of some great principle, no experiment is valueless, if simply and faithfully described; and that, if it do not serve as a signal-post to point the way to truth, it may at least prove useful as a beacon to warn from the path of error. It is to unsuccessful experiments that we owe many of our most valuable scientific discoveries. The failure of an attempt to make a sucking pump more than 33 feet long led to an acquaintance with the doctrine of atmospheric pressure, and opened a new field of research to the genius of Galilei, Torricelli, and Boyle; and Sir Humphrey Davy is reported, on an occasion where he was shown a dexterously manipulated experiment, to have exclaimed, "I thank God I was not made a dexterous manipulator, for the most important of my discoveries have been suggested to me by failures." Thus we find that the record of error may often prove a contribution to truth; and the man who is sufficiently unselfish to impart to others the benefit of such experience, is the disinterested friend of science. Had all the failures of the rotatory engine been publicly recorded, that avenue of misdirected effort would long ago have been closed.

Prevalent ignorance of what has already been done.

Our present object is to bring together, and place under the eye of the reader, all that has been done upon this subject, the attempts that have been made, and the failures of those attempts. We shall thus show that the attempts at a successful rotatory steam-engine which are every day produced, are mere repetitions of experiments which have long ago been tried in circumstances precisely the same, and have long ago hopelessly failed and been abandoned: that these attempts were made in circumstances that were well suited to ensure their success, had success been possible. Let it be recollected that the only office performed by machinery, is the transmission of power from an animal or element, and never the creation of power. It can modify motion in direction, velocity, and force, so as to expend itself in one manner rather than another, but it can never create motion or generate power. This is true, or all the experience of the laws of matter which has been obtained since the use of inductive philosophy is false. Solid matter may obey force and modify it, but can never create power. The only enquiry to be made, therefore, in regard to any engine is this: when force is applied to the machine, whether the force of steam or any other, does it turn all the force of the agent to a useful purpose, without further diminution than is occasioned by necessary friction and resistance of the air, and the least possible loss of power by transmission? When steam bursts a boiler, or water overturns the embankment of a reservoir, the power of heat and of gravity produces its full effect; but it is not a useful effect. The object of a machine is to expend it parsimoniously in rendering the greatest portion of its effect useful. The only question entertained is, which form of engine is best calculated for converting the power of steam to a useful purpose, so as to do so with the smallest diminution in its quantity?

The common, or reciprocating steam-engine, is distinguished from the rotatory steam-engine by the nature of certain parts of its mechanism, which convey the motion of the steam to the machinery which is to be moved: these are a piston-rod and crank. Now, it is owing to a radical misconception of the nature of this elementary machine, the crank, that innumerable schemes have been devised for the production of circular motion, without the intervention of the crank, either by giving to the steam itself an immediate circular action, or by the substitution of some other less elementary mechanism between the reciprocating piston and the revolving axis, as the means of producing its rotation. In the most common form of the rotatory engine, the cylinder, piston-rod, and cranked axle are superseded by a cylinder, valve, stop, and axis. In the same way as a mill-wheel is compelled to move in a circle, either by the direct action of water or wind upon it, so is the drum, or wheel, with valves, fans, or other projections on its circumference, urged round by the force of the steam, and, enclosed in an outer cylinder, or case, gives revolution to an axis to which it is attached. This direct rotatory action of the steam will, it is imagined, give out the effect of the steam more powerfully, uniformly, and economically, than the common mode of reciprocating action when converted by the crank into revolution.

Rotatory engines may be arranged, according to their manner of action, into four classes :—

1st Class—Rotatory engines of simple emission.

2d Class—Rotatory engines of medial effect.

3d Class—Rotatory engines of hydrostatical reaction.

4th Class—Rotatory engines of the revolving piston.

As closely connected with the rotatory engines, in the fallacy which has given rise to most of them, we may add a series of inventions, forming a

5th Class—Revolving mechanism substituted for the crank.

Class I.—The rotatory engine of simple emission forms the earliest, as well as the most rude and elementary, method of giving motion to mechanism by the escape of vapour or steam. It is described by Hero of Alexandria, in his *Pneumatica*, upwards of 120 years before the Christian era, and depends for its effect upon the same principle which gives to a rocket its career, and makes a fire-wheel revolve in displaying its beautiful lights. In these, as in all instances where fire or steam or any fluid or gas is generated in a chamber, from which it is permitted to issue with violence, it will, in its exit, drive the vessel from which it issues away from it in the opposite direction; and it is, in fact, merely an application of the principle of recoil, where the gas generated by the explosion of the powder urges the ball outwards in one direction, and forces the breech of the gun backwards in the opposite one. The same recoil is felt in all cases of simple emission of a fluid from a reservoir; and if it be so arranged that water, steam, air, or the gaseous product of gunpowder, rushes out of a chamber through the arms of a revolving wheel, the openings of escape being properly directed, the recoil will urge round the wheel, and we shall have a revolving engine of simple emission. By availing himself of this principle, the machinist of Alexandria produced a working engine, merely by heating a vessel containing water and air, and allowing the vapour to rush from two opposite orifices, at the end of two arms proceeding from a sphere, which the emission was employed to move.

Instead of using the principle of recoil, the force of steam, issuing with violence as we see it from the mouth of a kettle or boiler, may be directed upon the naves of a wheel so as to blow them round; and thus we have a second variety in the manner of converting the simple issue of steam into a moving power. This second species of the rotatory steam-engine of simple emission was invented by Branca, 1629. Since that time the engines of this class have been frequently re-invented and slightly modified.

The theory of machines of simple emission has been frequently and fully investigated; and the result is, that there is no possibility of obtaining by simple emission, in the most favourable circumstances imaginable, more than one-half of the whole power of the steam, so as to make it available to useful mechanical effect. The other half is wasted in giving off its impulsion to the air, or is expended in a current equally unavailing. Practical experience corroborates the predictions of theory. Smeaton and Pelectan have made the machine of simple issue the subject of careful experiment:—3 parts out of 11, 8 parts out of 27, and 2 parts out of 5, are the highest measures of the useful effect that it has been found practicable to attain; and by no possible improvement can more than one-half of the whole power be turned to a useful effect.

Rotatory Engines of the Second Class.

Class II.—Rotatory engines of medial effect are those which do not immediately give revolution to an axis, by the action of steam upon the wheel, but have a medium of communication between the power and the effect, which medium is the direct agent in circular motion. This class of engines will be well understood, by taking as its type any simple steam-machine, such as Savary's or Newcomen's, used for raising water; which water, by falling on the floats of a common mill-wheel, will then give rotatory motion to it. The engine of Savary raises water by pressing directly on its surface; and it is only necessary to allow this water to fall on a wheel, and it will be made to revolve, and form an engine of the second class.

A variety of this class has been invented, of which the Fire-wheel of Amontons is a type. The steam pushes water through certain channels that form the arms of the wheel, from a set of chambers on one side of the wheel, to a corresponding set of chambers on the opposite, and thus the side filled with water preponderates over the other, and the wheel revolves. The water being constantly driven off by the steam from a given side of the wheel to that opposite, uniform revolution is the result of the weight of the water. In this case, although steam is the agent, water is the means of communicating the rotatory motion.

Solids have also been made the medium of effecting rotation in this manner. Weights of solid matter, in the form of pistons, have been transferred by the force of steam to a considerable distance from the centre on one side of a wheel, and drawn nearer to it on the other side, so as, by bringing about a continual preponderance of one side, to effect a revolution. Watt and De Witty have designed arrangements of mechanism of this nature.

In this class of engines the loss of effect is manifest; for it is necessary that the steam, in order to produce the circular motion, shall give out its force in setting the medium in motion, and in overcoming the very great resistance of the liquid in all the pipes and passages and valves, through which it is transmitted to alternate sides of the wheel in every revolution. The force thus subtracted from useful effect, is power lost.

In those which move weights from and towards the circumference, there are mere groups of reciprocating pistons, without cranks, and partaking of the defects to be explained in Class V. In fact, in the engines of Watt and De Witty of this class, we have a number of reciprocating engines ranged round a wheel to do the work of one.

In the case of the fluid medium we have not only a loss of all the power expended in moving the medium itself, but also the additional loss of effect encountered in all modes hitherto adopted for applying a fluid to the rotation of a wheel; a loss, in the best examples ever presented in practice, amounting of itself to more than $\frac{1}{6}$th part of the power.

Rotatory Engines of the Third Class.

Class III.—Engines of hydrostatical reaction are more effective than either of the former classes. As invented by Watt, in 1796, this species of engine consisted of steam-vessels, in the form of hollow rings or circular channels, with proper inlets and outlets for the steam, mounted on horizontal axles, like the wheels and buckets of a water-mill, and wholly immersed in some fluid.

Rotatory Engine.

These tubular wheels were made of iron, six feet in diameter, and the reaction of mercury was employed to give revolution to them. The engine moved, but was found to be inefficient, and was abandoned, although it had been tried in very favourable circumstances. The principle of action is this. Steam is admitted into a circular channel, or chamber, on the circumference of a wheel. This chamber is partially filled with some liquid; the pressure of the steam is expended in pushing the mercury in one direction, and the end of the chamber in the opposite way; so that, while the liquid is thus forced out of the chamber, the chamber is by an equal force pushed away from the liquid. The wheel is thus moved round. It is apparent that a part of the force is employed in propelling the wheel, and the remainder is expended in overcoming the resistance of the liquid of reaction, and expelling it from the chambers, which remainder is a large portion of the power withdrawn from useful effect.

Rotatory Engines of the Fourth Class.

Class IV.—Rotatory engines of the revolving piston are constructed on a much better principle, and hold out much fairer prospects of successful competition with those of the reciprocating piston, than any of the species of the first three classes that have been already considered. In these classes the steam is not confined in rigid vessels, but its action is expended in producing currents in fluids, and expending motion in medial effects, which are useless. This is not the case in the steam-engine of the revolving piston. The steam is confined in a close and rigid chamber, and acts only on solid inflexible surfaces, and escapes along confined passages, so that its full effect may be obtained in useful work. Abstractly considered, it is an engine capable of giving out the full power of the steam, and, therefore, may fairly be imagined to come into competition with the ordinary reciprocating crank engine. The objections to it are entirely of a practical nature, and regard the engine, not in its abstract mathematical form, but as a machine made of destructible matter—of matter imperfectly elastic—of surfaces offering resistance to motion—of matter obeying the known laws of motion and rest. These objections are not the less valid that they are of a sensible and tangible, rather than a speculative description. But, as a natural consequence of the more plausible deceptions held out by this species than by any of the three preceding ones, it has followed that the fallacies of this class have been more widely seductive than the others; and many eminent mechanicians have been led astray by them. The fallacy of this class of engines we shall expose in conjunction with the next class, as the same misconceptions lie, to a considerable extent, at the root of both.

Rotatory Mechanism of the Fifth Class.

Class V.—Revolving mechanism substituted for the crank of the common steam-engine, for the purpose of obtaining from the reciprocating piston a rotatory effect otherwise than by the crank, and in a better manner than by the crank, forms a class of inventions involving fallacies similar to those in which the revolving piston has originated. These two may therefore be considered together.

Although the name of Watt has been included in the list of inventors of substitutes for the crank, it should be observed that he was only driven to the invention of a substitute by the circumstance of a patent having been previously obtained for the crank in its simple form; and that he abandoned his beautiful, but more complex, mechanism on the instant that the elementary crank was released from the fetters of monopoly. It is due also to his memory to say, that the sun and planet wheel, which he substituted for the crank, is a disguised crank, possessing all the valuable properties, excepting simplicity and smallness of friction, which give to the crank its present eminence as a mean of obtaining rotatory effect. It is remarkable that the fallacies regarding the now universally employed crank were coëval with its first suggestion as the vehicle of rotative steam power. John Stewart, in describing his mechanism for this purpose, in the Philosophical Transactions, 1777, observes that “the crank or winch is a mode of obtaining the circular motion which naturally occurs in theory, but in practice it would be impossible, from the nature of the motion of the engine, which depends on the force of the steam, and cannot be ascertained in its length; and, therefore, on the first variation, the machine would either be broke to pieces or turned back.” Mr Smeaton agrees with Mr Stewart on the inapplicability of the crank; but adduces another objection, “That great loss would be incurred by the absolute stop of the whole mass of moving parts as often as the direction of the motion is changed, and that although a heavy fly-wheel might be applied to regulate the motion, it would be a great encumbrance to the mill.” In such phrase of evil omen was it thus confidently predicted that the simple means now in every-day use for the communication of steam power to revolving machinery would either be attended with great loss, be very desultory in its action, or altogether break the machine to pieces. At that time, however, the crank was not in use; but the very same objections are still urged by those who have, every day, before them the practical confutation of their assertions.

Steam Engine

Rotato Engine

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I. In the abstract and purely theoretical view of the subject, it can be shown that the present mode of applying the steam possesses none of the disadvantages, and that the rotatory mode possesses none of the superiority attributed to it.

In making the comparison between the rotating and reciprocating piston, let it be supposed that the vessels containing the steam are equally rigid, equally perfect in their form, and are equally divested of friction, and that there shall have been obtained for the steam a *point d'appui* as satisfactory in the case of the rotatory, as that which the reciprocating engine possesses in the ends of the cylinder; then, upon this hypothetical condition, neither engine will excel the other, each will move over a space with a power and velocity proportioned to the steam which it makes use of, and that engine will do most work which uses the greatest quantity of steam.

Fund menta princi *vis vi*

The great fundamental principle in the construction of machinery is, that the work done depends in quantity only upon the quantity and velocity of the power applied, and not at all upon the form of the machine; in other words, that a machine has no power, either of consuming or creating motive power; that it can only transmit it; that it can only modify it to suit particular purposes; and that what it loses in pressure it will gain in velocity; this is on the supposition, of course, that the machine is perfectly well made, without friction, and without permitting the escape and waste of power in some effect not conducive to the end in view. Setting out, then, from this great fundamental principle of virtual velocities, we might satisfy ourselves with asserting the truth we now wish to establish as a simple self-evident deduction from it, and conclude that from this great principle of virtual velocities there could not possibly be loss of power by the crank steam-engine.

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This summary process would not, however, satisfy the enquirer or inventor who has taken the erroneous view of the subject, unless he were given to understand how this great doctrine may be made to bear on the peculiar difficulties of the case. He will return upon us with the question—“How is it that, in the common crank, we are able to show that, at two given points in its revolution, the position is such that an infinite power would produce no effect at all; that there are only two instants of time in which the force and its effect are equal; and that, at every other point, the pressure given out by the steam to the crank is less than the original pressure of the steam on the piston? How is this inconsistency to be reconciled?" We think it right to give a direct answer to this question, because a considerable authority, Mr Tredgold, has committed a grievous error in reporting, and apparently demonstrating, that the rotatory and crank engines actually differ in theory in the proportion of 3 to 2 — the proportion being against the rotatory engine; whereas, if they be not equal, our whole system of mechanics since the time of Galileo has been resting on a fallacy.

Let it be recollected, then, that at the two extremes of the line of centres the greatest loss is said to take place. Now, here the fact is, that it is impossible there can be loss of power, for there is no power at all exerted; there is no steam in action: it is forgotten that, at this point, the communication which supplies the steam from the boiler has been cut off. The steam on one side of the piston having done its work, only waits to be released from the chamber, and escapes on the instant of the opening of the eduction-valve, and at the same instant is in the act of being permitted to enter on the opposite side, for reversing the motion. At these points, therefore, all application of force has ceased, and arrangements are making for reversing the motion; and, as no power is applied, none can be lost.

In regard to the remaining points of the circle, at which it is said that power is lost, it is easy to show that the velocity imparted to the crank is such as to be an exact equivalent to the force which is apparently lost. The following table presents the results of very accurate calculations of power and velocity, showing that the velocity at a given point in the circle is increased exactly in the same ratio as the force or pressure is diminished, so as at all times to present the same dynamical equivalent. The table extends from one neutral point to the other neutral point of the orbit of the crank, comprehending a semicircle divided into ten equal parts. The first column indicates the point in the semicircle at which the force and velocity are estimated; the next column shows the percentage of the direct force of the steam on the piston, which is given out in pressure upon the crank of the engine; and the last column, the velocity given out at each point.

Place of the crank.	Per centage of power given out in pressure.	Relative velocity.
0°	0.00	Infinite.
18°	30.90	3.236
36°	58.78	1.701
54°	80.90	1.236
72°	95.11	1.051
90°	100.00	1.000
108°	95.11	1.051
126°	80.90	1.236
144°	58.78	1.701
162°	30.90	3.236
180°	0.00	Infinite.

From this table it is evident that when we take note, as we must do in every correct estimate of power, both of force and velocity, the crank has at each point the equivalent in greater velocity for less force.

The numbers in the second column also represent the velocity of the piston in relation to the crank, so that when the velocity of the crank is uniform, the velocity of the piston, or the steam consumed, which is proportional to its velocity, is in the exact ratio of the pressure on the crank.

The last consideration which we shall submit upon this part of the subject is, that if the average of the pressures on the crank be taken for every point of its orbit, it will amount to about 63.3 per cent. for the whole circumference of the circle. Now, as the same circumference of the orbit of the crank is greater than the stroke of the piston in the cylinder, the whole space described in a given time by the crank is greater than the whole space described by the piston, also in proportion of 3.1416 to 2; so that if we combine the greater length of the whole orbit with the force on it, we shall have an exact equivalent to the greater force on the piston moved through a smaller space.

The error of Mr Tredgold lies, not in his estimate of the effect of the crank, but in his estimate of the effect of the steam in the rotatory engine. By a strange oversight, he gives a statement of its power as much over the truth as that of the crank is generally stated under the truth. We admit that, in the first abstract view of the subject, the rotatory is theoretically a perfectly efficient propagator of power, and we have merely designed to show that in theory the crank has not the faults usually attributed to it, and is also a perfect machine. We shall by and by show what the considerations are by which the impracticability of the rotatory scheme is exposed.

It appears, therefore, that the power of steam is by no means disadvantageously applied through the medium of the crank in the ordinary way, because, 1. the velocity of the crank is in the inverse ratio of the pressure upon it; 2. because the mean pressure on the crank during the whole revolution is less than the pressure on the piston, only in the proportion in which the whole space moved over by the latter is less than the space described by the former, so that the whole effect is equal to the whole power; 3. because the steam is not at all expended at the neutral points, and because its expenditure is at every point exactly proportioned to the pressure which it gives out, the velocity of the piston being in that ratio. In theory, therefore, the ordinary crank possesses no inferiority to the rotatory machine, as an engine for applying the power of steam to revolving machinery.

Practical View of the Rotatory and the Common Crank Engine.

II. In a practical point of view, it may be shown, that the rotatory steam-engine is greatly inferior to the common reciprocating crank-engine in simplicity of parts, easy construction, cheapness, amount of friction, compactness, precision and uniformity of work, and durability and economy in use; and that it does not possess any of the peculiar applicability that has been attributed to it, to the great purposes of inland navigation and railway transport.

1. Simplicity. — A little unfairness is sometimes inadvertently used by inventors of rotatory engines, in making comparisons with their machines and the common crank-engine; they select the large beam-engine with all its conveniences and appendages, and compare it with the simplest form of the rotatory engine; but in justice we may be allowed to take the simplest form of both. Now, there is a simple form of engine used both in America and in this country, of the oscillating species as it is called, and this species of reciprocating engine consists only of the following parts:—cylinder, piston, and cranked axle; there are no valves or further mechanism of any kind, so that where simplicity is the first great requisite, this kind may be used with advantage. The rotatory engine of the most simple species must have its drum, diaphragm, piston, and axle.

If we take those forms of the rotatory engine which require valve-gear, air-pump, condenser, force-pumps, &c., such appendages will have no advantage of any kind, in either form; but in working the pumps which are themselves reciprocating, the reciprocating engine will have the advantage of more direct, immediate, and simple action; for in the rotatory engine additional mechanism is necessary to convert the revolving motion into one calculated for reciprocating pumps.

2. In ease of construction the simple form of reciprocating engines incomparably excels the rotatory. To possess equal powers, the rotatory drum would require to be of much larger diameter than the reciprocating cylinder; and the difficulty of construction increases in a high ratio with the diameter. The diaphragm is also a sliding or revolving piece of mechanism, whose rubbing surfaces require the greatest precision of workmanship. The revolving piston is also a practical problem of the greatest difficulty, and one which has never been satisfactorily solved; for if it be rectangular with plane surfaces, it is scarcely possible to make its surfaces steam tight; and if it be a circular and revolving piston, its surface and that of the drum become surfaces of double curvature, and the difficulty is then prodigiously increased. The metallic piston of the common steam-engine is the most perfect and most simple piece of mechanism, which can be made by a very ordinary workman, and which, if imperfectly fitted, will, in the progress of doing its work, become of itself every day more and more perfect. An editor of a well-known practical journal, although a believer in the rotatory engine, speaking of one of its simplest forms is compelled to admit, "that there being no mode described of making the parts of the engine steam-tight by packing, they must be all made so by accurate workmanship and grinding, the expense of which, in the outset and in repairs, would certainly be too considerable to allow it to come into competition with other steam-engines of a more common and practicable construction." His admission is equally applicable and fatal to all the forms of the engine.

3. The cheapness and first cost of the engine, will result from the two former points of inferiority, and will be further shown, from those which follow, to be greatly and necessarily in favour of the common engine. Not only are the parts, from their nature, more easy of construction, but the extent of polished surface will be shown to be much greater in the rotatory, than in the reciprocating engine.

4. The quantity of surface exposed to friction is greater in the rotatory engine. Let it be recollected that, in the rotatory engine, the piston describes the semi-circumference of the circle, while the piston of the reciprocating engine is describing the diameter of it. Let it also be recollected, that the reciprocating piston passes back through the returning stroke, over the very same surface through which it formerly descended, while the rotatory piston necessarily revolves over a new surface, forming the other semi-circumference of its orbit. Let it also be recollected, that the form of the reciprocating cylinder may be so proportioned, that it may have a minimum of surface, while the length of the circuit of the rotatory piston prevents the possibility of giving it a proportion to the radius of the piston by which this object would be attained; for it would be equivalent to making a circle whose diameter should be equal to its circumference, which is impossible. It is impossible, therefore, that the friction can ever be as small in the rotatory as in the reciprocating engine.

5. Compactness.—It follows in like manner, that the bulk and space occupied by the rotatory engine must be greater than in the reciprocating engine; for in the one case the piston must describe the circumference of a circle, whose diameter is greater than twice the radius of the piston, and in the other case it is only necessary that the piston pass through the diameter of it.

6. In precision and uniformity of working, its inferiority will be rendered manifest under head III., when the peculiarities of the crank are explained

7. In durability and economy in the wear and tear of ordinary working, the rotatory must, from certain elements in its constitution, be necessarily far inferior to the common engine. It contains in the very nature of its action, elements of speedy destruction and expensive and frequent repairs, so that it can never become an economical engine. Before proceeding, however, to demonstrate the cause of this inferiority, the fact of this inferiority, as existing in all previous engines, we shall adduce from the unwilling evidence of a friend to rotatory engines. Speaking of Mr Halliday's engine, he says that, "the extreme accuracy and nice fitting of parts necessary for it, will make it very difficult to execute and very easily deranged. Rotatory steam-engines possess considerable advantages both as to speed and economy of power, and would therefore be preferable if they could be made to work as well for a continuance, and be as easily kept in good order as common alternating steam-engines; but from their being so very seldom used, we apprehend that this is very far from being the case with any of them at present, and that the production of a rotatory steam-engine possessed of these necessary qualities, is still an object of research." So far the Editor of the Repertory of Arts, in testimony that the rotatory steam-engine *never has* been made to work durably and economically; we now go on to show that it *never can*.

It is essential to the durability of a machine that its parts should wear uniformly, and that, if possible, the mere process of wearing should make them fit each other more closely. This is pre-eminently true of the piston and cylinder of a common reciprocating steam-engine. Its piston, cylinder, and valves fit more closely as they wear, and are worn with perfect uniformity, so as not to require repair until, by long working, the whole thickness of matter in action shall at length have been consumed. This is the perfection of mechanism, and is admirably exemplified in the metallic piston of a steam-engine, which, working night and day, will require no repair of any kind until, after a long period of years, the whole strength of the metallic rings shall have been consumed.

In the very nature of the rotatory piston, this uniformity of friction, this increasing adaptation of surfaces, this permanence of the best working condition is impossible. A common reciprocating steam-engine attains its best working condition after it has wrought for some years; but a rotatory steam-engine, if it have been brought by care and precision in workmanship to a state of high finish and perfect accuracy, so as to work well for a day, commences from that moment a rapid course of deterioration, every succeeding degree of which accelerates the progress of decay; a decay which can only be retarded by continual, laborious, and expensive repairs. The following considerations may render obvious the nature of the elements of self-deterioration in the constitution of a rotatory steam-engine.

Suppose two perfectly flat plates of polished metal perfectly round to be laid one upon the other, so as exactly to coincide at every point; let the undermost rest upon a table, and let the uppermost be so made as to turn round on an axis while in contact with the other, and let a rapid motion be communicated to the uppermost; let us consider what the result of the attrition of one of these upon the other will be: will they wear equally, so as to remain in a state of mutual adaptation, or will they not? Experience furnishes us with a reply that exactly quadrates with a reasonable expectation: they will not wear equally, they will not retain their form, they will not remain flat; they will wear away most rapidly at the circumference, and wear open there while they are quite close at the centre. Let it be considered that the outer edge performs a larger circuit than a part nearer to the centre; that, therefore, since all

Rotatory Engines.

the parts revolve in the same time, those nearer to the circumference move with greater velocity than those towards the centre; that the attrition is consequently most rapid at the circumference, and diminishes uniformly towards the centre of the plates; and it necessarily follows, that towards the edges the plates must commence an immediate and rapid waste, while the centre remains uninjured. This result is established as matter of experience. It is a circumstance that has caused the failure of many beautiful inventions. It is the reason why conical bearings have been universally abandoned for cylindrical ones; and it is the reason why a most beautiful class of inventions has been totally useless to the improvement of the common steam-engine; we refer to the revolving valves invented by Oliver Evans and by Murray, but now universally abandoned, in spite of their simplicity and original cheapness, on account of this inequality in the attrition of flat surfaces revolving round a centre.

The application of the result of this illustrative experiment to the subject in question is abundantly obvious. The rotatory piston is necessarily and inevitably of this nature. Performing a circuit round a centre, different portions of the bearing surfaces subjected to pressure, and necessarily in contact and requiring to be steam-tight, revolve at unequal distances from the centre, and therefore with unequal velocities; hence the circumferential surfaces, under this excessive attrition, wear more rapidly, and become unfit for use long before the central parts have suffered any sensible effect. It is to this difference of velocity and of attrition, arising from the necessary circumstance of motion round a centre, which renders it impossible to keep the rotatory engine in a working condition with advantage, and from which it follows that each day's work renders the engine less fit for the duty of the succeeding day.

8. The peculiar applicability of the rotatory form of steam-engine to the purposes of steam navigation and land locomotion, has been much insisted on by projectors of rotatory engines. To both these purposes it is, from its form, supposing it to possess no other disadvantage, most inapplicable. In a steam-vessel, it is first of all desirable to have the axis of the paddles as high as possible, and the weight of the engine as low as possible. Now if the engine be placed on an axis, which is the case in this application of the rotatory engine, one of two evils is incurred: either the axis of the wheels must be brought low, which impairs the action of the paddles, or the weight of the engines must be exalted so as to render the vessel top-heavy, unsteady, or, as it is technically called, "crank," and liable to be upset. By the ordinary engine, the axis is elevated to or above the deck, while the weight of the engine remains on the floor, at the bottom of the vessel. Again, to the application of the rotatory steam-engine to the purpose of terrestrial locomotion in propelling carriages on railways or other roads, there are insuperable objections. As the rotatory engine is placed immediately upon the axle of the propelling wheels, there can be no springs between it and the wheels, so that every jolt would derange the machinery. The weight of the engine placed on the axle would in turn reciprocate the evil by knocking the wheels to pieces. In the reciprocating engine these evils are prevented by the detachment of the engine from the axle, and the propagation of power through rods, wheels, or chains, to the propelling wheel or axis; and if any fault still remain in the principle of locomotive engines, it is the want of perfect detachment in the very respect which the introduction of the rotatory engine would render impossible.

In addition to all these obstacles which stand in the way of rotatory engines, it may be worth while to mention another circumstance of a practical nature which gives great superiority to the common steam-engine; we mean the facilities which it presents, and which the rotatory engine does not possess, for the attachment of the appendages that are indispensable to the functions of a perfect steam-engine. The subordinate parts of an engine which belong equally to a rotatory and reciprocating steam-engine are, an air-pump, a feed-pump, and a well-pump. These merely require to be attached directly to the beam of the common engine, and they are worked without the intervention of auxiliary mechanism, because the motion of the pumps is reciprocating, and the action of the steam is also in the common engine reciprocating; while, on the other hand, in the case of the rotatory steam-engine, it would be necessary to convert the revolving movement, by a crank or other more complex mechanism, into the very reciprocating effect which it is intended to supersede.

All these considerations, of a most important and immediate practical bearing, clearly prove that although, in the most abstract and elementary theoretical view of the subject, there be an apparent equality of effect in the rotatory and the reciprocating steam-engines, yet there are practical objections of an insuperable nature inherent in the very constitution of rotating mechanism, that prevents the possibility of rendering it more perfect.

The Crank considered.

III. It is lastly our duty to show that the common reciprocating crank steam-engine, not only does not possess the disadvantages attributed to it, but that it possesses certain very peculiar properties which may not have been hitherto clearly understood and defined, but which nevertheless do adapt it in so admirable a manner to the nature of steam and of solid matter, and to the necessary imperfections of all human mechanism, as to have rendered it triumphant in universal practice over every competitor.

1. It was long imagined that the transmission of power through a *crank*, or *bend*, or *handle* in an axle, was attended in the steam-engine with great loss of effect. In the opinion of such men as Smeaton, the crank was never likely to be used as the means of obtaining rotatory motion from steam; while it is this very crank that is, in our day, used alone and universally over all other methods, although a great variety of other methods have been successively invented, and finally abandoned for the simple elementary crank. Yet it is not without some show of reason, that objections have been made against the practical working of the crank. We admit that the argument was rather a staggering one, but the difficulty has lately been wholly removed.

The staggering fact, to which we refer, was this: it is given as stated by Dr Penneck of Penzance, Cornwall, in describing a substitute proposed by him for the crank. "Some have considered a wheel as one-third more powerful than the crank, and others that no power is lost by the crank; but, confining myself to *practical results*, it appears from the report of the duty of steam-engines as done in Cornwall, and published by the Messrs Lean, that the performance of the crank-engines bears no proportion to those in which no crank is employed." He then proceeds to show the advantages of his own engine, in which a ratchet-wheel is moved by an arm, always acting at the extremity of a radius, by which means he hopes to save the loss of power occasioned by the crank. The fact related by Dr Penneck was perfectly accurate. It had happened that the crank steam engines, working expansively in Cornwall, had never given out an adequate effect. That the fault did not lie in the crank, but in other parts of the arrangement, is now apparent: it consisted in the want of proper adjustments to admit of favourable action in using the steam expansively. Arrangements for this purpose have, however, been at length accomplished, and crank-engines are now in Cornwall doing the same work as the average of those that have no crank. We have before us the printed reports of last year, stating the duty done by the crank-engines of Charleston and Wheal Kitty, constructed by Mr Sims. We have also before us indications of the *actual pressure of the steam on the cylinder*, as obtained by a very accurate indicator, applied in the course of the summer of 1837 by Mr Smith for Mr Fairbairn of Manchester, who visited the mines for that purpose, and has been kind enough to favour us with a copy of his diagrams and observations. We have thus the means of comparing the power actually exerted on the piston with the work done, and find the result of the comparison to be, that *the work done is within ten per cent of being perfectly equal to the power employed.* Here, then we arrive at this conclusion, that the utmost conceivable reach of improvement in the mechanism of the steam-engine, if it even attained to perfection, would not save more than a few per cents. That the crank engine is, therefore, as at present used, as near in practice to the perfection of mechanism as any thing we can hope to obtain, is, we think, satisfactorily explained.

2. The crank, as a means of converting the reciprocation of the piston of a steam-engine into continuous revolving movement, possesses certain singular and beautiful properties which distinguish it from every other means of producing that conversion, and which appear to be so perfectly adapted to the nature of steam and the constitution of solid matter, that we are indebted to it materially, though indirectly, for the very great advantages which we derive from the modern steam-engine as a source of mechanical power. Let us examine into the causes of this well-established practical superiority of the crank to all other modes of producing revolving motion. Let it be observed, that in the reciprocating piston, from which the crank derives its motion, the following things take place: the piston is to be put in motion in one direction, then stopped, then put in motion in the opposite direction, stopped again, and then its motion resumed in the first direction. We shall see how admirably the crank adapts itself to these changes; so that, while the piston with which it is rigidly connected takes every velocity between its maximum velocity and perfect rest, the crank goes forward with a motion perfectly regular and perfectly unimpeded. The necessity of this gradual change from motion to rest, and a reverse direction of motion, is obvious. Matter in motion acquires momentum and cannot be stopped, but its impetus must be equally and gradually removed, otherwise these moving parts are subjected to concussion as if by the stroke of a hammer, and must either suffer injury or produce it; for, when in motion, matter requires a force to stop it equal to the force which gave it that motion. And, on the other hand, when brought to rest, matter cannot instantly be set in motion in the opposite direction without a stroke and concussion equally violent. To work smoothly, durably, profitably, and uniformly, matter must be put in motion by gentle gradations, beginning with a very gentle velocity, and gradually increasing in velocity like a body set in motion down an inclined plane, where, if it move one foot in the first second, it moves three in the next, five in the next, seven in the next, and so on: and in like manner in coming to rest, it must do so in the same gradual way in which an arrow shot from a bow vertically into the air loses its motion; for in the end of its course it moves seven feet in the first quarter of the last second of time, five feet in the next quarter of a second, three feet in the next, and only one foot in the last, and then subsides into rest at the instant before it again recommences motion downwards, which it does in a manner perfectly similar. It is required, therefore, that while the motion which the steam gives off by the crank be uniform and continuous, the parts of the engine itself shall be allowed time to be alternately brought into a state of rest, without shock, concussion, or jolt, and equally, gradually, and gently be again urged to their greatest velocity in the opposite direction. All this the crank effects with the most exquisite nicety of adjustment; it stops the piston when in motion as gently and softly as if a cushion of eider were placed to receive it; and after having brought it to rest again begins and accelerates its motion, as gradually and gently, to the highest velocity in the opposite direction. An adjustment so perfect is only possible in such a relation as that which subsists between the circle of the crank and the axis of the piston. Now if we compare this mode of action with any of the substitutes for the crank, by which it has been proposed to gain uniformity of power, we shall find that in these it would be required that the transitions from rest to motion and from motion to rest should be instantaneous; and hence such arrangements, being soon disordered, have been abandoned. It will also be found that in rotatory engines it is necessary that the transitions and changes of arrangement, where these exist, are necessarily instantaneous, or if not, that steam is lost, or that the boasted uniformity of power is sacrificed.

3. The next property of the crank, as an elementary machine for the conversion of motion, is its remarkable power of reducing errors of construction, arrangement, and execution. It is one of the highest recommendations of a piece of mechanism that any trivial errors committed in its construction shall not materially injure its efficiency; and that any slight derangement in its adjustment shall not be attended with immediate deterioration or aggravated injury; but that, on the other hand, the efficiency of the machine shall be consistent with such degrees of correctness in workmanship, and accuracy in adjustment, and care in making use of it, as are consistent with the ordinary amount of intelligence and attention of ordinary workmen; and that the progress of derangement and necessary tear and wear shall be so gradual as to give timely warning of danger, and admit of ready repair and re-adjustment. The crank is precisely such a piece of mechanism. Errors in adjustment or construction of valves and other vital mechanism, are diminished in effect by the crank one hundred-fold; the changes of the valves, the essential part of the mechanism, take place only at the top and bottom of the stroke. Now at these instants the crank is on the "line of the centres," as it is technically called; and it is just in this position that a minimum of force is made to act on the crank, so that if the valves do not open with perfect precision, but either a little too soon, or a little too late, then will such error at that part of the circuit be of comparatively trifling consequence, because then the motion of the piston is so slight, that through an arc of twenty degrees of the crank it does not describe the hundredth part of that space; and the effect of any error committed within that range, will not affect the result in the crank by one hundredth part of its full amount.

In like manner, errors in management and errors arising from wearing, are reduced a hundred-fold in effect by transmission through the crank. It has frequently been to us matter of astonishment, to see at the mouths of coal-pits, mines, and quarries, mere remnants of engines, frail rusty old fragments of iron and wood, so loose as scarcely to stand upright upon their bases, to see these superannuated drudges still performing heavy work to a very large percentage of their full power.

4. To these circumstances we may add, that it is to the possession of these properties that we may attribute the fact, that reciprocating engines are constructed of enormous weight in their moving parts, and of ponderous dimensions, without being thereby sensibly deteriorated in working. The crank acquires a slow motion at the commencement of the stroke, and an accelerated motion is thereby acquired in a manner equally gradual by all parts of the machine; and in like manner, at the termination of the stroke, it brings them to rest again in a gradation so gentle and uniformly retarded, as again to receive from them much of the impetus which it had formerly communicated. The impetus, therefore, given to the reciprocating parts is only *lent*, not *lost*.

We have thus endeavoured to expose the nature of the fallacy under which they labour who imagine that the present steam-engine, as derived from Watt, is a machine which destroys or absorbs a large portion of the power it is designed to transmit, and who look to the rotatory engine as a means of increasing the amount of the power given out in useful effect. That the rotatory engines which appear day after day are not new, we show from the fact, that the five great classes which comprehend them all have already been invented and re-invented by upwards of a hundred individuals. That their inventions have been unsuccessful, is manifest from the non-existence of their machines in the daily use of ordinary manufactures. That the failures of these contrivances did not arise from defects accidental to the peculiar arrangements and contrivances of the engine, is rendered probable by the great variety of forms in which they have been re-invented, tried, and abandoned. That they have not failed from deficiencies in the workmanship and practical details, is rendered still more probable by the circumstance of finding among the names of inventors those of the most eminent practical engineers. We have next shown, that in theory, the crank of the steam-engine in common use cannot, as has been supposed, be attended with a loss of power, as such loss would oppose the established doctrine of virtual velocities. It is also shown, from very simple and elementary considerations, that what appears to be lost in force is resumed in velocity; that in proportion as the mean force on the piston is greater than the mean force on the crank, in that proportion is the space described by the latter greater than the space described by the former; that the dynamical effect produced in a given time, is exactly in the proportion of the steam expended in that given time. And thus have we arrived at the conclusion, that the common reciprocating crank steam-engine has not the faults attributed to it in theory, and which the rotatory engines have been designed to remedy. We have next taken the practical view of the subject. In simplicity of parts, the rotatory engine has no advantage over the reciprocating piston; in difficulty of construction, the rotatory piston far exceeds the reciprocating engine: it is more expensive at the outset—it has more friction—it is more bulky and less compact—it is inferior in precision and uniformity of action to the crank-engine—and there is a radical fault inherent in the very nature of rotatory mechanism, from which it follows that the rotatory engine can never be rendered either an economical or a durable machine. We have further shown, that even if the rotatory engine could be made economical and durable, its very nature renders it unsuited to the great purposes of steam navigation and inland locomotion; objects to which it has been considered peculiarly applicable. We deemed it an appropriate and instructive conclusion to our enquiry, to examine into the action of the crank, for the purpose of discovering what those remarkable qualities are which have given to the crank of the common steam-engine its unrivalled superiority as an element for the production of circular motion, and a degree of perfection unattainable by any other mechanism. We have seen that well constructed crank steam-engines are daily performing duty which is within ten per cent of the theoretical maximum of possible effect—of absolute perfection; that this practical perfection arises from the simplicity of the crank, from its wonderful adaptation to the nature and laws of matter, and of circular motion in connexion with rectilineal motion—from its reduction of errors either in construction, adjustment, or management, so as to work well without the absolute necessity of greater intelligence, expertness, and precision than belong to ordinary workmen—and from the compensating nature of the arrangement of its structure, by which it is accommodated in a remarkable degree to the necessary imperfections of all human mechanism.

ON STEAM-ENGINE BOILERS.

The construction of a boiler must appear so simple an arrangement of materials, as to require very little ingenuity or contrivance; a large enough boiler placed upon a large enough fire being sufficient to generate any requisite supply of steam. Simple, however, as such an arrangement may seem, the best construction of boiler is a subject upon which very widely different and even opposite opinions are entertained by men of the greatest science and experience. There is perhaps no branch of practical art in which so much remains to be determined and improved, and scarcely any which science has done so little to advance. To follow servilely what has, in a given instance, been "found to answer," is the rule of the most sagacious mechanics, and the doctrine of the wisest authors. Those who have attempted to invent have commonly erred; those who have generalized have invariably been rash and unsuccessful, and their erroneous theories have led astray their followers, when they happen to have any.

The art of constructing steam-boilers is, we have said, in its infancy; but it is likely, we think, to make rapid progress. The construction of the boiler of the locomotive-engine, which every day performs what at a former period we should have termed impossibilities, exhibited a strikingly anomalous phenomenon, by which the attention of all men who thought upon such subjects was suddenly arrested: this little barrel of water generates as much steam in an hour, as would formerly have been raised from a boiler and fire occupying a considerable house. The frequent explosion of boilers, both here and in America, has also directed attention to the efficient construction of boilers. The patient experimental enquiry that has since been set on foot, must lay open the whole of the important parts of the question so thoroughly, and bring out the facts with such clearness and precision, as to lead, by safe and rapid induction, to the general principles by which we may be able to predict the result of every supposed case, and deduce safe rules for the guidance of practical men in all circumstances. The investigation of the whole subject of steam-boilers, recently undertaken in America by the Franklin Institute, has already done much to settle many points of dispute. The publication of the reports of the American and English Governments on the explosions of steam-boilers, has elicited many valuable contributions

Steam-Engine Boilers.

to the stock of knowledge; the useful practical treatise of Mr Armstrong has given us an instructive view of the state of practice in the busy district of Lancashire; the treatises of Mr Wood and M. de Pampbour on Railway Locomotives; and the papers, in the Transactions of the Institution of Civil Engineers, on the statistics of Boilers and Combustion, have supplied and discussed a large collection of important facts, that will materially assist the future investigation of the best construction of steam-boilers.

During the first period of the history of the steam-engine, the danger of bursting the boiler, and the difficulty of making it strong enough to resist the internal force acting towards explosion, and also of making the joints tight against the leakage of highly elastic steam, formed the chief obstacles to the introduction of steam as a mechanical mover.

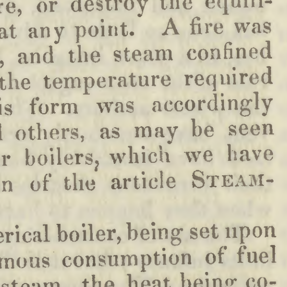
The first important point in preparing a steam-boiler is to secure strength, without unnecessary expense of materials. If we take the simplest form of vessel: suppose a simple rectangular water-tank—suppose the vessel on a small scale, made of sheet-iron, and soldered at the edges so as to form an air-tight box; then, by simply blowing into it, we shall manifest its weakness; for the sides will first of all bulge out, and, if the materials yield and allow the vessel to change its shape, it will at last swell into a globular form, with angular knobs upon it at the corners, from which pyramidal extremities, the globular parts, will finally be torn away with an explosion which will, in all probability, take place long before the vessel has attained the shape mentioned above.

The Spherical Boiler.

The globular or spherical shape was very early adopted, as one of greatest capacity, as a shape in which, the pressure at every point being equal, there remained no force tending to produce flexure, or destroy the equilibrium of strength and strain at any point. A fire was then lighted below the boiler, and the steam confined until the heat had raised it to the temperature required for the given pressure. This form was accordingly adopted by Hero, Savary, and others, as may be seen in the representations of their boilers, which we have given in the historical portion of the article STEAM-ENGINE.

It was soon found that a spherical boiler, being set upon an open fire, required an enormous consumption of fuel to raise a small quantity of steam, the heat being copiously radiated not alone to the water in the boiler, but also in very great quantity to the surrounding objects, besides being rapidly carried off by the air. To surround the spherical boiler with non-conducting substances, and to keep the flame throughout its whole extent in contact with the surface of the boiler, so as to prevent radiation to surrounding objects, and also to diminish the size of the fire by making it wind round the boiler, were the first steps towards improvement; and we accordingly find in the work of Dr Desaguliers the subsequent form of a boiler. Fig. 198 is a front view of the boiler *set* in a building of brick, a substance which is good as a non-conductor of heat, and calculated to withstand the destructive action of fire. A deep *ash-pit* lies immediately under the fire, which rests on a number of parallel iron *bars*, placed so close to each other as to prevent the fuel from falling through, and at the same time to admit between them the air requisite for combustion; and the *door of the furnace* being kept closed at all times, except when fuel is to be added to the fire, the whole of the matter of the fuel is in this way supplied with air, which passes up through the interstices of the bars. The flame, after having passed along the bottom of the boiler, winds in a corkscrew form around its sides, in contact with the surface of the boiler, in a spiral channel formed by the bricks, and called a *flue*, by which the smoke and hot air are at last conveyed into a *chimney*. A *damper*, as it is called, is formed by a small plate of iron, admitted through a slit into the opening where the flue joins the chimney; so that, by pushing this plate into the opening, the passage of the smoke out into the chimney, and consequently of the fresh air into the fire, may be obstructed, the combustion of the fuel retarded, and the too rapid generation of steam prevented. In this simple way, the attendant is enabled, by merely pushing in or drawing out the damper, to regulate with great precision the generation of the steam. The pipe which conducts the steam to its ultimate destination, is called the *steam-pipe;* and there is another pipe necessary to the continued action of the boiler, called a *feed-pipe*, through which water may be made to enter the boiler, as it is evident that otherwise the water, being continually boiling off in the shape of steam, would soon leave the boiler empty; so that a constant supply of an inch of water forevery foot of steam, or six gallons of water for every horse power, is required to enter the boiler through the feed-pipe.

Fig. 198.



The form of boiler next in simplicity to the spherical boiler is the cylindrical. From the facility with which a cylinder is made, it was introduced at a very early period. It stood upright, as in fig. 199, the fire being placed at the bottom, and the flue winding round that part of the sides covered with water. This form of boiler was found, however, to have the disadvantage of weakness in the bottom part.

Fig. 199.

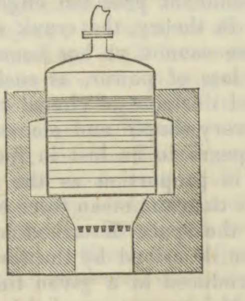
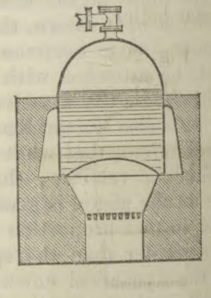


Fig. 200.



For the prevention of these two evils, the cylindrical form of boiler was very soon modified and improved by two opposite expedients, one applied at the top and the other at the bottom of the cylinder. The top being made hemispherical, possessed all the advantages of a spherical boiler; and the bottom being arched upwards, so as to present a large concave dome to the impact of the flame, this dome being sustained by the cylindrical belt round its spring, a very strong and extensive surface was obtained, as in Fig. 200.

In this cylindro-spherical boiler, it was found that the action of the flame on the upright round sides produced a very slight effect in raising heat. It was therefore desirable that the flame should be brought somewhat under the sides, by inclining them a little outwards. The boiler then assumed a form which has since become very common, and from its shape, has not inaptly been named the haycock boiler, fig. 201.

Fig. 201.

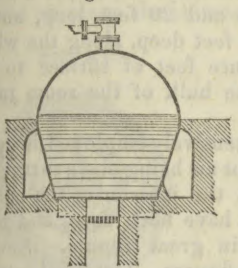
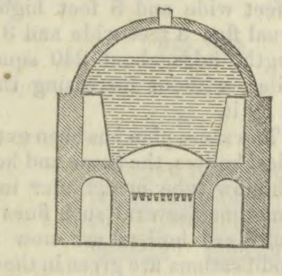


Fig. 202.



The same effect was next obtained in many of the boilers of Newcomen, in the way represented in fig. 202, so that the flame in the flues impinged upon a surface directly over them; the flues in this case forming a recess in the sides of the boiler, instead of being built around it by the brickwork alone. In process of time, boilers of much larger size came to be required, and the spherical shape was found cumbrous and too capacious, that is to say, contained an enormous mass of water, which it required much time and fuel to heat to the boiling point before any steam could be raised. The diameter, also, of the boiler was so great when much steam was required, that the enormous dome became weakened. To make a stronger boiler, and one which should, at the same time, cover a large fire, the *waggon boiler* was introduced by Mr Watt; an oblong boiler, of whose form no better definition can be given than the descriptive epithet which forms its name. It closely resembles those long, heavily laden, four-wheeled waggons, which a team of six or eight horses may occasionally be seen dragging along with difficulty.

The waggon boiler is made of considerable length, and its transverse section, fig. 203, resembles that of the old circular boiler.

Fig. 203.

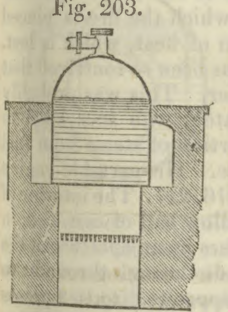


Fig. 204.

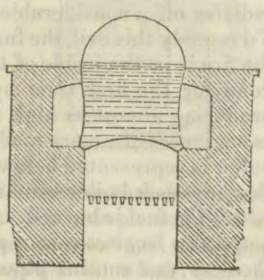
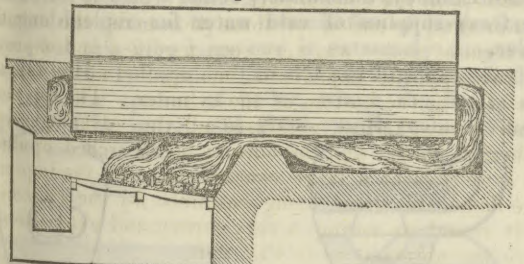


Fig. 205.



In this form the boiler was long made by Messrs Watt and Bolton. It was afterwards improved by hollowing inwards the sides, for the purpose of bringing them more immediately over the flame. Of this form of the waggon boiler, which is universally used at the present day, fig. 204 exhibits a transverse, and fig. 205 a longitudinal section. These forms of boiler, although very convenient, are weak: they are very different from the spherical or cylindro-spherical boilers in strength and safety. The metal of which they consist is not in the form that will resist, to the utmost of its tensile force, a change of shape; but, on the contrary, a very small pressure has been found sufficient to bulge these boilers downward towards the fire, and outwards at the sides.

Steam-Engine Boilers.

Means used for Strengthening Boilers.

From this circumstance it has been found necessary to place in them strong iron stays, for the purpose of connecting a given part of the surface of the boiler having a tendency to bulge out in one direction, with a similar portion of surface, having a tendency to bulge out in the opposite direction; so that this tie-bar being stretched in opposite ways, is made to resist, by its tensile force, the outward or bursting pressure. These stays are essential to strength and security in boilers having large surfaces, concave outwardly, or perfectly flat. Their application to the forms of boilers which we have just described, is seen in figs. 206, 207, and 208.

Fig. 206.

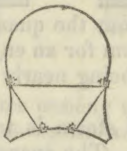


Fig. 207.

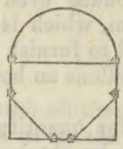
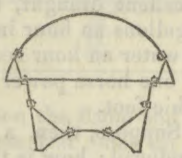


Fig 208.



The Horizontal Cylindrical Boiler.

To avoid the use of stays, and to secure great strength without any other metal than the shell of the boiler itself, is the object of that construction of cylindric boiler now much in use, especially where considerable pressure is used. It is certainly one of the cheapest, safest, and best boilers. A cylinder, figs. 209 and 210, perhaps thirty feet in length and four feet in diameter, with two hemispherical ends, is laid with its axis nearly horizontal; and below it, at one end, is placed the fire, enclosed by brick, as usual. The flame traverses the bottom of the boiler, beating directly upon its under horizontal surface till it reaches the end farthest from the fire. The flame and hot air then return along the one side of the cylinder, being confined in a brick flue, and, passing along in front of the end which is over the fire, traverses the other side towards the chimney, which it enters after having thus traversed the length of the boiler three times, and applied its heat successively to every point of the cylinder which is covered with water. This is a boiler that requires no stays, and is valuable where room is not important. It contains much water, requires much heat to raise its temperature after being cooled at night, and is very bulky.

Fig. 209.

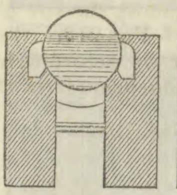
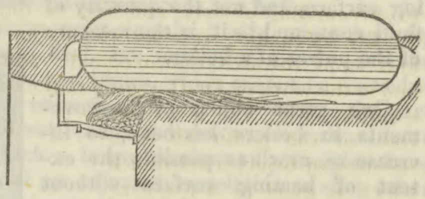


Fig. 210.



The Americans have adopted this boiler to a great extent. It was introduced among them by the ingenious Evans. It is generally of a smaller diameter than three feet, and has flat cast-iron ends of great thickness, which they call heads.

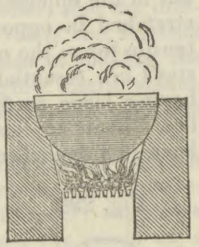
These boilers, the spherical, cylindrical, and waggon shaped, may properly be denominated the simple boilers. But some hundreds of kinds of boilers have been invented for different purposes; almost all of them designed to save either bulk, weight, or fuel. Some of these have been much more successful than others; and it

Steam-Engine Boilers.

is necessary to examine upon what principles any improvements attempted in boilers should proceed. In steam navigation, diminished bulk, weight, and consumption of fuel, are all objects of the first importance, as also in locomotive engines on land.

To make a little boiler generate a great deal of steam in a very short time, is a very difficult matter. Let any one take a common open caldron, or boiler such as is used to boil a few gallons of water; suppose the vessel to hold 84 gallons of water, to be set on a fire so that 9 or 10 feet of its bottom surface are exposed to the fire; then he will find that he cannot turn more than about 6 or 7 gallons of water an hour into steam. By blowing the fire violently, this quantity may be exceeded, but with a great waste of coal: and it will require a very good chimney, with an excellent draught, to produce even 6 gallons an hour in steam, which is about the quantity of water an hour required to furnish steam for an engine of one horse power; 6 gallons an hour being nearly one cubic foot.

Fig. 211.



Suppose, then, a greater quantity of steam is to be produced; how is that to be obtained? The answer is this: only by a larger boiler and a larger fire, acting on a larger surface. This general statement must be understood in the following way.

A larger boiler, calculated to generate more steam, does not exactly mean one which holds more water. It is found that the power of the boiler depends primarily upon the extent of its exposure to the action of the fire, or, as it is generally designated, the extent of heating surface. It appears that the heat cannot penetrate through the material of the boiler with more than a certain rapidity, and that the water evaporated over each square foot by the heat passing through, is not more than about $\frac{3}{5}$ths of a gallon in an hour; and so it requires some 9 or 10 such feet of heating surface to boil off 6 gallons, or a cubic foot of water, capable of producing one horse power in the steam-engine. Now, for every such foot of heating surface there will be a corresponding generation of steam; and a boiler having 100 square feet of surface exposed to the fire will be capable of evaporating 100 times $\frac{3}{5}$ths of a gallon of water an hour, being 60 gallons, and about 10 horse power. The extent of heating surface, and not the quantity of fluid contained in it, is the measure of the power of a boiler.

Fig. 212.

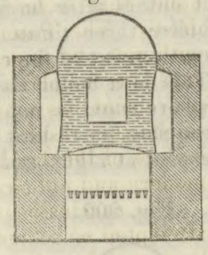
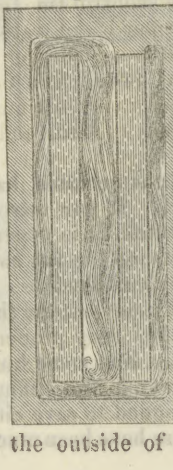


Fig. 213.



Boilers with Internal Flues.

One great object of improvements in boilers has been, to increase as much as possible the extent of heating surface without increasing its general dimensions. One very efficient mode of doing this, is by the adoption of internal flues. Thus Bolton and Watt have inserted a flue in the middle of the large waggon boiler, in the manner shown in figs. 212 and 213; so that, after the flame has passed along the bottom of the boiler to the further end, it returns along the flue in the middle of the water to the front, and then makes an entire circuit of the outside of the boiler before entering the chimney. Thus, in a boiler, 6 feet wide and 8 feet high and 20 feet long, an internal flue 3 feet wide and 3 feet deep, along the whole length, adds about 240 square feet of surface to the boiler, without increasing the bulk of the room taken up by it.

The same plan has been extensively employed in cylindrical boilers, the flame and hot air being made to traverse a hollow tube or cylinder in the interior of the boiler: sometimes several such flues have been used, and these multiflued boilers are now in great repute. Several modifications are given in the figures. The small internal pipes or cylindric flues, surrounded with water, traverse the whole length of the boiler, and expose a greater quantity of surface of water to the action of heat, in proportion as the tubes are small and numerous. These tubular-flued boilers are at the present day extensively used. They economize space, and, with a small exterior surface of boiler, generate a large quantity of steam. They are much used in Cornwall, in marine boilers, and in locomotive boilers.

Fig. 214.

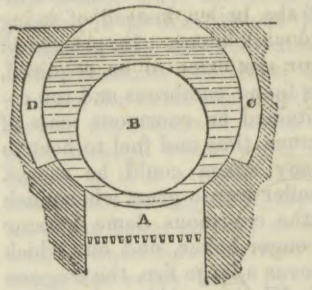
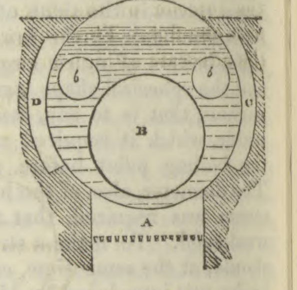


Fig. 215.



In these boilers a large surface is still exposed to the cold air, and the brick-work in which the fire is placed radiates off a considerable portion of heat, which is lost. To remedy this evil, the furnace has been so contrived that the fire is in the inside of the boiler. This was probably done for the first time by Smeaton, who succeeded in producing almost as high a proportion of steam from fuel as engineers of a more modern date. His portable-engine boiler is represented below, figs. 216, 217. The interior of this hay-cock boiler contains a hollow ball of cast-iron, in which the fuel is burned. Air enters by an aperture at the bottom, a large cast-iron pipe leads through the water to the door, and another pipe in the opposite direction passes through the water, conducting the products of combustion to the chimney, immediately round which is introduced the fresh supplies of cold water for replenishing the boiler.

Fig. 216.

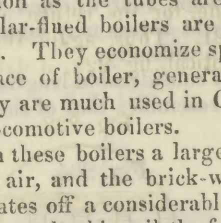
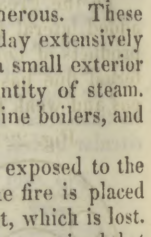


Fig. 217.



But a much better boiler than this, and one indeed which might bear comparison with many boilers of the present day, is one given by Mr Farey as the invention of an unknown author. In the centre of a large old-fashioned hay-stack boiler, figs. 218, 219, is placed a large round furnace, from which there passes a simple rectangular flue, winding round and round the boiler in spiral circuits till it reaches the outside, and thence passes to the chimney.

Fig. 218.

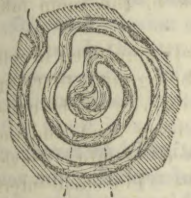
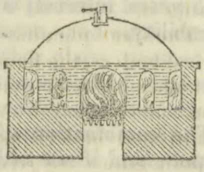
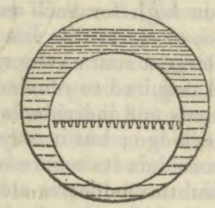


Fig. 219.



In the same way it has often been provided that the furnace should be in the interior of a cylindrical boiler, by placing another cylindrical tube of large dimensions in the interior of the outer case, to serve at once as furnace and flue. This was probably first done by Trevithic, the advocate of high-pressure engines in this country.

Fig. 220.



To the great central flue there have been sometimes added lateral flues on each side, for the return of the products of combustion, fig. 221. Thus, again, this internal flue has been made elliptical, fig. 222, a dangerous and weak form.

Fig. 221.

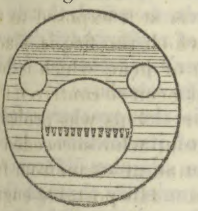
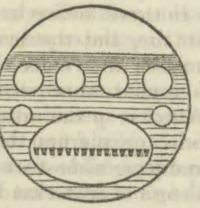


Fig. 222.



It is one of the faults of the boilers that have their fires in the internal tubes, that the ash-pit and interior of the furnace over the fuel are so confined, as to prevent that perfect combustion of fuel which may be obtained by a deep ash-pit, a large expanse of fire-grate, and a deep and wide furnace. These evils may, in some measure, be obviated by an internal flue of large dimensions; but this very large one is extremely dangerous, and liable to explosion. The evil has been remedied by the following species of boiler, where the fire is still surrounded by water, and gives ample room for most perfect combustion.

Fig. 223.

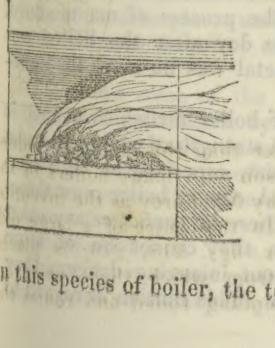
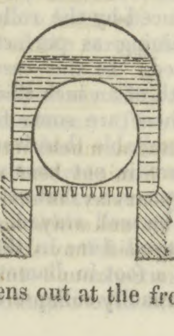


Fig. 224.



Steam-Engine Boilers.

In this species of boiler, the tube opens out at the front, so as to leave a semicircle or a semi-cylinder above the fire, and two vertical spaces, or "water legs," as they are called, which cover the fire on both sides; thus obstructing the heat that would otherwise pass away into the brick building, and at the same time covering a large and wide space of furnace bars, a deep ash-pit, and so ensuring adequate combustion. The internal surface of this boiler has been still further increased, by substituting for this single tube a number of smaller ones six inches in diameter.

Fig. 225.

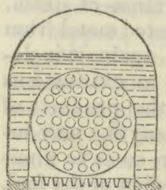
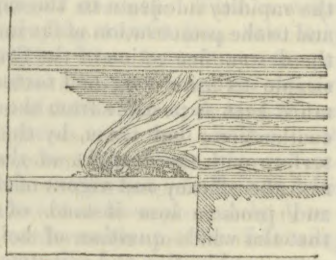


Fig. 226.



After passing through all these tubes, the flame and hot gases again return along the bottom and sides on the right of the boiler, and pass back on the other side to the chimney. A form of boiler similar to this is much used in Lancashire, and is called the Butterly Boiler. It has the large internal flue, but wants the fire-legs, and in this respect is inferior to the former.

Fig. 227.

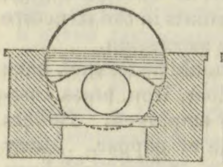
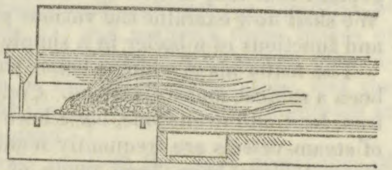


Fig. 228.



Those boilers, already described, are the practical forms in use among intelligent engineers. The varieties of boiler that have been invented, amount to some hundreds. The Patent Records of the present day teem with new and improved boilers; and yet it is a matter of constant complaint with engineers, that no great improvement has ever been made in boilers, but that as satisfactory results have been obtained from plain, simple boilers, of the kind used half a century ago, as from the modern and most complex forms.

The conclusion to be drawn from all that has been attempted or achieved in boilers is, we believe, the following: that there exist certain limits prescribed by the constitution of fuel, the nature of metals, and the properties of water and steam, which cannot be exceeded without incurring evils that greatly overbalance the partial gain. The best boilers that have ever existed have been those in which a large number of principles have been applied, and so adjusted in relation to each other as to gain the maximum, not of any one property, but of all the valuable properties, each in the degree of its individual importance. The first cost of the boiler must not be rendered too great, or that will neutralize the economy of using it: the space to which it is confined may be as small as possible; but if that be produced by intricacy of construction, the loss may surpass the advantage. Then, again, if complex and confined, it may be impossible to cleanse or to repair the boiler; and therefore it must be remembered, that, unless easy access can be gained to every part of a boiler, and of its flues, that boiler will soon become totally useless. Then it is further demanded of a good practical boiler, that, if one part should be damaged or give way, the whole should be so constructed that the damage done to that part must not endanger the rest. An extensive heating surface is to be obtained for economy's sake; but that large surface must at the same time remain unimpaired to resist bursting; a property to a certain extent inconsistent with extensive surface. The surface which is thus spread as widely as possible, so as to apply the fire to the water through every part of its mass minutely and in great subdivisions, if extended beyond a certain degree, will not have over it a body of water capable of conducting heat from it with the rapidity adequate to the rapid generation of steam, and to the preservation of the intensely heated metal from the destructive action of the fire. Then, again, it is desirable to have long and tortuous flues, to extricate as much heat as possible from the fuel and the products of combustion; but these, by their very length, may interfere with the draught of the chimney, so as to diminish the efficacy and vigour of the combustion of the fuel, and produce loss instead of gain. Thus it happens that the whole question of boilers is an exact and judicious combination and adjustment of parts, so as to obtain each of these many points in that degree which is most advantageous for every one of the other qualities, and of all of them together. The question is a practical one of no common difficulty.

It is principally by the collection of facts, of accurately recorded statistics of boilers, of the practical experience of the most eminent engineers, that we can gather data for the solution of the question of the best boiler. We are not without such data, although it is much to be regretted that they are not so abundant as we should wish. We shall now examine the various points in the structure and functions of a boiler in a simple succession.

Materials of which boilers have been formed.

The materials of which a boiler should be formed, have been a subject much discussed. Copper, iron, brass, cast-iron, lead, and even stone, have been employed. Boilers of steam-vessels are frequently made of copper. Many steam-boilers have been made of cast-iron, and have lasted long, and been very efficient under careful management. Wrought-iron-plate boilers are very common in this country; and in America have been much used, with cast-iron ends or heads of considerable thickness. The boilers of locomotive engines have the interior, which is exposed to the direct impact of the flame, formed of copper, and sometimes partly of brass; the exterior of the boiler being wrought-iron. Cast-iron boilers were extensively used under Mr Smeaton, towards the end of last century; and when used with care, were employed with advantage where fuel was plentiful, from their cheapness. A stone exterior jointed with cement, the interior being copper, where subject to great heat, and when the steam has scarcely any greater pressure than the atmosphere, has also been employed; and a dome or cupola of lead was often seen, in earlier times, when the art of working iron-plate was less common than it is now, forming the cover of the antiquated Hay-stack Boiler, which, in these times, the "Waggon" of Watt has almost entirely removed out of use.

Copper. Its advantages as a material for boilers.

Copper is the best of all substances for steam-engine boilers, in a mechanical point of view. That it is not best in a mercantile point of view, is proved by the almost universal use of wrought-iron boilers. Yet it is difficult to see why this should be the case, if we remember that copper lasts for ever, and is worth, when old, nearly two-thirds of its first cost, besides being a much better conductor of heat, and so saving fuel and space. The labour, too, of making a copper boiler is no greater than an iron one. The relative value of these materials for boilers may be stated thus:—

The efficiency of a copper boiler in generating steam, is to that of iron as .	3 to 2
The cheapness of equal weights of copper and iron boilers, are as . .	30 to 130
The value of old materials diminished by 15 years' interest, is	4 to 3
Durability, ...	5 to 1
	30 to 13

The combination of all these ratios is in favour of copper; and if we add the trouble of replacing the new iron boiler, and detaching it from all its connexions, five times for once in the case of copper, the scale still further preponderates on the same side. We must look, therefore, for the explanation of the general use of iron to the state of mercantile affairs, and the value of money in a commercial community. It proves that a certain loss, within 15 or 20 years, in a proportion of 12 to 1, is considered preferable to an original expenditure of four times the amount of capital; showing either that the price of money is too high for such an investment, or that the contingencies of mercantile life are too great to allow the risk of so large a sum as the value of a copper boiler for the period required to reimburse the proprietor. Rich governments and individuals have not failed to profit by this knowledge; but it may be noticed of a government which considers its tenure of office insecure, that it does not furnish even its war-steamers with copper boilers, as that would involve the expenditure of a large sum by which their successors would profit. So also the man who is shortened in means, but hopes to be rich enough by the time one boiler is done to get a new one; or who does not know whether he shall be solvent so long as to see the boiler out; or who, at any rate, cannot spare so much money at once—procures at once the cheapest boiler he can; and finds, as usual, that in a short time the expenses of coal and of repairs have drawn from him a heavier than the usurer's percentage. All this applies more peculiarly to steam-vessels.

Another peculiarity of copper is the greater safety which arises from the uniformity of its texture. It is scarcely possible to account for the singular differences of sheets of iron that have passed nominally through the same processes of manufacture. One plate will become deteriorated by heat in half the time of another apparently identical. The parts of the same plate are frequently heterogeneous. The consequences of this heterogeneity are serious, and sometimes destructive: a single plate in a series gives way, and, having broken the chain of connexion, the whole fabric is destroyed; or a latent crack developes itself in the place most difficult to restore; or one plate, or a part of it, is burnt through when all the rest remains sound. All this tells in favour of copper. The matter of the copper is very nearly homogeneous: its durability is nearly uniform, if it is not made too thick. We have examined the part of a copper boiler exposed to most intense heat after years of action, and found, when the soot was cleared away, the smooth shining surface, produced by the rollers in the process of manufacture, remaining as perfect as the day after the boiler was started. In this case the metal was no more than one-eighth of an inch thick.

There are some forms of boiler for which copper is less suitable than iron. The strength of copper to resist flexure is not nearly so great, especially at high temperatures, as that of iron. A copper boiler must therefore be well stayed, and if there be round, or any other unstayed flues in the boiler, they cannot be of more than a foot in diameter without incurring danger; they will readily collapse or bend. This caution in regard to am- gine ilers.

copper being given, it may be unhesitatingly recommended in point of safety, durability, and ultimate economy.

eri- s of Frank- sti- on the ngth iler erials.

In the article Steam, we have already introduced our readers to the important experimental researches of the Commission of the Franklin Institute in America, concerning the structure, phenomena, and explosions of steam-boilers. We shall, in another place, present the results of their investigations of the causes of explosion. But there is a branch of the investigation undertaken by the committee, which is of importance to our present enquiry. It regards the strength of the materials of steam-boilers; a subject not before satisfactorily examined; and relates more immediately to the effect of high temperatures on the cohesive attraction of the particles of metals; an enquiry essential to our knowledge of the manner in which the known strength of metal, when cold, may be altered when, in a boiler, it is subject to the action of a fierce fire. The subcommittee to whom this subject was intrusted, were men of great practical skill and eminent scientific attainments. Professor Walter R. Johnson, Benjamin Reeves, Esq., and Professor A. Dallas Bache, were the members to whom the enquiry was committed; and it has been carried on with a degree of judgment in its arrangements, and of precision in the experiments, which warrant our implicit confidence in the results, and deserve our sincere thanks for the valuable additions made to our knowledge of this important and difficult subject. The importance of the branch of enquiry committed to these gentlemen, may be judged of from the following statement of its principal branches.

1. What is the absolute tenacity of rolled boiler iron at ordinary temperatures, and how great the irregularities to which it is liable?

2. A similar determination for copper boiler plates.

3. What effect is produced on the tenacity of these boiler plates by change of temperature?

4. What is the effect produced on the tenacity of iron by various processes of manufacture, such as wire-drawing, hammering, or rolling into bars or rods?

5. What are the comparative tenacities of boiler plate made from different mixtures of crude iron and from refined irons?

6. What is the comparative value of sheet iron manufactured by the processes of puddling, blowing, and piling respectively?

7. What is the effect of piling, into the same slab, iron of different degrees of fineness?

8. What is the comparative tenacity of rolled iron in the longitudinal, diagonal, and transverse directions of the rolling respectively?

9. What is the influence of frequently repeated heating on the plates of a boiler?

10. What relation exists between the force that will produce a permanent elongation in boiler plate, and that which will entirely overcome its tenacity?

11. What amount of elongation may the several kinds of metallic plates undergo before fracture?

12. What is the effect of rivets on the strength of a boiler?

These are some of the many important subjects of experiment undertaken by the committee. They have discharged the duties devolved upon them in a manner which is highly honourable to themselves, and which reflects great credit on the institution and the country that has sent forth into the world so valuable a contribution to practical science. We regret that the limits of this article will not permit us to enter into the experimental details and subsidiary enquiries connected with the extensive and laborious investigation; details which are always ingenious and instructive, and will amply repay the minute study of the mechanical philosopher or engineer as a valuable body of experimental truth. But, although we cannot convey to our readers the pleasure we have enjoyed in the perusal of these interesting records, we should do them and our subject injustice did we omit to convey to them the general conclusions which have been obtained.

Steam-Engine Boilers.

Copper boiler plates.

Strength of Copper Boiler Plates.—The experiments upon this subject were very numerous. 32° being taken as the standard, it was found that the increments of heat always caused a diminution of strength. Thus, a stripe of copper, capable of carrying 10,000 lbs., was only capable of carrying 7,500 lbs. when heated to a temperature of 500°; while at 820° the same bar could support no more than a tension of 5,000 lbs, and at 1200° a visibly red heat in day-light no more than about a tenth part of the strength remains. By these experiments the law which connects the diminution of cohesion with the increase of temperature has been accurately determined, and it appears conformable to the following simple expression,

$$\left(\frac{t'}{t}\right)^3 = \left(\frac{d'}{d}\right)^2$$

when

$$\text{Log. } d' = \frac{3}{2}(\text{Log. } t' - \text{Log. } t) \text{ Log. } d$$

by means of which the diminution of strength having been ascertained for one temperature, it may be found for every other according to the following rule. From the logarithm of (t') the temperature (reckoned from 32°) of the diminution sought, subtract the logarithm of a given temperature, (t) and multiply three halves of the remainder by the logarithm of the known diminution (d) of strength at the latter temperature, and the product is the logarithm of the required diminution at the temperature assigned.

The following table exhibits the close accordance of the experiments with this law.

Table of Diminution of Strength of Copper Boiler Plates when heated. Their standard strength at 32°, being 32,800 lbs. per square inch.

	Temperature above 32°.	Diminution of Strength.		Temperature above 32°.	Diminution of Strength.
1	90°	0.0175	9	660°	0.3425
2	180°	0.0540	10	769°	0.4398
3	270°	0.0926	11	812°	0.4944
4	360°	0.1513	12	880°	0.5581
5	450°	0.2046	13	984°	0.6691
6	460°	0.2133	14	1000°	0.6741
7	513°	0.2446	15	1200°	0.8861
8	529°	0.2558	16	1300°	1.0000

We are, therefore, warranted in admitting the conclusion, that the square of the diminution of strength varies with the cube of the temperature.

Hence we learn, that between the temperature of freezing and boiling water copper loses 5 per cent of its strength; that at 550° it loses about a quarter of its strength; at 850° the half of its strength; and at 1330° loses all its strength, becoming a viscid, granular, soft, incohesive, substance; although it does not actually melt until it attains nearly 2000°. These phenomena in copper are strikingly at variance with the phenomena exhibited by iron at the same temperatures.

Iron boiler plates.

In this substance the remarkable anomaly was discovered, that the additions of heat, instead of weakening the metal, as we should have expected, and as was found

Steam-Engine Boilers.

to be the case with copper, actually increased its strength, so that iron plate at 550° above the freezing point was 16 per cent stronger than when cold. After this point the strength began to diminish rapidly, so that this point appears to be the temperature of maximum strength. It was assumed as the standard strength, on both sides of which the strength was found to be diminished both by heat and cold. The strength diminishes rapidly with increments of temperature, after passing the maximum at 570°: thus,

At 32° to 80° the tenacity was = 56,000 lbs. or 1-7th below its maximum.
At 570° —— = 65,500 lbs., the maximum.
At 720° —— = 55,000 lbs., the same nearly as at 32°.
At 1050° —— = 32,000 lbs., nearly ½ of the maximum.
At 1240° —— = 22,000 lbs., nearly ⅓ of the maximum.
At 1317° —— = 9,000 lbs., nearly 1-7th of the maximum.
At 3000° iron becomes a fluid.

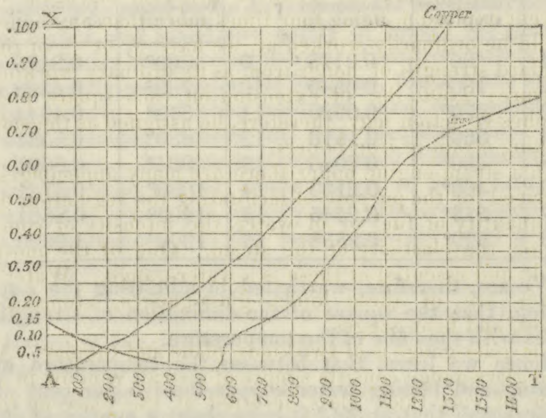
The following is a table of a series of these experiments.

Table of Experiments on Iron Boiler-Plate at High Temperatures; the Mean Maximum Tenacity being at 550° = 65,000 lbs.

Temperature observed.	Diminution of Tenacity observed.	Temperature observed.	Diminution of Tenacity observed.
550°	0.0000	824	0.2010
570°	0.0869	932	0.3324
596°	0.0899	947°	0.3593
600°	0.0964	1030°	0.4478
630	0.1047	1111	0.5514
562	0.1155	1155	0.6000
722	0.1436	1159	0.6011
732	0.1491	1187	0.6352
734	0.1535	1237	0.6622
766	0.1589	1245	0.6715
770	0.1627	1317	0.7001

The law of variation of the strength of iron and of copper by temperature may be easily illustrated by the following curves, of which the horizontal ordinates are temperatures, and the vertical abscissæ are diminutions of strength.

Fig. 229.



The temperatures are measured from the origin A towards T. The total strength being = AX = 1000, the diminutions of strength are represented by the fractions of A X measured from A towards X. These curves represent to the eye very distinctly the characteristics of the metals. The line for copper, rising from zero at A, shows, by continual recession from its maximum AA, the continual and regular diminution of strength by increased temperature according to the law already stated. The line representing the iron, on the contrary, having its origin 15 per cent above A, descends and shows an increase of strength until it reaches a maximum about 500°, whence it suddenly rises, showing a very rapid diminution of strength up to 1000°, when again it changes, turns outwards having a point of inflection beyond which it may be carried to a great distance, while at last it becomes liquid between 2000° and 3000°.

Iron plate.

The next branch of the enquiry was, how the strength of iron is affected by the mode of its manufacture, and by the different states in which it is used, as in bars, in wire, or in plates, produced by hammering, drawing, or rolling. The following are the results of several experiments on the tenacity of different kinds of iron, at ordinary temperatures.

Iron Wire, diameter	0.333	84,186 lbs.
	0.190	73,888
	0.156	89,162
Russian Bar Iron,		76,069
English Cable Iron, hammer-hardened,		71,000
English Cable Iron,		59,105
Lancaster Co. U.S.		58,661
Centre Co., US.,		58,400
Swedish Bar,		58,184
Salisbury Com., U.S.,		58,009
Tenessee Bar, U.S.,		52,099
Slit Rods,		50,000
Missouri Bar Iron,		47,909

No. 1. Pig iron, of the white fracture, produces the most cohesive bars.

No. 2. Pig iron, of a lively gray fracture, produces bars inferior to No. 1 by 1½ per cent.

No. 3. Pig iron of a dead gray fracture, produces bars inferior to No. 1 by 2 to 3 per cent.

No. 4. Pig iron, of a mottled fracture, produces bars inferior to No. 1 by 5 per cent.

A mixture of all the kinds produces bars inferior to No. 1 by 5 to 10 per cent.

The difference between the strength of boiler-plate, cut lengthways and across, was found to be about 6 per cent in favour of the longitudinal over the crosscut.

Stripes cut longitudinally sustained	63,947 lbs.
Stripes cut transversely sustained	60,176 lbs.
Stripes cut diagonally sustained	53,925 lbs.

The specific gravity of iron boiler plate was found to range from 7.7922 to 7.6013., and to be at a mean value 7.7344.

The effect of repeated piling and welding was found to be a great increase on the strength of iron. The iron given in the preceding table, from the Centre Company's manufactory, whose strength when rolled amounts to 58,400, was found to be so much improved by piling four bars and welding twice, as to support a mean of 59,247 lbs., and to be so homogeneous that the highest did not differ from the lowest results by more than 3.4 per cent in the different specimens. Simple welding twice without piling, gave a result of 58,787 lbs.

It has been thought that by welding together different kinds of iron of different degrees of fineness, and then rolling it out, a valuable boiler-plate might be obtained. This was tried, and the highest result gave only 40,600 lbs.

The weakening effect of riveting is thus calculated from these experiments, being a diminution on the whole of ⅓ of the original strength.

Strength of the stripe without riveting.		9290.
Strength of the remaining metal, deducting rivet-holes,	+	5662.
Diminution of strength by rivet-holes,	−	3628.
Strengthening effect of rivets,	+	679.
	−	

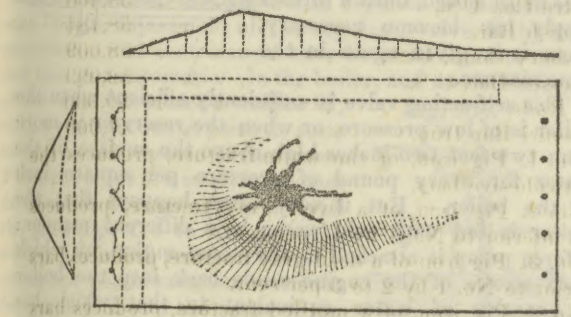
The effect of use and long exposure on the strength of boiler iron was found to be a great diminution of its strength, none of the specimens coming up to 50,000 lbs.

The effect produced by the accidental overheating of a boiler, was found to be the permanent reduction of its strength from 64,000 or 65,000 lbs., to 45,000 lbs. per square inch, being about $\frac{1}{3}$d of the original strength.

The permanent extension produced on iron plate by weights much less than are required finally to overcome its cohesion, was a subject of careful examination. The extension began to take place in general when $\frac{3}{5}$ths of the breaking weight were applied, and sometimes when only $\frac{2}{5}$ths had been applied. The total extension varied between $\frac{1}{10}$th and $\frac{1}{16}$th of the total length, and was greater in the longitudinal than the transverse direction of the bar.

The following diagram of a fracture is highly instructive. The elongation transversely is $\frac{1}{10}$th of the original dimension, and the curve, is $\frac{1}{7}$th longer than the chord. The longitudinal direction of the fibres is in the line of the shortest dimension. It is evident that the diminution of the thickness, previously to fracture, must have greatly weakened the plates of the boiler. This boiler plate was taken from that part of the boiler immediately over the fire, and had burst where sediment had collected, and excluded the water from contact with the boiler, so as to allow it to get overheated.

Fig. 230.



It is evident that the diminution of area at the point of fracture, which accompanies this stretching of the plate before fracture, must weaken the plate very greatly when it is exposed to strains that stretch it much beyond its initial length, this strain being about half the breaking strain due to the original thickness. This constriction or thinning out of the plate is observed to take place much more in thickness than in breadth, and to amount in iron to about 16½ per cent of the whole area. It is remarkable, that the constriction was found less in heated than in cold specimens of iron, a result the reverse of that which we should have anticipated. The fractures at high temperatures were found to take place suddenly, and the surfaces of fracture presented appearances altogether different from those exhibited at low temperatures; the peculiarity of the fracture at high temperatures being, that the section is smooth and flat instead of jagged, fibrous, and irregular, and that it takes place directly across the plate, and tapering off at an angle of 45°, so that the separate fragments resemble "the edges of two mortising chisels." One result which we deduce from the American investigation is, that boiler iron cannot safely be trusted with a greater pressure than $\frac{1}{5}$th of its standard maximum cohesion. Such are some of the valuable facts elicited by this transatlantic investigation. The experiments should be repeated in this country upon the different species of our own iron; and we have no doubt the subject will be taken up by some of those gentlemen who have prosecuted valuable researches on the strength of metals; into which, however, they have not yet introduced the element of high temperature.

The increase of the strength of iron, with the increase of its temperature up to 570°, is a remarkable anomaly which should incite us to examine other metals, and metallic alloys, in a similar manner, for the purpose either of resolving this phenomenon into some general law of corpuscular force, or of setting it aside as a characteristic and distinctive property of that singular metal. To the practical man, this discovery is of importance, insomuch as it has shown him a quality in iron, as a material for boilers, which may weigh strongly with him when he hesitates in choosing.

The comparative valne of copper and iron boilers is materially affected by this enquiry. The great advantages of copper are its durability, its high conducting power, and the valne of the old materials. It is by no means so strong as iron, being, when cold, $\frac{3}{5}$ths of the strength of iron, and at 500° only about $\frac{3}{8}$ths of the strength of iron. But thin iron decays so rapidly, that its strength to-day is no criterion of its strength to-morrow: it decays so rapidly, especially with the salt water of steam vessels, that its very strength at first is necessarily followed with subsequent danger; for an iron boiler having once borne a great pressure with impunity, will afterwards, when the rapid but unseen decay has insiduously eaten through the metal, be again subjected to the same ordeal by which it had been formerly proved; and although under apparently the same circumstances, it may yield to the strain, and produce the distressing consequences of a violent explosion. It is time alone, then, that is the great enemy of iron boilers, while the integrity of the copper will continue unimpaired for a quarter of a century. On the whole, we find that the following general result should limit our faith in the materials of boilers :—

General practical result of the enquiry.

Standard strength of boiler plate, . .	55.000.
Strength after riveting, ...	$\frac{2}{3}$.
Strength after heating and cooling in use, .	$\frac{2}{3}$.
Strain of permanent extension, . . .	$\frac{2}{5}$.

Greatest practical strength $= \frac{2}{5}$ of $\frac{2}{3} + \frac{2}{3} = \frac{8}{45} = \frac{1}{6}$ nearly.

The greatest practical strength being $\frac{1}{6}$th of the absolute cohesion, and the greatest practical strength, to prevent explosion, being four times more than any boiler should be ordinarily worked at, we have $\frac{2}{45}$ or $\frac{1}{22}$ of the standard strength of boiler iron, as its ordinary working pressure; 2,500. lbs. of extension on each square inch of cohesive action may, therefore, be assigned as the safe working strain of iron boilers.

Appendages to Steam-Boilers. Water-Gauges.

To a steam-engine boiler there are many appendages, contrived for the purpose of facilitating the regulation of the quantity of fuel or of water, the intensity of combustion, the elasticity of the steam. One of the most simple and essential of these is a water-gauge. Water-gauges are of three kinds, glass-gauges, stopcock-gauges, and float-gauges.

The glass-gauge is of two kinds, plane and tubular. A plane glass-gauge consists simply of a small window in a boiler, of very thick glass, inserted at the place up to which the water should rise in the boiler. The tubular glass-gauge is a small pipe of glass about half an inch in the internal diameter, and an inch and a quarter in thickness. It is placed on the outside of the boiler, and communicates at the top and bottom by stopcocks with the interior of the boiler; the higher stopcock enters the boiler among the steam, a little above the upper surface of the water, and the lower stopcock enters a little below the surface of the water, so that the water, standing in the glass tube on the same level with the water in the boiler, shows itself in the glass tube to the attend-

Steam-Engine Boilers.

ant. These two gauges are shown in the accompanying drawings.

Water-Gauges.

Fig. 231.

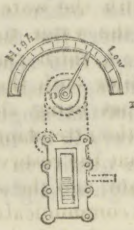


Fig. 232.

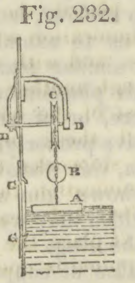
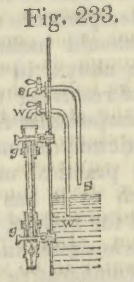


Fig. 233.



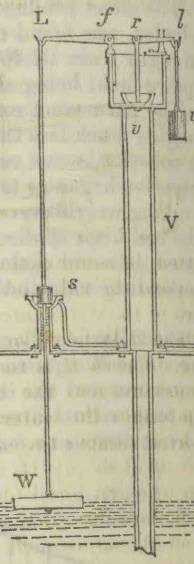
In figs. 231, 232, G is the window of very thick glass, set in a brass frame with a cement of red and white lead, after which, the frame is firmly bolted on the front of the boiler, at the aperture to which it is fitted. *gg*, fig. 233, is the tube glass-gauge, communicating with the water below and the steam above. There are shown in the same figure two other kinds of gauges. W*w* is a tube open at both ends, regulated at the external termination by a stopcock, but passing into the boiler, so that the other end descends below the surface of the water in the boiler. Another gauge-tube S*s* is of similar construction, and is placed higher up, so that the end S is open in the boiler among the steam. By this means the engineer has it always in his power, on opening these cocks successively, to determine whether there be an excess or deficiency of water in the boiler; for, the orifices of the tubes in the inside of the boiler are adjusted in such manner, that when the water is at the proper level, it covers the orifice of the lower one, but does not reach the orifice of the upper one. In this state steam will issue from the upper pipe, and water from the lower pipe; but if it should be found that water issues from both, the water is too high, and if steam from both, there is too little water in the boiler. Another species of gauge is also shown in figs. 231, 232. It consists of a float A resting on the surface of the water in the boiler, to this is attached a chain, which passes over a pulley C, and carries at its other end a counterweight R. The pulley is fixed on an axle DD, which passes through the boiler and carries on its outer end an index. The index shows, by means of a dial-plate, the state of the water in the boiler.

By these means, a careful attendant may always ascertain the state of the water in the boiler, with sufficient ease to enable him to regulate the supply of water thrown in, or the feed of the water to the boiler, so as to replace, with cold water, the deficiency occasioned by the continual conversion of the water into steam. But if by any cause the attention of the keeper should be directed from the examination of the state of the boiler, it will gradually become emptied, and will either be exploded or burned out, from being made red hot. Various contrivances have been attempted for the purpose of rendering boilers automatic; so that the very fact of the water becoming low in the boiler should of itself be the means of furnishing a fresh supply. The manner of accomplishing this is somewhat different in different circumstances; but the following methods are the most common and the best.

Feeding Apparatus.

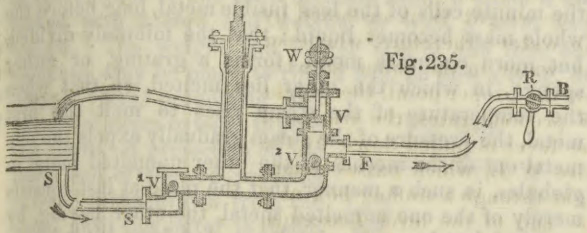
A self-regulating feeding apparatus may be adapted to the boiler of a low-pressure steam-engine, in the following simple way. The water that is to feed the boiler, is to be conducted into a reservoir *v r*, of some 18 inches diameter, having a long pipe to lead down from it to the bottom of the boiler. The top of this pipe is closed by a tapered plug which hangs by the rod *v r*, from a lever supported at *f*, and having two weights, one at either end, W and *w*. The larger weight W, of stone or cast iron, rests on the surface of the water, in the boiler, and is counterpoised by a smaller weight *w* in such a manner, that a part of the weight W is sustained by the water; therefore, whenever the water in the boiler falls below the proper point, the weight W preponderates, the arm L of the lever is pulled down by the wire W L, which passes steam-tight through a stuffing box at *s*, the end of the lever *l* ascends, and the valve *v* being withdrawn, allows the water to descend through the open end of the pipe, and replenish the boiler; and after a time, when the supply has become sufficient to raise the water to its proper level, the weight W, and the end L of the lever, are raised, the opposite end *l* is depressed, and the valve *v* once more closed, until a further supply has become necessary, when it is given again in the same manner.

Fig. 234.



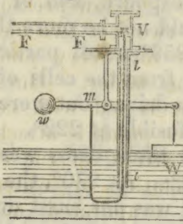
This self-acting valve is sufficiently efficient when the boiler is of low pressure, or when the reservoir is more than two feet two inches high above the surface of the water for every pound of pressure per square inch of the boiler. But it very often happens that the boiler is fed with cold water in a different manner: a force pump is attached to the steam-engine, by which each stroke of the engine sends back into the boiler a quantity of water equivalent to that which has been evaporated out of the boiler in forming the volume of steam which has given to the engine motion through that stroke by which the pump has been impelled. Now, if the size of the pump were accurately proportioned, so as to replace in the boiler at each stroke the precise quantity of water evaporated from it in the same interval of time by the engine, it is evident that no further provision for adjustment would be necessary. This quantity is exactly one cubic inch of water for each cubic foot of atmospheric steam given to the engine, or one cubic foot = six gallons per horse-power per hour. But the evaporation of the water to a steam-engine is not thus uniform, nor so easily determined. The variations of intensity in the fire cause steam more or less dense to pass over into the engine; the steam now raises the safety-valve and escapes into the air, and now falls below the standard; the boiler, now tight, and again allowing water and steam to leak through its joints, consumes a greater or a less quantity of steam; and thus, even with this automatic supply, there is required a regulating or governing power. A stopcock is attached to a pipe by which the feed-pump obtains its supply of water to force into the boiler, and so, by impeding or facilitating the passage of water into the boiler, the attendant may regulate the supply. We have said that this cock is attached to the pipe by which the pump obtains its supply of water, and not to the pipe by which the same pump forces its contents into the boiler it is about to supply; and we have done so for this reason, that it is dangerous to apply such a stopcock on the pipe between the pump and the boiler, because, if the force-pump become once filled with water, and be forced down by the engine when the stopcock is wholly or nearly closed, the pipe will be burst from the incompressibility of the water, unless its valves should be so leaky as to allow the water to pass back into the reservoir from which it has been withdrawn. As, however, it is sometimes desirable to have the regulating cock on the boiler feed-pipe, the following provision is made to render that method of regulation safe and efficient. Between the feed-pump and the boiler, there is inserted, in connexion with the feed-pipe F, at any point V beyond the valve of the pump V^2 which prevents the return of the water into the pump, a loaded escape-valve V; its load W being so adjusted, that whenever the regulating stopcock R is turned so as to impede the passage of water towards the boiler B, the force of the feed-pump pushes the water up against the loaded valve V, and by it escapes through the return pipe *r r r* into the reservoir of supply H, again to be brought back into the pump when required for the future supply of the boiler.

Fig. 235.



Still, however, this apparatus depends in some measure on the adjustment of the regulator-valve R by an attendant; and contrivances have been invented to render this also automatic. In the boiler, and on the surface of the water, is placed a weight W, with a partial counterpoise *w*, so as to rest on the surface of the water. From the point *m* a small rod passes downwards and up again, through the feed-pipe L *l* to the point V, where a conical valve or plug V opens the communication with the feed-pipe F F and the water of the boiler when it is raised, and shuts it again when depressed. Now, when the water is abundant, the weight W floats high, and keeps down *m* and V; and when low, W descends, and raising *m* and V, admits the required supply into the boiler without any assistance.

Fig. 236.



Where a high-pressure boiler is used for purposes in which a steam-engine is not employed, detached self-acting feeding apparatus must be employed. The following elegant and most effective apparatus has been invented by Mr Macdowall of Johnstown, and is now in extensive use in Scotland. We have seen it in an efficient working state, after being employed for many years, and it only costs about £20. It is nothing less than a small steam-engine, but it is applied in a most effective and simple way to the purpose designed.

Fig. 237.

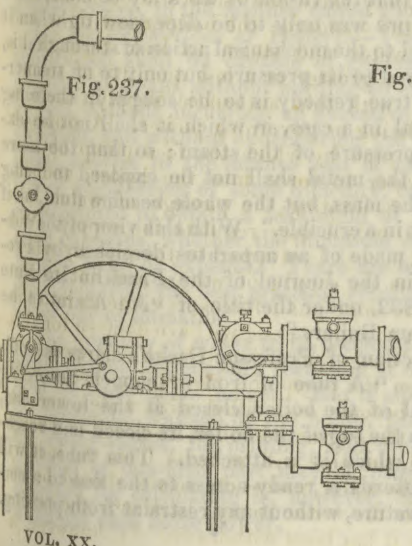
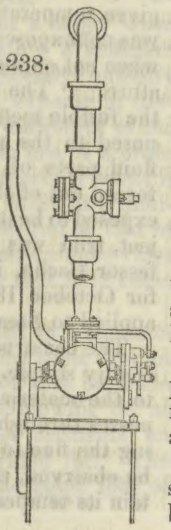


Fig. 238.



Automatic Feeding Apparatus.

A very simple feeding apparatus, on a similar principle, was adapted some years ago to the purpose of feeding a boiler without the assistance of a steam-engine. A close vessel or reservoir is placed above the level of the boiler, and is in communication with the water in the boiler through one pipe, and with the water to be supplied to the boiler through another; a third small pipe connects the steam-chest of the boiler with the top of the said reservoir. All these pipes being closed by moveable regulators or stopcocks, the attendant is first to open the steam communication, that the reservoir may be emptied of air and filled with steam, and the stopcock is then shut. In the next place, the communication with the cold water to be supplied is opened, and the reservoir on getting cool becomes vacuous, so that the pressure of the atmosphere fills it with cold water, and the communication is then cut off. Lastly, the third stopcock is opened, and the water in the reservoir having free communication with the water in the boiler, it is only necessary to open the steam-cock once more, and the water, being in equilibrium by the pressure of the steam, will run freely, by its own pressure, from its height above the boiler, into it; and the process of alternately filling and emptying the boiler may be repeated as often as required by turning the cocks in this succession. A simple process renders all these valves self-acting.

Fig. 239.

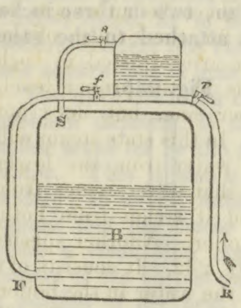
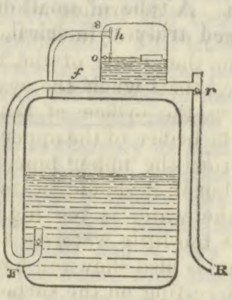


Fig. 240.



The reservoir, fig. 239, is a close vessel above the boiler B; R *r* is the cold-water pipe, by which the water is obtained, and is regulated by the stopcock *r*; F *f* is the feed-pipe for the boiler, regulated by the stopcock *f*; S *s* is the steam-pipe opened by the stopcock *s*. In the next figure, there is a balanced float on a pivot *o*, and a slit bar *h* connecting a small slide-valve *s* with a pin on the float-bar; *r* is a common ball valve, acting only upwards; and in F is a valve permitting the descent of the water in the pipe F *f*, and preventing its return. The latter is the self-acting form, of which the action once begun will continue indefinitely. A commanding valve being connected with the boiler-float, would render the play of this apparatus dependent on the requirements of the boiler itself. The reader who is acquainted with the steam-engine of Savary, will perceive at once that this reservoir, with its apparatus, is a mere Savary's steam-engine, applied to pump water into the steam boiler; and that this application of that engine is not liable to the objection urged against it in other circumstances, namely, that the water is heated as well as raised. In this instance, the communication of heat is attended with no loss.

Indices of Pressure.

Indices of pressure and safety apparatus, form an important series of appendages to a boiler. These are of four kinds; dynamometers, safety-valves, fusible plugs, and alarms.

The dynamometer, which is generally applied to measure the force of steam in a boiler, is a simple tube, bent upwards at the end, and formed sometimes of glass

Bent-tube Dynamometers.

and often of iron. The two ends of this tube being curved up, so as to give it the form of the letter U, one of these extremities is applied to the boiler, and placed in communication with the steam; mercury is poured into the tube, so as to fill one-half of it, and the pressure of the steam upon one of the extremities of the column of mercury, forces the mercury to ascend in the other, and to indicate, on a divided scale, the amount of pressure, which is about one pound on the inch for each inch of height on the scale. It is necessary, in all these mercurial gauges, that the tube be of equal diameter throughout its length. If the tube be of iron instead of glass, it is necessary that a float of wood, or iron, or ivory, figure 241, resting on the top of it, thould ascend above the tube, and indicate on a scale the place of the mercury. For high-pressure boilers a longer tube and scale are, of course, necessary; and a very convenient form for this purpose is given in figure 243. From a float resting on the fluid stretches a string carrying a counterpoise at the other end, and passing over a pulley raises or depresses the index of a valve on which the pounds of pressure are indicated by the inches of the scale.

Figs. 241, 242.

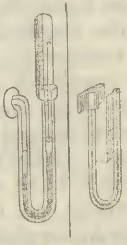
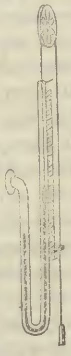


Fig. 243.



The Piston-Gauge.

Another very convenient index of pressure, preferable to any other with which we are acquainted, is the piston-gauge. A tube of small diameter, two or three inches, is bored truly cylindrical, and attached to the steam chest of the boiler, figure 244. This cylinder has a solid plug or piston truly turned, and ground exactly, but not loosely, into it. The pressure of the steam bearing up the piston on the lever, one end of which is attached to the spring indicator, gives the true indication of the pressure on the piston. The spring is also applied directly above the piston, as shown in the second figure; but this instrument is used on a smaller scale than the other. The ordinary safety-valves are described in another part of this article.

Fig. 244.

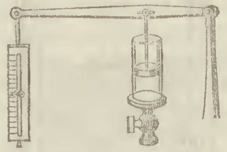
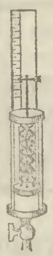


Fig. 245.



Safety Apparatus. Fusible Plugs.

There is a species of safety boiler apparatus in which great faith has been placed by many mechanicians and men of science. It has been proposed and enacted that boilers be furnished with fusible plugs, or that in parts of a boiler exposed to high temperature and pressure, there should be placed plugs, forming small parts of the boiler, which plugs being composed of metals easily melted, shall give way when by accident too great pressure and heat have been employed, and so, by a less evil, prevent the greater one of total disruption of the boiler. This method of creating a less evil to avoid a greater, has lately been shown to be fallacious, and ought to be abandoned. For the complete exposure of the inadequacy of the system of *rodelles fusibles*, we are indebted to the Committee of the Franklin Institute, already so often named with gratitude. The American experimenters found, that when alloys of tin, lead, and bismuth are applied to steam boilers in the way recommended by the Commission des Rodelles Fusibles, the alloy does not melt in the manner of an homogeneous metal, as has been supposed; but that, in fact, the more fusible metal melts in the minute cells of the less fusible metal, long before the whole mass becomes liquid; that the minutely divided, but more obdurate metal, forms a grating, or rather sponge, in which the other lies melted, so that when the temperature of the steam rises to melt the first metal, the pressure of the steam gradually expels the one metal out of the meshes of the other unmelted metal in globules, in such a manner, that the plate at last consists merely of the one unmelted metal, the other having, by repeated heatings, completely exuded from it, and been replaced by such particles of debris as the water of a boiler in common use always supplies in abundance. Thus, a plate of two metals, originally designed to give way at 250°, may still deceive the unconscious attendant, and withhold its warning till it have reached a temperature of 500°, and contain a combination of caloric and water as dangerous as gunpowder, and greatly more treacherous.

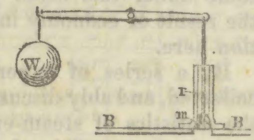
The following experiment will illustrate the whole of this enquiry. A plate of alloyed metals, of which the melting point in the crucible was about 260°, was submitted to heat under pressure. Such a plate would be applied to a boiler, of which the temperature was not designed ever to exceed in the most extreme case one atmosphere, and of which the usual working pressure would not be more than 5 or 10 lbs. It was found that at 256° small particles of melted metal began to exude from the cells of the unmelted metal; the globules thus driven out were carefully examined, and found to be fusible at 222°. At 260°, a second portion exuded, and their dross were found to melt by themselves at 232°. At 270°, the remaining metal was still tenacious, and was not burst until the steam reached a temperature of nearly 300°, with an explosive force of three times that at which it should have given warning by fusion, and the escape of water and steam, from the small aperture it had filled. This last residual porous plate of metal was found not to melt until it reached the temperature of 345° instead of 260°. "These experiments the Committee (properly enough) deem conclusive, in regard to the use of fusible plates in the ordinary way; and they conceive that substituting fusible plugs of greater thickness, say half an inch, as has been directed by a recent ordinance in France, would not serve as a remedy to the defect thus exposed."

The true remedy for this evil was the next object o the enquiries of this excellent Committee. They properly inferred, that the fusion of an alloy of metals at a given temperature was only to be depended on when it was not exposed to the mechanical action of steam, that is, when not exposed to its pressure, but only to its temperature. "The true remedy is to be sought in enclosing the fusible metal in a case, in which it shall not be exposed to the pressure of the steam; so that the more fluid parts of the metal shall not be exposed to being forced out of the mass, but the whole become fluid, as if exposed to heat in a crucible." With this view of the subject, trial was made of an apparatus described by Professor Bache, in the Journal of the Franklin Institute for October 1832, under the title of "An Alarm to be applied to Steam Boilers."

The construction of Professor Bache's alarm is sufficiently simple. "A tube of iron or copper, according to the material of the boiler, closed at the lower end, passes through the top of the boiler, its closed end reaching the flue to which it is attached. This tube, it will be observed, affords a ready access to the flue to ascertain its temperature, without any restraint from packing.

A mass of fusible metal placed at the bottom of the tube will become fluid very nearly as soon as the flue takes the temperature of its fusion. To show when the metal at the bottom of the tube becomes fluid, a stone is attached with a cord and weight, or with a lever and weight. The weight and longer arm of the line, descending, may be made to ring a bell, or turn a cock, or open a valve, permitting just enough of steam to issue, to give the alarm. A projection on the lower end of the rod prevents it from being drawn from the metal until this latter is fused, and by widening the lower part of the tube the metal is kept from being drawn out by the rod. BB, fig. 246, is part of the boiler plate; *m* the fusible metal in a tube; *r* the rod to which it is, as it were, soldered, and when the metal melts, the weight *W* will descend and give the alarm, either by striking a bell, opening a steam whistle or trumpet, or raising a valve. This apparatus of Professor Bache's is a valuable addition to the mechanism of steam.

Fig. 246.



The common alarms, the steam whistle, and the steam trumpet, may be made to give noisy indications of an excessive pressure of steam. A small box on the steam chest is to cover a lock-up safety-valve, loaded at the highest pressure the boiler should endure. On this box is to be placed a steam whistle or a steam trumpet, so that an alarming noise will be the consequence of any excessive pressure; for the steam issuing through the aperture of the instrument will give it voice with an intensity proportioned to the pressure.

Fig. 247.

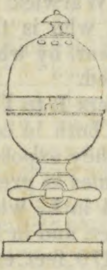
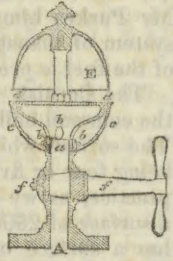


Fig. 248.



In figs. 247, 248, a steam whistle is represented. A *a* is a tube leading from the boiler; in it is a stopcock. On the top of the tube is a hollow piece *bb*, surrounded by a thin cup *cc*, and carrying, by a pillar fixed on its top, another inverted cup E. When the stopcock is opened, the steam enters the cup *cc* through holes in the foot of the hollow piece *bb*, and rushing out at the narrow orifice *dd*, between the cup *c* and hollow piece, strikes on the edge of the cup E, and produces an exceedingly loud and shrill sound. No stopcock is, of course, required when this alarm is placed on the box of a safety-valve, in the manner stated above.

On the Proportions of Boilers.—That a boiler when constructed shall be capable of generating a sufficient quantity of steam, without burning an excessive quantity of fuel, without incurring an excessive expense in construction, and without endangering the durability of the metal, subject to the intense heat of the fire, is a problem of engineering of some difficulty, especially when it is attempted to obtain a maximum of effect at a minimum of means, whether the minimum desired be that of weight, bulk, or expense. There are some simple rules deducible from the best practical results that have come under our examination.

The quantity of water to be evaporated in a common steam-engine, is generally reckoned at one cubic foot an hour for each horse power. But if allowance be made for accidental leakage of the boiler, for blowing off at the safety-valves, for priming, and other accidents, an addition of one-fifth part may be provided for. The standard for calculating is, however, one cubic foot of water for each horse power.

Area of the Fire Grating.

The area of the grating in the furnace on which the fuel is laid, is an important element of efficiency in a steam-engine boiler. Here practice somewhat varies. The bars are generally about one inch wide on the top and the interstice from $\frac{1}{4}$ to $\frac{1}{2}$ an inch. These apertures supply oxygen to the fuel, and regulate the combustion, which is only perfect when the supply of air to the incandescent fuel is ample. It is found that a supply of air, such as will pass through each square foot of the area of the grate of the fire, is adequate to the effectual combustion of so much fuel as will, in a proper boiler, evaporate one cubic foot of water an hour, and supply one horse power in a steam-engine. Thus, a fire grate 6 feet long by 6 feet wide, containing $6 \times 6 = 36$ square feet, is found to give an ample supply of air for the combustion of as much fuel as will supply an engine of 36 horse power, evaporating 36 cubic feet of water an hour. But although this is a safe and excellent proportion for ordinary practice, yet it has been found, that with a quick draught a smaller amount of fire surface is adequate to the effect required. So low a proportion of fire grate as $\frac{2}{3}$ds of a foot, and even $\frac{1}{2}$ of a square foot to each horse power, has been employed by eminent engineers, and has succeeded, while others recommend a much larger allowance even than one square foot. It is certain that the larger area of fire-grate is conducive to economy and durability. The standard of surface is, therefore, to be taken at the most desirable proportion, and only to be deviated from where limited space, as in locomotive-engine and steam-ship boilers, renders this rule inapplicable. This standard is one square foot of area of grate for each horse power.

Extent of heating surface, per H.P.

The next condition on which the success of the boiler problem depends, is the extent of the surface of the boiler acted on by the fire, so as to apply its heat to the water. This is also a subject on which practice varies widely; so widely indeed as from 8 square feet to 36 square feet per horse power. Eight square feet require a clean thin copper boiler, and a very direct impact of the hottest part of the flame, with the loss of a portion of the heat; but 36 square feet, on the contrary, imply the possession of profuse space, and a desire to economise to the very utmost the powers of the fuel. The standard of practical effect with the usual iron boilers, in ordinary circumstances, is fifteen square feet of heating surface for each horse power.

Of this surface, about one-third is horizontal, and two-thirds are vertical surface; and of these, the horizontal surface is imagined to be twice as effective as the vertical surface. Arguing on this supposition, some have given it as a rule to calculate *each vertical foot as only half an effective foot* of heating surface, and so to make nine or ten square feet of effective heating surface the standard of boiler power. But this rule, though giving the same result as the former, proceeds on a supposition not yet established, and which does not always coincide with the fact. It will be easily seen that 5 feet of horizontal surface, added to 10 feet of vertical surface, making, according to the one mode of calculation, 15 feet of surface, divided in the proportion of two-thirds vertical and one-third horizontal surface, forms an exact equivalent to the other mode—of reckoning the 10 feet of vertical surface only equal to 5 effective feet of surface, and adding to the said 5 effective feet of surface the 5 feet of horizontal surface, making in all 10 feet called effective feet of heating surface.

Area of Chimney and Flues.

The next essential consideration is the area of the chimney and flues. It has already been given as a standard, that the fire grate should have the area of one square foot for each horse power. Now, this area for the admission of air should be accompanied with a sufficient passage to carry off the gaseous products, and hot air and flame resulting from combustion. From an examination of the best boilers, it appears to us decided that one-fifth of the area of the fire grate, gradually diminishing to a chimney, which shall have one-tenth of the area of the fire grate, is an excellent proportion. We therefore feel disposed to recommend it as a standard for steam-engine boilers: one-fifth, diminished at the chimney to one-tenth part of the area of fire grate.

The chimney should be of the same diameter throughout its interior; and if of 40 feet height and one-tenth part of the area of the fire grate, it will give an abundant draught. If the height of the chimney be greater than this, the area may be diminished as the square root of the height is increased.

Data for fixing the size of a boiler.

The quantity of water to be contained in a boiler is a matter of some importance. If we consider bulk and weight as of no consequence, and if the boiler be in constant work, there cannot, perhaps, be too much water. On the contrary, if there be only a small quantity, many evils are encountered. In the first place, a large mass of water serves to regulate the production of steam from a boiler, much in the same way as a fly-wheel regulates the speed of an engine; whereas with a small charge of water, the unavoidable oscillations that happen in the supply of cold water or the additions to the fire, make sudden and injurious changes in the production of steam. In the next place, it is well known that steam is a very bad conductor of heat, and has a single capacity in its gaseous state for the acquisition of caloric. Hence it is found that if the production of steam be rapid, and the water present in a smaller proportion, the caloric is not carried off from the metal heated by the fire sufficiently fast, the boiler is overheated and rapidly deteriorates, while the production of steam is greatly retarded. For these reasons, it is necessary to have a large supply of water. Eight to thirteen cubic feet are very commonly allowed by practical men. As a standard, or perhaps as a minimum, we may assign for the quantity of water in the boiler, in its mean condition, ten cubic feet of water in the boiler for each horse power. In like manner, we will do well not to leave a smaller proportion of capacity in a boiler for containing steam than the quantity assigned for the water, being ten cubic feet of steam in the boiler for each horse power.

Economy of Fuel in Steam Boilers.—The ordinary consumption of coal by one of Mr Watt's engines is 10 lbs. of fuel for each horse power every hour. The work done by this fuel is equivalent to the power of raising 150 lbs. 220 feet high in a minute, or of raising 220 times 150, that is (220 × 150 = 33,000) 33,000 lbs. one foot high, or any equal product of mass by height in every minute, by the combustion of 10 lbs. of coal, or 3,300 lbs. of weight raised one foot high every minute, which gives in every hour 198,000 lbs., raised one foot high by the combustion of one lb. of coal. This, however, by care and economy, is often exceeded by Mr Watt's engines; and the following are about the standards of work done at a given expenditure of fuel in ordinary engines, which is called the Duty of Steam Engines.

Duty of engines.

The Duty performed by Ordinary Steam Engines is—

One horse power exerted by 10 lbs. of fuel an hour.

Quarter of a million of lbs. raised one foot high by one lb. of coal.

Twenty millions of lbs. raised one foot by each bushel of coals.

The constant aim of engineers is to increase the amount of this duty; in other words, to make a less quantity of fuel than 10 lbs. do the work of one horse, or to obtain a greater duty than a quarter of a million of lbs. from one lb. of fuel, or more than 20 millions of duty from a bushel or 84 lbs. of fuel. To such an extent has this effort been successful, that one cubic foot of water has been converted into steam capable of exerting one horse power by the combustion of less than 5 lbs. of coal; and this steam has been so managed in the engine as to raise one million of lbs. one foot high by one lb. of coal, and in one case 125 millions of lbs. by a bushel of coals was the duty obtained in Cornwall. Of these improvements part is due to the economy of steam in the engine itself, and does not come under this head. That part, however, which is the result of economy in the boilers deserves our attention here.

By a series of experiments, carefully conducted or collected, and ably discussed, by Mr. Parkes of Warwick, the statistics of steam-engine boilers have been placed in an aspect sufficiently clear to enable us to deduce some general results of considerable economic importance. These experiments are contained in the table on the opposite page.

The observations contained in this table are made upon three great classes of boilers; the Cornish high-pressure boiler, I. to IV.; the waggon boiler and common low-pressure boiler, V. to XIV.; and the locomotive-engine boiler, XV. and XVI. The waggon boiler, V., was treated at Warwick in a peculiar manner by Mr Parkes himself, who is the advocate of a peculiar system of management, by which very slow combustion of the fuel is produced.

The Cornish boilers I. to IV. are distinguished from the common boilers, both in construction and treatment. The surface which they expose to the fire is enormous, being four or five times as great as the standard of usual practice, as we find in I., where 34 horse power has a surface of 2600 feet, and in II., where 48 horse power has a surface of 3170 feet exposed to the fire. This species of boiler is invariably cylindrical, and traversed longitudinally by cylindrical iron flues. It is also surrounded by external flues, except on the upper surface, which is placed under a roof, and enclosed to a considerable depth in sawdust, or other nonconducting matter. The circuit which the flame and hot gases perform, in contact with the flues, is about 150 feet long. The treatment of the Cornish boiler is as peculiar as its structure, for instead of a strong draught, a tall chimney, and an intense fire, the fuel is laid on in large masses, it is allowed to cake and to consume very slowly, while its products pass up the chimney after having paid a leisurely visit to the two or three thousand feet of absorbent heating surface that surround its long and circuitous passage towards the open air. Very perfect combustion is obtained by the thorough combination of the oxygen, and the ample time permitted for the communication of the heat thus developed. Durability in the materials used, economy in the fuel employed, and increase of useful effect, are obtained by the Cornish construction and usage, to an extent that excels every other mode of generating steam with which we are acquainted.

The economy of the Cornish boiler and its causes may be estimated by comparison with the standards we have already given of very ordinary practice.

CONDITIONS.	ORDINARY STANDARD.	CORNISH BOILER.
Area of fire grate in square feet	1	2
Area of heating surface in do..........	15	60 to 70
Circuit of heat	60 ft.	150 ft.
RESULTS.		
Fuel per horse power per hour	10 lbs.	$5\frac{1}{4}$ lbs.
Fuel consumed per hour per ft. of grate	10 lbs.	$2\frac{5}{8}$ lbs.
Water evaporated by each lb. of coal	6 lbs.	$11\frac{4}{5}$ lbs.

Steam-Engine Boilers. Statistical Tables.

STATISTICAL TABLES
OF THE
EVAPORATION AND COMBUSTION OF STEAM BOILERS.

			PARTICULARS OF THE BOILERS.										PARTICULARS OF THE COMBUSTION.				PARTICULARS OF THE EVAPORATION FROM THE INITIAL TEMPERATURE OF THE WATER.					PARTICULARS OF THE EVAPORATION OF WATER AT THE TEMPERATURE OF 112°.				PARTICULARS OF THE PROPORTIONS OF HEATED SURFACE TO FUEL BURNT AND WATER EVAPORATED.					
No. of experiment.	Place of experiment.	Nature of coals used.	Form of the boilers.	No. of boilers in use.	Length.	Breadth.	Diameter.	Total area of heated surface.	Surface exposed to radiant heat.	Surface exposed to communicative heat.	Length of circuit made by the heat in one boiler.	Area of the grates.	Weight burnt per square foot of grate per hour.	Weight burnt per square foot of heated surface per hour.	Temperature of the water entering the boilers.	Pressure of the steam above the atmosphere.	Cubic feet evaporated per hour.	Pounds evaporated per 1lb. of fuel.	Pounds of fuel evaporating one cubic foot of water.	Pounds of water evaporated by the products of combustion per square foot of grate per hour.	Pounds of water evaporated per square foot of heated surface per hour.	Pounds evaporated by 1lb. of fuel.	Pounds of fuel evaporating one cubic foot of water.	Pounds of water evaporated by the products of combustion per square foot of grate per hour.	Pounds of water evaporated per square foot of heated surface per hour.	Square feet of heated surface to one square foot of grate.	Square feet of heated surface per lb. of fuel burnt per hour.	Square feet of heated surface per lb. of water evaporated per hour from its initial temperat.	Square feet of heated surface per lb. of water evaporated per hour from 212°.	Square feet of heated surface per cubic foot of water evaporated per hour from its initial temp.	Square feet of heated surface per cubic foot of water evaporated per hour from 212°.
	Cornwall.				ft.	ft.	ft. in.	sq. ft.	sq. ft.	sq. ft.	ft.	sq. ft.	lbs.	lbs.	deg.	lbs.	c. ft.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	sq. ft.	sq. ft	sq. ft.	sq. ft.	sq. ft.	sq. ft.
I.	Huel Towan	*W.	Cyl.	3	36	..	6 0	2600	114	2486	152.	72.0	2.83	0.078	93.8	49.4	34.82	10.58	5.90	29.94	0.829	11.89	5.25	33.66	0.932	36.11	12.75	1.205	1.072	74.67	67.04
II.	United Mines	W.	Cyl.	3	2, 36 1, 40	..	6 4	3170	98	3072	158.	70.0	4.09	0.093	96.0	35.0	48.04	10.48	5.95	42.90	0.977	11.76	5.31	48.13	1.096	43.88	10.72	1.022	0.911	63.94	56.98
†II.	Mean of exp. I. & II.	W.	Cyl.	3	36.66	..	6 2	2885	106	2779	155.	71.0	3.46	0.085	94.9	42.2	41.43	10.53	5.92	36.42	0.903	11.82	5.28	40.89	1.014	39.99	11.73	1.113	0.991	69.30	62.01
III.	East Crinnis	W.	Cyl.	3	2, 34 1, 36	..	2, 6 9 1, 7 0	2500	57	2443	152.33	37.5	7.00	0.104	..	..	..	..	..	..	..	..	..	..	..	66.66	9.52	..	..	..	..
IV.	Binner Downs	W.	Cyl.	2	30	..	6 0	1440	76	1364	132.	48.0	4.62	0.154	..	..	..	..	..	..	..	..	..	..	..	30.00	6.48	..	..	..	..
V.	Warwick	S.	Wag.	3	1, 15.0 2, 12.5	1, 6.0 2, 5 0	..	455.0	107.0	338.0	50.66	70.5	4.00	0.019	93.0	2.5	41.38	9.17	6.81	36.68	5.684	10.3.	6.05	41.28	6.396	6.45	1.61	0.1759	0.1563	10.99	9.77
VI.	Clithero	L.	Wag.	1	20.0	5.5	..	320.0	23.62	296.38	91.0	17.6	11.53	0.634	44.0	5.0	18.55	5.71	10.94	65.90	3.625	6.73	9.27	77.69	4.273	18.18	1.57	0.275	0.234	17.25	14.63
VII.	Ditto........	L.	Wag.	1	20.0	5.5	..	320.0	35.43	284.56	91.0	20.25	8.02	0.507	44.0	5.0	21.62	8.32	7.51	66.75	4.224	9.79	6.38	78.55	4.970	15.80	1.97	0.236	0.201	14.80	12.57
VIII.	Preston	L.	Wag.	1	13.5	8.0	..	297.0	46.85	250.15	70.0	27.75	9.97	0.931	76.0	4.0	33.17	7.49	8.33	74.74	6.984	8.56	7.28	85.44	8.000	10.70	1.07	0.143	0.124	9.00	7.82
IX.	Ditto........	L.	Wag.	1	13.5	8.0	..	297.0	46.85	250.15	70.0	27.75	9.27	0.867	80.0	4.0	35.00	8.49	7.36	78.82	7.360	9.67	6.46	89.77	8.388	10.70	1.15	0.135	0.119	8.48	7.45
X.	Ditto	L.	Wag.	1	13.5	8.0	..	297.0	46.85	250.15	70.0	27.75	11.88	1.110	74.0	4.0	44.25	8.38	7.45	99.65	9.311	9.60	6.50	114.13	10.663	10.70	0.900	0.107	0.093	6.71	5.86
XI.	Albion Mills ...	N.	Wag.	1	16.0	6.0	..	521.5	35.0	486.5	70.0	24.5	16.44	0.772	100.25	2.5	55.60	8.62	7.24	141.83	6.663	9.63	6.48	158.55	7.448	21.28	1.294	0.150	0.134	9.38	8.39
XII.	London	N.	Wag.	2	15.0	5.5	..	345.0	31.5	313.5	56.0	22.66	12.79	0.840	101.50	2.5	32.52	7.00	8.91	89.71	5.891	7.82	8.00	100.14	6.577	15.22	1.189	0.169	0.152	10.60	9.50
XIII.	Ditto	N.	Wag.	2	15.0	5.5	..	345.0	52.5	292.5	56.0	40.50	6.17	0.725	96.50	2.5	34.53	8.10	7.70	53.28	6.254	9.09	6.87	59.75	7.015	8.51	1.379	0.159	0.142	10.00	8.91
†XIII.	Mean of exp. VI.—XIV.	L. N.	Wag.	1	36.66	6.5	..	342.81	39.82	302.98	72.5	26.09	10.75	0.798	77.0	3.68	34.40	7.76	8.18	83.83	6.289	8.86	7.15	95.50	7.166	13.88	1.315	0.171	0.149	10.77	9.39
XIV.	Long Benton ..	N.	Circ.	2	..	..	1, 12 1, 13 6	459.0	71.0	388.0	52.8	35.10	20.34	1.55	152.0	1.5	90.00	7.87	7.93	160.25	12.250	8.37	7.46	170.36	13.02	13.08	0.642	0.0816	0.0767	5.10	4.79
XV.	Manchester & Liverpool Railway....	Coals Coke	Loc.	1	7.0	..	..	334.56	41.47	293.11	7.0	7.03	79.33	1.66	60.0	50.0	55.48	6.21	10.05	493.27	10.360	7.21	8.66	573.25	12.04	47.59	0.581	0.096	0.080	6.02	5.03
XVI.	Killingworth...		Loc.	1	10.0	..	..	124.06	22.56	101.5	..	12.90	45.49	4.73	60.0	..	41.92	4.46	14.00	203.10	21.118	5.17	12.07	235.50	24.48	9.61	0.211	0.047	0.040	2.95	2.55
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

* W. indicates Welsh S. Staffordshire; N. Newcastle; L. Lancashire.

Steam-Engine Boilers.

The few selections from the valuable magazine of practical facts presented in this table, serve to show how much is to be gained even without the assistance of new inventions, by judicious construction and treatment of ascertained and practical kinds of boilers and ordinary fuel. A saving of 50 per cent over ordinary practice is gained in Cornwall by large fire grates, thick fires, slow combustion, internal flues, extensive fire surface, and external coverings. He who desires to improve the construction or management of his boilers, has only to fulfil the conditions that are now brought under his attention.

The common waggon boiler stands contrasted in all points with the Cornish boiler. Yet it is cheering to see how much advantage may be gained by judicious construction of fire grate, and a proper system in managing the fire, as is shown in Mr Parkes's experiments on his boiler at Warwick. The only peculiarities of the Warwick treatment appear to have been a large fire grate, $1\frac{3}{4}$ square feet to the horse power, and slow combustion, the high result of 10 lbs. of water evaporated by each pound of fuel, and the economical result of only 6 lbs. of fuel to each H.P. per hour, appear as the reward of this treatment.

The locomotive-engine boiler is in every point contrasted with the Cornish boiler. To pursue this part of the investigation more minutely than its exhibition in the table, would not coincide with the objects of this section.

STEAM NAVIGATION.

Steam Navigation.

The application of steam-power to navigation is one of the most wonderful triumphs of human ingenuity.[1] By this power vessels of gigantic size are impelled across the trackless ocean; and, in spite of its storms and resisting tides, establish a chain of communication between the shores of the remotest regions, as safe and as certain as if connecting the cities of a continent. Thirty years have scarcely yet elapsed since the first steam-ship of traffic was launched on the Hudson, and now there is hardly a navigable river or an inland lake whose waters are not agitated by the steam-boat paddle, and its atmosphere darkened by her smoke; while even the ocean itself is crossed in almost every direction by lines of steam-ships of immense size, and of beautiful construction. Many individuals have claimed the merit of inventing an art so pregnant with interest to mankind; and almost every civilized country contends for the honour of its birthplace. If the mere suggestion of the application of steam-power to the purposes of navigation entitle an individual to the credit of having invented the art, there are, doubtless, many who may be regarded as its inventors; for this suggestion was repeatedly made almost as early as the invention of the steam-pump, although from the nature of steam machinery, then and for long after, no advantage could be derived from it. To show how the ingenious of that time were led to propose steam as a motive power in navigation, we shall give a brief account of the contrivances which had been devised for the propulsion of vessels.

The substitution of other apparatus than oars, and of other power than human labour, to impel vessels in a calm or against the wind, is of unknown antiquity. The Egyptians are said to have used, in their boats, wheels like the paddle-wheels of the present day, but moved by oxen working in a gin on the deck of the vessel. Valturius, in his treatise *De Re Militari*, gives an account of paddle-wheel boats used by the Romans as transports, the paddle-wheels being driven by men or by horses; and we have, from many sources, abundant evidence of the existence of similar boats elsewhere. In a book published in London in 1578, called *Inventions and Devices*, by William Bourne, we find the following passage: "And farthermore, you may make a boat to go without oars or sail, by the placing of certain wheels on the outside of the boat, and so turning the wheels by some provision, and so the wheels shall make the boat goe." Thus we see that the means of making the boat go by paddle-wheels was already discovered, and the "some provision," by which these paddle-wheels were to be moved, was the desideratum. Horses, oxen, and human power had already been used for this purpose; and the first indication of some different power occurs in the Marquis of Worcester's *Century of Inventions*, published in 1663. The marquis, describing his *quintessence of motion*, says, "By this I can make a vessel of as great burthen as the river can bear to go against the stream, which, the more rapid it is the faster it shall advance, and the moveable part that works it may be, by one man, still guided to take the best advantage of the stream, and yet to steer the boat to any point. And this engine is applicable to any vessel or boat whatsoever, without being therefore made on purpose, and worketh these effects—it *roweth*, it *draweth*, it *driveth*, (if need be,) to pass London Bridge against the stream at low water; and, a boat laying at anchor, *the engine may be used for loading or unloading*." What the marquis's quintessence of motion was, or how applied to the moving of the vessel, we have not now the means of discovering; but, in his proposed applications of it, he has more than anticipated all that has yet been done; for we do not yet employ our steam-engines for loading or unloading. Savary, the inventor of the next steam-engine, proposed to apply his engine to impel boats. The only way, however, in which a rotatory motion could be derived from his engine was, by it to raise water into an elevated cistern, whence it could fall upon the floats of a water-wheel. This clumsy machine was not well adapted for a boat; and we hear nothing of its application. About the year 1688, the ingenious Dr Papin, who had been engaged with the project of an atmospheric vacuum-engine for moving machinery, proposed to form a vacuum in his cylinder with gunpowder, as had been proposed by Hautefeuille ten years before, and by Huyghens in 1680; but this scheme being found impracticable, he proposed, about two years afterwards, "to turn a small surface of water into vapour, by fire applied to the bottom of the cylinder which contains it, which vapour forces up the plug or piston in the cylinder to a considerable height, and which, as the vapour condenses, descends again by air pressure, and is applied to raise water out of the mine." Besides raising water from mines, he proposed also by a motion derived from the piston-rod of his engine, to impel the paddles of a boat. Here, with the discovery of the high-pressure engine within his reach, Papin relinquished his experiments; and Newcomen, adopting his cylinder and piston, and Savary's mode of condensation, a few years afterwards completed the atmospheric engine. The difficulty of converting the reciprocating motion of the atmospheric engine into a rotatory motion was the great bar to the use of it in any other way than for pumping water. Yet not a few speculators are to be found at this time inventing other means of propelling vessels than by paddle-wheels, so as to take advantage of the single reciprocating action of the engine. In 1730, Dr John Allen proposed to give motion to vessels by forcibly ejecting a stream of water or current of air from their stern; a scheme which, since his time, has been again and again invented, patented, and abandoned. Seven years after his proposal, Jonathan Hulls published an account of a steam-boat invented by him. In this boat, he had two paddle-wheels suspended in a frame projecting from its stern. In the body of the boat were two atmospheric engine cylinders with their pistons: to each piston one end of a rope was fastened; the rope was then carried round a pulley on the corresponding paddle-wheel, and one end was allowed to hang free, with a weight attached to it. When one of the pistons was pressed down in its cylinder by the weight of the atmosphere it pulled its rope, and, consequently, moved round the paddle-wheel in a degree due to the length of the stroke and the diameter of the pulley. While the piston was ascending in the cylinder, on the admission of the steam, the counterbalance weight, at the outer end of the rope, dragged round the pulley in the contrary direction; but the pulley being attached to the paddle-wheel by a ratchet-wheel, the latter remained stationary during the retrograde motion of the former. There being two cylinders and two paddle-wheels in the boat, it was so ordered that one should be in motion while the other remained stationary, and that thus the boat's motion should be continuous. However ingenious this plan of a steam-boat may be, we find no evidence that it was ever reduced to practice; but in a tract which Hulls published in 1737, he meets, and combats in a most masterly manner, every objection which he conceives might be urged against his project.*

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[1] For these historical notices, ending in p. 693, we are not indebted to the same contributor who wrote the rest of the article.

In 1757, the celebrated Daniel Bernoulli, in an essay which obtained a prize from the Academy of Sciences, after demonstrating the effect of many mechanical contrivances which might be substituted for oars in moving vessels, suggests paddle-wheels moved by steam-power or the force of gunpowder. Another of the essayists, Gautier, a canon of Nancy, in suggesting the same mechanism and the same power, shows very great fertility of invention, and skilful application of mechanical resources in the adaptation of the different parts of the machinery.

In 1759, Mr J. A. Genevois, a minister of Berne, invented a species of propellers, which, like a duck foot, would expand, and present a large surface to the water when moved against it, but would fold up into small compass when moved in an opposite direction. It is scarcely necessary to say, that these duck feet oars failed; but it is a melancholy fact, that similar apparatus has been frequently re-invented since the days of the pastor of Berne, and with the same degree of practical success.

The Comte d'Auxiron, in 1774, under the auspices of a company formed for the purpose, made some experiments with steam-boats on the Seine. These unfortunately failed; but M. J. C. Perier, who had been present, repeated them with improved machinery, a year or two later. His success was so indifferent as to offer no inducement to him to continue his experiments. It is unnecessary to swell the present work with examples such as these; and we shall therefore at once proceed to the time of Watt, whose labours gave to the steam-engine its power of almost universal applicability, and eminently fitted it for the moving of paddle-wheels.

Leaving undescribed the experiments of the Marquis de Jouffroy on the Seine in 1782, and the attempts of Rumsey, of Fitch, and of Evans in America, between the years 1775 and 1787, which were attended with no beneficial effect, we proceed to notice the first attempts which were perfectly successful, and to which we more immediately owe the benefits of steam navigation. These were made in 1787, by a Scottish gentleman, Patrick Miller, Esq. of Dalswinton in Dumfries-shire, who, in that year, published an account of some experiments which he had made on the best mode of impelling single, double, and triple vessels, by the power of men and of horses applied to paddle-wheels. In this publication, Mr Miller states, "I have reason to believe that the power of the *steam-engine* may be applied to work the wheels, so as to give them quicker motion, and consequently to increase that of the ship. In the course of this summer I intend to make the experiment." He owed the suggestion of the steam-engine to a young man, Mr James Taylor, who resided in his family as tutor, and who had assisted him in his experiments; but neither Mr Miller nor Mr Taylor could devise a way of applying the engine to the boat. In this dilemma, Taylor suggested that they should have recourse to the aid of an old school-fellow of his, Mr William Symington, an engineer, at that time assiduously employed in endeavouring to adapt the steam-engine to wheel carriages. Mr Taylor seems to have sent an account of their project to Mr Symington, as we find the latter thus writing to the former, on the 20th August 1787: "I must make some remarks on your summer's inventions, which, if once made to perform what their author gives them out for, will undoubtedly be one of the greatest wonders hitherto presented to the world, besides its being of considerable emolument to the projector. Great success to you, although overturning my schemes." In the winter of the same year, Mr Miller was introduced to Mr Symington in Edinburgh, and saw the model of his locomotive carriage. Convinced of the perfect applicability of a similar engine to drive the paddle-wheels of a boat, Mr Miller gave orders for the construction of an engine on the same plan, under the direction of Symington and Taylor. The engine was accordingly made in Edinburgh, and sent to Dalswinton, and by them put together in October 1788. The engine, in a strong oak frame, was placed on one side of a twin or double pleasure boat on Dalswinton lake. The boiler was placed on the opposite side, and the paddle-wheels in the middle. In the middle of October, the machine was first put in motion; and the ingenious inventors had the gratification of witnessing the perfect success of the first steam-boat. Although the cylinders of the engine were but four inches in diameter, yet the boat attained a speed of five miles an hour. Mr Miller, anxious to try the experiment on a larger scale, commissioned Mr Symington to purchase a *gabert*, or large boat at the Forth and Clyde Canal, and to get suitable engines constructed at Carron. Every thing being completed, a trial took place on a level reach of the Canal, of about four miles in length, at Lock Sixteen. The trial was made in presence of many spectators, who were however disappointed in their expectations, owing to the breaking of the paddle-wheels. Stronger wheels were obtained, and another trial took place on the 26th December 1789, and the vessel moved at the rate of about seven miles an hour. Next day and afterwards the experiment was repeated with equal success; and the following account of it was transmitted by Lord Cullen to several of the Edinburgh newspapers:—"It is with great pleasure I inform you that the experiment which some time ago was made upon the great canal here by Mr Miller of Dalswinton, for ascertaining the powers of the steam-engine when applied to sailing, has lately been repeated with great success. Although these experiments have been conducted under a variety of disadvantages, and with a vessel built formerly for a different purpose, yet the velocity acquired was no less than from six and a half to seven miles an hour. This sufficiently shows that, with vessels properly constructed, a velocity of eight, nine, or even ten miles an hour may be easily accomplished, and the advantages of so great a velocity in rivers, straits, &c., and in cases of emergency, will be sufficiently evident, as there can be few winds, tides, or currents which can easily impede or resist it; and it must be evident that, even with slower motion, the utmost advantage must result to inland navigation." It is much to be regretted that Mr Miller, having made so successful an experiment, carried his attempts no further. The boat was dismantled and laid up at Carron; and this ingenious and public-spirited gentleman directed his attention to other objects. His pursuits had a greater tendency to improve the condition of his country, than to enrich his own family.

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* A Description and Draught of a new invented Machine for Carrying Vessels or Ships out of, or into, any Harbour, Port, or River against Wind and Tide, or in a Calm: for which his Majesty has granted Letters Patent, for the sole benefit of the author, for the space of fourteen years. By Jonathan Hulls. London, 1737, 12mo.

In 1793, Rumsey, who, as we have already stated, had been unsuccessful in his experiments in America, got some American residents in London to defray the expenses of another experiment there. He, however, died before his boat was finished; and when it was got afloat by those engaged with him, it attained a speed of four miles an hour against wind and tide. The propulsion of this boat was effected, on the principle of Dr John Allen's, by ejecting a stream of water at the stern.

In 1795, Earl Stanhope revived the pastor of Berne's duck feet oars; but he could not cause his vessel to move at a higher rate than three miles an hour.

In the year 1801, Thomas Lord Dundas employed Mr Symington to make a tug-boat for dragging vessels on the canal. With this view, a series of experiments were made between 1801 and 1802, at a cost of £3000. In March 1802, Lord Dundas, Mr Speirs of Elderslie, and several other gentlemen, being on board of the newly-constructed tug-boat, which was named the Charlotte Dundas, it "took in drag," says Mr Symington, "two loaded vessels, each upwards of 70 tons burden, and with great ease carried them through the long reach of the Forth and Clyde Canal to Port Dundas, a distance of 19½ miles in six hours, although the whole time it blew a very strong breeze right ahead."

In consequence of an impression in the minds of some of the canal proprietors, that the paddle-wheels of the boat injured the banks of the canal, the project of the steam-tug was with great reluctance abandoned, and the boat was laid up in a creek of the canal, where it remained for many years exposed to public view. A year after this most successful experiment, Mr Fulton, an American, made a similar experiment on the Seine at Paris, under the auspices of the American chancellor, Mr Livingstone. Owing to a miscalculation of the strength of the boat, it had no sooner received the weight of the engine than it broke through the middle, and went to the bottom. Not disheartened, Fulton set about building a new vessel; and in August 1803 he launched it with its machinery. This vessel was 66 feet long and 8 feet wide; but moved so slowly, that we may describe the experiment as a failure. He afterwards came to Scotland, and saw Mr Symington's vessel. Of this visit, a memorial of Mr Symington's, which we have before quoted, gives the following account:—"When engaged in these last experiments, I was called upon by Mr Fulton, who very politely made himself known, and candidly told me that he was lately from North America, and intended to return thither in a few months, but having heard of our steam-boat operations, could not think of leaving this country without first waiting upon me, in expectation of seeing the boat, and procuring such information regarding it as I might be pleased to communicate; he at the same time mentioned, however advantageous such invention might be to Great Britain, it would certainly become more so in North America, on account of the many extensive navigable rivers in that country; and as timber of the first quality, both for building the vessels, and also for fuel for the engine, could be purchased there at a small expense, he was decidedly of opinion it could hardly fail, in a few years, to become very beneficial to trade in that part of the world; and that his carrying the plan to North America could not turn out otherwise than to my advantage; as, if I inclined it, both the making and superintendence of such vessels would naturally fall upon me, provided my engagements with steam-boats at home did not occupy so much of my time as to prevent me from paying any attention to those which might afterwards be constructed abroad. Mr Fulton having thus spoken, in compliance with his most earnest request I caused the engine-fire to be lighted up, and in a short time thereafter put the steam-boat in motion, and carried him from Lock No. 16, where the boat then lay, four miles west the canal, and returned to the place of starting, in one hour and twenty minutes, to the great astonishment of Mr Fulton, and several gentlemen who at our outset chanced to come on board. During the above trip, Mr Fulton asked if I had any objections to his taking notes regarding the steam-boat; to which question I said, none, as I considered the more publicity that was given to any discovery intended for general good, so much the better; and having the privilege secured by letters patent, I was not afraid of his making any encroachment upon my right in the British dominions, though in the United States I was well aware I had no power of control. In consequence, he pulled out a memorandum-book, and, after putting several pointed questions respecting the general construction and effect of the machine, which I answered in a most explicit manner, he jotted down particularly every thing then described, with his own remarks upon the boat, while moving with him on board along the canal; but he seems to have been altogether forgetful of this, as, notwithstanding his fair promises, I never heard any thing more of him, till reading in a newspaper an account of his death.

"From the above incontrovertible facts, which can be corroborated by a number of persons of respectability living at this day, it is very evident that commerce is not indebted to North America for the invention of steam-packets, it being hereby established beyond the possibility of doubt, to be truly British, both in the idea and practice; and that Mr Fulton's steam-vessel did not make its first appearance in the Hudson river earlier than 1806 or 1807, four years at least posterior to his having been on board the Charlotte Dundas steam-boat, and minutely examined it, when at work on the Forth and Clyde Canal, and eighteen years later than the date of the first experiments made by me upon steam-boats, on the lake at Dalswinton, Dumfries-shire, in Great Britain."

Fulton, having obtained what information he could, ordered, under an assumed name, it is said, a steam-engine from Bolton and Watt. He shortly afterwards returned to America, and in conjunction with Mr Livingstone obtained a patent, securing to them the prospective advantages of steam navigation in America, by what they rather insincerely termed *their* invention of steam-boats. In 1806 Bolton and Watt's engine arrived, and in 1807 the first steam-vessel in America was launched on the Hudson river. It was called the Clermont, which was the name of Livingstone's residence. In spite of the advantages which it possessed over the Scottish vessels, in having better engines, and in its projectors having the benefit of Symington's experiments, it was a comparative failure, attaining at the utmost a speed of only *five* miles an hour. The boat had not been long under weigh, on its first trip, when Fulton ordered the engine to be stopped. Having observed that the paddle-wheel floats were too deeply immersed in the water, he shifted them nearer to the centre of the paddle, so that they did not enter so deeply into the water; and this alteration had the effect of increasing the speed of the vessel.

Shortly after this first experiment, it was announced that the Clermont would sail from New York to Albany; and of this first voyage the following account was sent to the Editor of the *American Citizen* newspaper, by Fulton himself:—

"Sir,—I arrived this afternoon, at four o'clock, in the steam-boat from Albany. As the success of my experiment gives me great hopes that such boats may be rendered of great importance to my country—to prevent erroneous opinions, and to give some satisfaction to the friends of useful improvements, you will have the goodness to publish the following statement of facts. I left New York on Monday at one o'clock, and arrived at Clermont, the seat of Chancellor Livingstone, at one o'clock: time, 24 hours; distance, 110 miles. On Wednesday I left the chancellor's at nine in the morning, and arrived at Albany at five in the afternoon: distance, 40 miles; time, 8 hours. The sum is 150 miles in 32 hours, equal to nearly 5 miles an hour, &c.—ROBERT FULTON."

During the same season, the boat made many voyages between New York and Albany, and in these she met with not a few accidents, arising chiefly from the defective construction of her paddle-wheels, which were of cast-iron, and had no support beyond the vessel. She was likewise injured by the sailing vessels, whose owners, dreading the intruder, ran them against her. The Clermont was at length laid up during the winter; and being enlarged and strengthened, she was again, in the spring of 1808, employed as a passage-boat between the same stations, and continued during the summer crowded with passengers. The success of their first vessel induced Messrs Livingstone and Fulton to build other two vessels, the Car of Neptune, of 300 tons, and the Paragon, of 350 tons.

Thus it was that steam navigation in America originated; and the enthusiastic and speculative Fulton enjoys the honour of having first shown to the world its commercial value. It is now proper time to mention that Fulton had been aided in his experiments on steam navigation by Mr Henry Bell, by whom the first steam passage vessel in Britain was constructed. The nature of this connexion will be better seen from Mr Bell's own account of it, which was addressed to the Editor of the *Caledonian Mercury* in 1816.

"Sir,—I observed in your paper lately a paragraph respecting steam-boats, in which the Americans claim the right to the discovery which is become of so much utility to the public. On this account I propose to give you a full statement of what I conceive to be the truth. Mr Miller of Dalswinton first wrote upon the method of moving or impelling vessels or rafts through water by paddles, wrought by a capstan, or by the wind, in the manner of a wind-mill, which idea he afterwards gave to all the different courts in Europe. It will be recollected by most people in this country, that the French proposed to erect rafts for conveying troops to invade this country, by means of Mr Miller's wind-mill or capstan plan; for, it may be stated that this gentleman built two vessels at Leith, and put them in motion upon his new improvement, and even sent one of them to the King of Sweden as a present. After this, he thought that an engine could be so constructed as to be applied to work his machinery for the moving of his paddles; and accordingly he employed an engineer to put his plans in execution; but they failed for want of being properly executed. But to give you a more correct account of the manner Mr Fulton, the American engineer, came to the knowledge of steam-boats, that gentleman had occasion to write me about the plans of some machinery in this country, and beg the favour of me to call on Mr Miller of Dalswinton, and see how he had succeeded in his steam-boat plan; and if it answered the end, I was to send him a full drawing and description of it, along with my machinery. This led me to have a conversation with the late Mr Miller, and he gave me every information I could wish for at the time. I told him where, in my opinion, he had erred, and was misled by his engineer; and at the same time I told him, that I intended to give Mr Fulton my opinion on steam-boats. The friends of Mr Miller must have amongst their papers Mr Fulton's letter to me; for I left it with Mr Miller. Two years thereafter I had a letter from Mr Fulton, letting me know that he had constructed a steam-boat from the different drawings of the machinery I had sent him out, which was likely to answer the end, but required some improvement on it. This letter I sent to Mr Miller for his information, which must also be amongst his papers. This letter led me to think of the absurdity of writing my opinion to other countries, and not putting it in practice myself in my own country; and from these considerations I was roused to set on foot a steam-boat, for which I made a number of different models before I was satisfied. When I was convinced that they would answer the end, I contracted with Messrs John Wood and Company, shipbuilders in Port-Glasgow, to build me a steam-vessel according to my plan, 40 feet keel, and 10 feet 6 inches beam, which I fitted up with an engine and paddles, and called her the *Comet;* because she was built and finished the year that a comet appeared in the north-west part of Scotland. This vessel is the first steam-boat built in Europe that answered the end, and is at this present time upon the best and simplest method of any of them; for a person sitting in the cabin will hardly hear the engine at work. She plies on the Frith of Forth betwixt the east end of the great canal and Newhaven, near Leith. The distance by water is 27 miles, which she performs, in ordinary weather, in 3½ hours up, and the same down. There were many attempts to make steam-boats in this country before this one, but none of them ever answered the end; and even three years after the Comet was set a-sailing, there was a number of our first-rate engineers joined together, and obtained a patent for what they conceived a new discovery on the paddles for impelling the vessel forward. They were disappointed in their plan, and had to return to the model of the Comet."

The Comet was a vessel of about 25 tons, and her engine, which was a vertical one, exerted about three horses power. Bell's success immediately excited competition; and a vessel called the Elizabeth, 58 feet in deck, and with an engine of 8 horse power, was started by Mr John Thomson on the 9th of March 1815. The spirit of enterprise was now roused, and steam-boats rapidly succeeded each other, every succeeding one excelling its predecessor in power and beauty. No longer timidly confining themselves to the navigation of rivers, the projectors of those steam-ships boldly steered into the deep waters, crossing the channel between Great Britain and Ireland, and performing the dangerous coasting voyages between Glasgow and Liverpool, Leith and Aberdeen, and Leith and London.

The first person who ventured beyond the precincts of a river was in all probability R. L. Stevens of Hoboken. This gentleman had been associated with Chancellor Livingstone, previously to the connexion of the latter with Fulton, and had brought his experiments to a successful issue nearly as soon as Fulton and Livingstone. Fulton having, however, secured to himself the exclusive privilege of navigating by steam in the state of New York, Stevens at once conceived the bold idea of taking his vessel by sea from the Hudson to the Delaware. To Mr Stevens many of the improvements of steam navigation are to be ascribed. He introduced the modifications of Watt's engine, which we have represented in Fig. 2, p. 693, still in use in American vessels. He introduced engines of long stroke; and, as a necessary consequence, a long crank, and the further peculiarity of upright guides for the piston-rod, instead of the old parallel motion. To him we likewise owe the paddle-wheel with divided boards, by which the resistance of the water was rendered more uniform, and the concussions of the common paddle-wheels avoided. He improved the shape of the American steam-vessels, by substituting for the full round bows and sterns a fine entrance and a fine run. By this, and by making the length of his vessels eight or ten times their beam, he succeeded in raising their rate of sailing from nine to thirteen miles an hour.

Reverting to Britain, we find from the first introduction of Bell's Comet in 1813, steam navigation gradually improving as an art. The vessels were, however, of small dimensions, of low proportion of power, and of little speed, until the year 1818, when Mr David Napier directed his attention to the improvement of steam navigation. It is to this gentleman that Great Britain owes the introduction of deep sea communication by steam vessels, and the establishment of post-office steam-packets. In 1818, Mr Napier established between Greenock and Belfast a regular steam communication, by means of the Rob Roy, a vessel built by Mr William Denny of Dunbarton, of about 90 tons burden, and 30 horse power. For two winters she plied with perfect regularity and success between these ports, and was afterwards transferred to the English Channel, to serve as a packet-boat between Dover and Calais. Having thus ventured into the open sea, Mr Napier was not slow in extending his range. Soon after, Messrs Wood built for him the Talbot, of 120 tons. With two of Mr Napier's engines, each of thirty horse power, this vessel was in all respects the most perfect of her day, and was formed on a model which was long in being surpassed. She was the first vessel that plied between Holyhead and Dublin. About the same time he established the line of steam ships between the stations of Liverpool, Greenock, and Glasgow. For the traffic of these stations he built the Robert Bruce, of 150 tons, with two engines of 30 horse power each; the Superb, of 240 tons, with engines of 35 horse power each; the Eclipse, of 240 tons, with two engines of 30 horse power each. All these were established as regular deep sea traders before the year 1822, on a station which has not since been surpassed for the power, beauty, and speed of its steam vessels.

In 1822 was built by Messrs Wood on the Clyde, the James Watt steam-vessel, to ply between Leith and London. This vessel was of 448 tons measurement, and she carried two engines of fifty horse power each, made by Messrs Watt and Bolton, and completed entirely under the superintendence of Mr Brown of that firm. The James Watt was remarkable for having its paddles moved, not directly by the engine, but through the interposition of toothed wheels, so that the number of revolutions of the axis of the engine was greater than that of the paddles. With the exception of the low proportion of its power to its tonnage, the James Watt possesses almost all the qualities of the most improved vessels of the present day.

The next great advance in the art was made in 1826, when the first of the leviathan class of steamers, the United Kingdom, was constructed. This steam-ship was 160 feet long, 26½ feet beam, and 200 horse power. She was built by Mr Steele of Greenock, and the engines were constructed by Mr Napier. Mr David Napier was also one of the first persons to introduce surface condensation in marine engines. He used it successfully in the Post-Boy, a steam-vessel built by him. The condenser was composed of a series of small copper tubes, through which the steam passed towards the air-pump; and, a constant current of cold water encircling the pipes, the steam was cooled and returned into water, which was again sent into the boiler for conversion into steam, without being mixed with the cold salt-water, which, in the usual plan, is injected into the condenser. But, like Watt, Cartwright, and others, who have tried this system both here and in America, he did not find the rapidity of condensation sufficiently great, and he returned to the old system of condensation by jet. Some years afterwards, however, he reverted to this system in peculiar circumstances which rendered it desirable; and, using flat plates instead of tubes, was again perfectly successful, and plied for years with no other condenser. But, like all the other cases where it has been introduced, the advantages of the system were not reckoned equivalent compensation for its disadvantages. The plan of condensation by tubes, again introduced at a recent date by Mr Hall, has been tried in numerous vessels, in some of which it has been abandoned, and in others it still continues to be employed.

The next change introduced very extensively into steam-vessels by Mr Napier, was the use of an upright or vertical steam-engine, or engine of direct connexion. The first engine of Bell was to some extent a vertical engine, inasmuch as the axis of the cylinder and of the crank were placed in one vertical line; but there was no direct connexion between the crank and the piston-rod to the paddle-axle, the communication of motion to it being effected through the medium of toothed wheels. In the common or lever engine the piston-rod acts on a cross-head, the cross-head on side-rods, the side-rods on side-levers, the lever on a cross-tail, the cross-tail on the connecting rod, the connecting rod on the crank-pin, by which through the axle the paddle-wheels revolve. In the engine of direct communication, the side-levers, and some other parts of the train of communication, are removed by a device which enables the piston-rod to be almost immediately attached by a connecting-rod to the cranks of the paddle-shaft. This plan was first adopted by Mr Gutzmer of Leith, who built a vessel called the Athole, and another called the Tourist, on this principle; but his method, though very simple, was not applicable in ordinary cases; and Mr Napier made several modifications of the vertical engine, which, according to our judgment, include all the best that have yet been introduced. It does not seem to have been practically established that the engine of direct connexion is preferable to the lever engine; but the plans of Mr Napier appear to have been the best ever adopted.

It is now a considerable time since Mr David Napier relinquished all connexion with such operations on the Clyde; since his retirement, much has been done for the advancement of steam navigation in Britain, and to this work the ship-builders and engineers of the Clyde have contributed their full share. We have already stated that a regular communication by steam was early established between Liverpool and the river Clyde. This establishment has done much for the advancement of steam navigation. It has afforded scope for two extensive companies, who, employing the most eminent steam-engine and ship-builders for the construction of their ships, have produced a very superior class of vessels.

The introduction of wrought-iron hulls for steam vessels, has been the means of introducing a great improvement in the art. This method of construction enables builders to effect a combination of strength and lightness of draught, peculiarly advantageous in some branches of trade and in certain localities. One of the first iron steam-vessels was the Alburkha, of 55 tons. It was built to accompany the Quorra in the expedition to the Niger in 1832, and gave very great satisfaction. The builders of the Alburkha, Messrs Laird of Liverpool, immediately afterwards commenced another vessel, the Garry-Owen, destined to run between Limerick and Kilrush. The length of this vessel was 125 feet on deck, its beam 21 feet 6 inches, and its engines were fifty horse power each. The Garry-Owen was driven on shore, with many other vessels, in the great hurricane which happened about that time, and alone escaped uninjured. This, and other evidence of the power of iron vessels to withstand the casualties of the sea, so raised them in the estimation of builders, that their number was rapidly increased, and their size greatly extended.

For a long period there had been much speculation about the practicability of navigating the Atlantic by steam. So early as 1791, and while the steam-boat was yet in embryo, Fitch, the American, boldly predicted that sailing vessels would soon be superseded in transatlantic navigation. In 1819, an American steam-ship, the *Savannah*, of 300 tons' burden, arrived at Liverpool direct from the United States, having accomplished the passage in 26 days, partly steaming and partly sailing; and nearly ten years after, the Curaçoa, an English built vessel of 350 tons and 100 horse power, made more than one successful run in the same manner, between Holland and the Dutch West India colonies. Men of science, however, endeavoured to demonstrate that the navigation of the Atlantic by steam-power alone, was the dream of a visionary, and the tide of public opinion seemed to set in in the same belief; but a strong undercurrent was at work, and in 1838 the following advertisement appeared in the daily papers: "*Steam to New York.* The well-known steam-ship, Sirius, Lieutenant Roberts, R.N., Commander, is intended to leave London for New York on Wednesday 28th March, calling at Cork harbour, and to start from thence on Monday the 2d of April, returning from New York the 1st of May." Thus, a company of merchants was found sanguine enough to disregard the demonstration of the impossibility of an American voyage, and actually to advertise not only the day of sailing, but also the days of arrival and return. The *Sirius* was not expressly built for transatlantic navigation; she belonged to the St George Steam-Packet Company, and had run with a good reputation between London and Cork. Her tonnage was about 700 tons, and her engine about 320 horse power. Although advertised to sail on March the 28th, circumstances delayed her departure till the morning of the 4th April, when she started at ten o'clock, with 94 passengers. Though first in the race, she was only three days in advance; for on the 7th of the same month, the *Great Western*, built and fitted expressly for the purpose, followed her. In the interval, between the sailing of these vessels and the reports of their arrivals, much doubt prevailed as to the possibility of their accomplishing their task in safety, and the uncertainty was increased by vessels having arrived from America at ports in Britain, without having encountered either of the steamships; people having, for a moment, forgotten that there were more roads than one across the Atlantic. They were at length, however, spoken with by the Westminster, the Sirius on the 21st, within six hours' sail of New York, and the Great Western on the 22d; and in due time, reports of their having reached New York arrived, the Sirius on the 22d, being 17 days clear on the passage, and the Great Western on the 23d, being 15 days. The Sirius again sailed on her homeward passage on May 1st, afternoon, and the Great Western on May 7th, and they arrived, the first on the 18th, and the latter on the 22d, being 16 and 14 days respectively. The average speed, and expenditure of fuel of the Great Western was as follows. The whole distance run from Bristol to New York was 3125 miles, averaging each day 208 miles, each hour 8·2 miles; the distance run in returning from New York 3192 miles, each day 213 miles, each hour 9 miles nearly. She departed with 860 tons of coals, and on her arrival at New York she had 205 tons remaining. She left New York with 570 tons of Newcastle coals, and had on board when she arrived at Bristol 178 tons. Her average daily consumption was 27 tons; and, with the expansion valves up, 32 tons. In page 707 there is given a table exhibiting a comparative view of the size and power of six of the largest of the transatlantic vessels.

The practicability of transatlantic navigation being thus fully demonstrated, preparations for its continuance on a gigantic scale commenced, and the British Queen, the President, and other vessels of enormous size, were launched in rapid succession. In addition to these, the offspring of a state of peace, steam war vessels, of great size, are daily constructing, and call for the highest ingenuity of the ship-builders and engineers, in adapting them for taking the advantage of their sails as well as of their steam-paddles.

While the art was thus rapidly advancing, many ingenious men were making attempts to improve the form of the paddle-wheels, or to substitute for them some other impelling apparatus. Of the improvements in the paddle-wheels themselves, we shall have occasion to speak in the sequel. We shall, therefore, in this place, give some account of the most important of the substitutes, the Archimedes screw propeller. The idea of impelling a vessel by means of a screw of a large diameter, lying in the direction of the boat's motion, was originated some considerable time ago; but its first successful application was to a vessel named the Archimedes, constructed under the direction of the patentee of the screw, Mr Smith. From an interesting report of experiments made with this vessel by Captain Chappell, R.N., we condense the following statement:—The burden of the Archimedes is 237 tons, its mean draught of water 9 feet 4 inches. The diameter of the engine cylinder 37 inches, and the length of stroke 3 feet. The screw propeller consists of two half-threads of an 8 feet pitch screw, 5 feet 9 inches in diameter; each is therefore 4 feet in length, and they are set diametrically opposite to each other on the propeller shaft, at an angle of 45 degrees to the shaft. The propeller is placed longitudinally in a hole cut in the dead wood, immediately before the rudder, the keel being continued under the screw. The average performance of the engines is 26 strokes per minute, and the revolutions of the screw in the same time $138\frac{2}{3}$. If there was no slip or recession, the vessel ought to advance 8 feet for every revolution of the screw, or 12.60 miles per hour. The utmost speed ever obtained by her, under the power of steam alone, was 9.25 nautical miles per hour, showing a loss by recession of rather less than $\frac{1}{6}$th, under the most favourable circumstances. It is necessary to state that the Archimedes is not a fair exemplar of the screw-propelling principle, its steam-power being insufficient to drive a screw adapted to the size of the vessel.

The advantages of this species of propeller appear from Captain Chappell's statement to be these:—1. It occupies a position in the vessel in which it is not liable to injury, and in which it materially augments the power of the helm, enabling the vessel to be turned round and round in circles gradually smaller, until at length it seems to revolve on a pivot. 2. It retains its efficiency of action, even in heavy seas, the rolling, pitching, or lurching of the vessel not materially affecting it. 3. It offers little obstruction to the speed of the vessel, when the sails alone are employed. When to these are added the saving of expense, which is said to be great, and the removing the top-weight and unsightly paddle-boxes, we are of opinion that there is enough in its favour to recommend its further trial.

We have now traced the art of steam navigation from its first suggestion to its present state of high perfection. We have overlooked, it is true, much that is interesting in the minute progression of the art; but we have endeavoured to mark its greater advances. We have seen its advancement in the short period of a quarter of a century, from the canal boat experiment of Symington, and the three horse steam-boat of Bell, to the construction of the monster ships, the British Queen and the President, of 500 and 600 horse power. When, in 1820, steam-ships were first used for conveying merchandise, as well as passengers, the tonnage of the whole of the steam-traders amounted to only 505 tons. In 1821, it amounted to 36,194; in 1822, it had reached to 101,744 tons; and thus advancing, it had arrived, in 1836, at the prodigious amount of 5,429,226 tons. The number of vessels of the mercantile marine, with their power and tonnage, is exhibited in the following table.

An Account of the Approximate Number, Tonnage, and Power of Vessels belonging to the Mercantile Steam Marine of the United Kingdom and its dependencies, at the close of the year 1839.

SIZE OF VESSELS.	Total Number of Vessels, according to the Custom-House Returns in 1838.	Total Registered Tonnage.	Tonnage of Engine-Room, &c., not Registered at the Custom-House.	Total Computed Tonnage.	Total Computed Amount of Horse power.	Average Computed Power per Vessel.	Average Computed Tonnage per Vessel.
	No.	Tons.	Tons.	Tons.	Horse power.	Horse power.	Tons.
Under 50 Tons . . .	256	6,106	10,816	16,922	6,400	25	66
From 50 to 100 Tons . .	145	10,267	7,458	17,725	6,866	47	122
100 ,, 150 ,, . .	84	10,034	7,761	17,795	7,483	90	211
150 ,, 200 ,, . .	63	10,982	7,147	18,129	7,560	120	287
200 ,, 300 ,, . .	76	16,654	10,839	27,493	11,188	147	361
300 ,, 400 ,, . .	41	14,247	7,580	21,827	10,914	266	532
400 ,, 600 ,, . .	10	4,488	3,506	7,994	3,000	300	769
679 ,, . .	1	679	661	1,340	450	450	1,340
1,053 ,, . .	1	1,053	810	1,855	500	500	1,855
Number of vessels Registered in 1838 . . .	677	74,510	56,378	131,080	54,361	...	...
Not Registered	83	4,154	5,484	9,638	2,129	50	116
Total Number in Great Britain and Ireland, 1838	760	78,664	62,062	140,718	56,490	...	...
Isles of Guernsey, Jersey, and Man, 1837 .	6	832	618	1,450	600	100	241
British Plantations, 1837	44	8,411	7,253	15,664	6,160	140	356
Total . . .	810	87,937	69,933	157,840	60,840	...	...

THE THEORY AND PRACTICE OF MODERN STEAM NAVIGATION.

There is perhaps no popular error more injurious to the welfare of a mechanical nation, like our own, than the notion that theory is opposed to practice; and there is no subject in which this error has ever been more disastrous than in steam navigation, and naval architecture in general. It is by the combination of theory and practice that most is to be accomplished; and it may be hazarded as a general assertion, resting on all past experience, that the best promoters of the public welfare are—that theoretical man who has made himself best acquainted with the practice of his art, and that practical man who has acquired the greatest knowledge of its scientific principles. There is no art which does not attest this truth, and none attests it more than steam navigation. It is admitted, that out of every three steam vessels that are built, two fall very far short of fulfilling the intention with which they were constructed. We believe there is no error which it may be possible to commit in steam navigation, that has not already been perpetrated again and again.

To construct a perfect steam-vessel, it is necessary first of all to make a perfect ship; secondly, to construct a perfect steam-engine and boilers of a very complex description; thirdly, to apply a propelling apparatus of the most appropriate description; and finally, to combine all of these in a perfect and well-proportioned whole. Now, to construct a perfect ship, is itself a problem of the highest order, requiring a combination of the most profound resources of analysis, with the highest practical sagacity; a problem on which the reasoning of the mathematician, and the tact of the artist, have long been engaged, with few examples of complete success. To construct a sufficient, effective, powerful, durable, and safe engine and boilers for marine purposes, is a problem more easy, yet one in which there has been encountered continual failure. Then, the means of propelling the vessel over the element on which it floats, give rise to questions in the resistance of fluids which all the resources of hydrodynamic science, in the hands of the ablest mechanical philosophers of the last century, have failed to resolve. Then, last of all, the combination of all of these together, in the best possible way to bring about the precise effect desired, is a problem still more arduous; and all the skill of the analyst, the geometer, the mechanical philosopher, of the naval architect, the engineer, the mechanic, and the sailor, if combined in a single individual, or concentrated on a single object, are not more than sufficient to the arduous task of directing the wealth, enterprise, and resources of this country, in the attempt to render available to her own prosperity, and the interests of the human race, this most admirable of all her creations.

In the following enquiry, we shall soon see that neither practical experience without systematized knowledge, nor superficial theory ignorant of practical wants and practical means, will suffice to ensure success. Both physical science and practical sagacity will, in the art of steam navigation, find enough to exhaust their united resources.

We regret that we cannot record in the present work, that at this day the science of steam navigation is constructed and can be presented to our readers. Even the elementary principles of hydrodynamics are yet to be learned, before we can apply them to the ends of steam navigation. What seems the law of a fluid to-day, tomorrow shows to be a plausible fiction, or doubtful verisimilitude. How then can it be expected that a science should be determined, when its very foundations are yet to be laid? We shall, however, endeavour to generalize what we with certainty know, convinced that a clear statement of our ignorance is often the stepping-stone to truth. The steam-ship consists of three integrant parts: the marine-engine, with its boilers, by which the moving power is furnished; the propelling apparatus, by which it is rendered locomotive; and the ship itself, which contains both. We shall consider each apart, and then their combination.

The Marine Steam-Engine.—The marine steam-engine is of a structure more complex than the common fixed steam-engine, inasmuch as its function is locomotive, and it differs from a land-engine in those peculiarities which adapt it to the unstable nature of its support. He who looks at the ponderous masses of matter that form and sustain the shock of a powerful engine on land, the beams of iron, the blocks of stone, the deep buttresses, and the powerful walls which form its bed, on which it is adjusted at once with the greatest accuracy and power, and which it nevertheless causes to quiver and tremble by its giant strokes, will readily understand the incredulity with which the first projectors of steam navigation were regarded.

The earliest application of the steam-engine was to the pumping of water. We find that when it was first used to the effect of making machinery revolve, the great lever of the pumping-engine was retained. So was it in the application of the steam-engine to navigation; and the marine steam-engine, most generally used at the present day, both here and in America, is called the beam-engine, or lever-engine.

The first of the following diagrams represents the beam-engine, or lever-engine, as used on land to turn round machinery; the second represents the lever-engine, as used in America to give revolution to the paddle-wheels of a steam-boat; and the third represents the lever-engine of British steam-vessels.

Fig. 1.

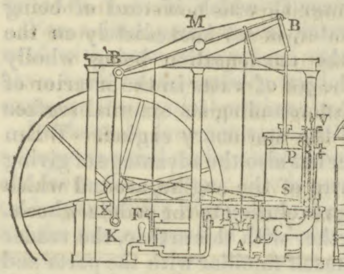


Fig. 2.

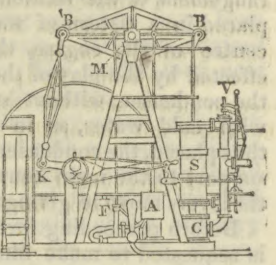
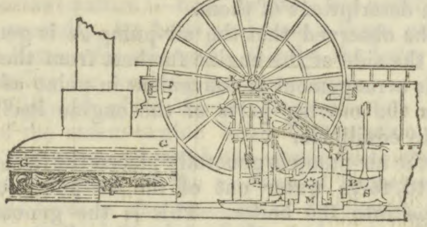


Fig. 3.



In all of these figures, S represents the place of the steam-cylinder, in which, by the alternate action of the steam on opposite sides of the piston P, that and the piston-rod P B are forced alternately to the top and bottom of the cylinder; and so the end of the lever or great beam B B is carried up and down around the centre M, carrying with it the connecting rod K B′, by whose reciprocation the crank-pin K, of the crank radius K X, is carried round on the great revolving shaft X; which, in the case of the marine engine, is the axis of the paddle-wheel, and in the case of the stationary engine, is the axis only of the fly-wheel. V is the place of the valves by which steam is admitted from the boiler into the cylinder, and, after having done its duty, is educted into the condenser C, where, by a jet of cold water constantly playing, it is immediately condensed into water of the seventeen-hundredth part of its bulk, and so leaves the cylinder empty, *i. e.* nearly a perfect vacuum; and as this condensing receptacle would soon, by the jet of cold water flowing into it, and the accumulation of condensed steam, be filled with water and its evolved gases, the air and water are pumped out at each stroke of the engine by the air-pump A, worked from the lever or working-beam B B, and so the vacuum is kept perfect and the condenser effective. The feed-pump F replenishes the boiler G with some of the water extracted from the condenser, at a temperature of about 90°, and so supplies the deficiency caused by the continual evaporation of the water, at the rate of 6 gallons for each horse power every hour.

Difference between the Marine Engine and the Land Engine.

The differences between the arrangements of the marine steam-engine used in Great Britain, and the land steam-engine, are chiefly these: the lever or great beam, which, in the land-engine, is above the top of the engine, and which in large engines is generally composed of a pair of thin deep beams of cast-iron, united side by side into one; this single beam is brought down in the marine engine to the bottom of the engine, or rather one-half of the great beam is placed on either side of the cylinder, the two being connected together from the opposite sides of the engine, so as to act simultaneously as a single lever. This form of engine, sometimes applied to other purposes as well as to navigation, is called, from this disposition of the working beam, the side lever engine.

Another peculiarity in the marine-engine, sometimes however adopted in land-engines, is the place and arrangement of the condenser C, which, instead of being placed in a cistern of water, is set immediately on the centre of the engine, the condensation being wholly effected by the play of the jet of water in the interior of the condenser, without surrounding its external surface with cold water, as in the stationary engine. When thus placed, the condenser has also the advantage of giving support to the main centre of the engine, around which the levers move in giving revolution to the paddle-wheels.

Before proceeding further with this article, the reader is requested to make himself familiar with the parts and arrangements of the engine already described, by referring to the plates of the marine-engines given at the end, and to the descriptions of them.

It will be observed that the air-pump A is generally placed on the side of the engine furthest from the cylinder. This arrangement is convenient in point of room, and keeps the moving parts of the engine itself more perfectly in equilibrio.

Beside the air-pump is generally placed the feed-pump, designed to force water out of the air-pump or discharge-pipe into the boiler. This is the general disposition of parts, which the reader will easily be able to recognise in the plates given with this article.

Although the lever-engine is the form most commonly employed for marine purposes, it is by no means the only form. Very many attempts have been made to obtain engines more compact and of less weight and bulk than the lever-engine. These are distinguished from the lever-engines by the names vertical engines, steeple-engines, and engines of direct connexion. It is still doubtful whether any of them, except in very peculiar circumstances, are practically to be preferred to the lever-engine; on the contrary, objections of a serious nature are alleged against them.

We have already seen that the first steam-boat, the Comet of Mr Bell, had a vertical engine. It was remarked of this vessel that the strain of the engine on the vessel was very small; but this has been attributed to the low proportion of power to the tonnage of the vessel.

Fig. 4.

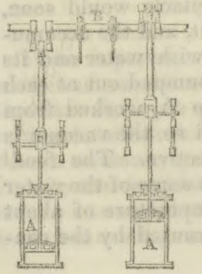
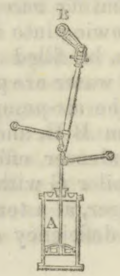


Fig. 5.



The first steam-vessel whose engines we had the pleasure of seeing, had a pair of vertical engines, made by Gutzmer of Leith; the paddle-shaft B being directly over the axis of the cylinders A, as in figs. 4. and 5.

Modifications of this plan of direct or immediate connexion have been recently tried on a larger scale; but the method has the disadvantages of admitting only a short stroke and a short connecting rod, and requires that the height of the axis above the bottom of the cylinder should be at least three times the length of the stroke. Thus, one of the extremes, too short a connecting rod, too short a stroke, or a paddle-axis too high above the floor of the vessel, is incurred.

To obtain the same object without incurring those evils, many descriptions of engine have been contrived. The following admits of placing the paddle-axis at little more than double the height of the stroke of the engine, and gives a connecting rod of $1\frac{1}{2}$ or 2 times the stroke. The piston-rod P is inserted into a cross-head *d d*, to the extremities of which two vertical rods *d e*, *d e*, are attached. With the lower extremities of these rods the side-rods *g f*, *g f*, are connected; the upper ends of these side-rods are attached to the cross-head *g g*, to the centre of which the crank-rod is attached.

Fig. 6.

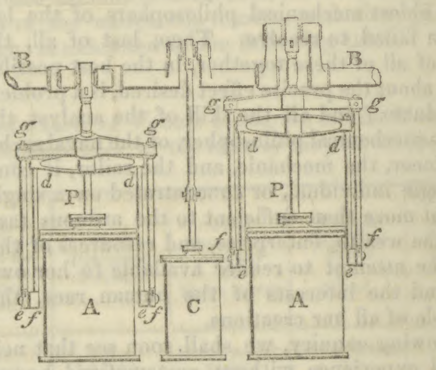
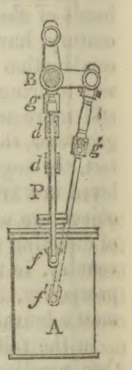


Fig. 7.



This species of engine has the great disadvantages of a multiplicity of shafts, bearings, and cranks. It was afterwards simplified by Mr David Napier in the manner represented in the following figures; viz. by uniting into one forked cross-head each cross-head with its side-rods.

Fig. 8.

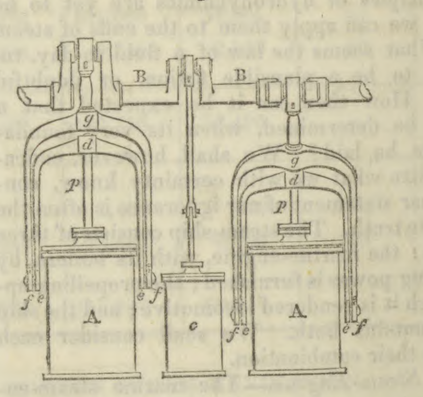
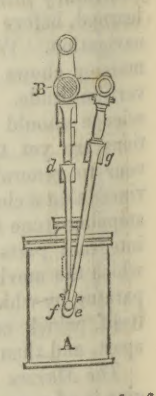


Fig. 9.



Even thus, however, limits are placed on the length of stroke and height of shaft, so as to give rise to inconvenience in many circumstances. To remedy these evils, Mr Napier appears to have invented the following class of engines, to which the cant term of steeple-engines appears to be sufficiently appropriate. In the steeple-engine the piston-rod is made forked or divaricated, so as, passing round the shaft, to rise above it to a considerable height, from which again descends the connecting rod to the crank. The following example is that of the engine of a vessel named the Clyde, the first of the kind we ever saw:—

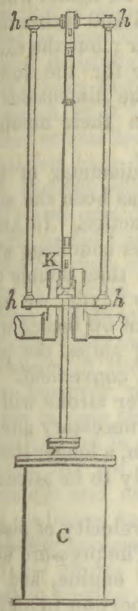


Fig. 10.

Fig. 11.

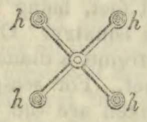
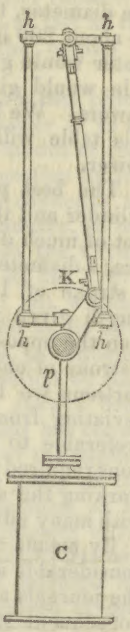


Fig. 12.



The top of the piston-rod carries a quadripartite cross-head *h h*, on each end of which stands a pillar *h h*; these four pillars again unite in another quadruple cross-head, sustained upright by a vertical guide; and it is from this summit that a connecting rod descends to the crank *k*. We believe that this principle of continuing the piston-rod round the axis by a forked frame was first devised, at the end of the last century, by Trevithic, the famous high-pressure engineer, and by him applied to steam-carriages. It is drawn in his patent specifications.

After passing through a great variety of phases, the steeple-engine appears to have settled down into the two following shapes. In figs. 14 and 15, the piston-rod is seen united to a triangular frame, from the apex of which the connecting rod descends to the crank. In fig. 16, this frame is shown to be square, and fig. 13 is the side view of both varieties.

Fig. 13.

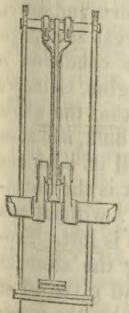


Fig. 14.

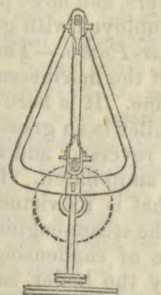


Fig. 15.

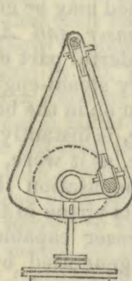
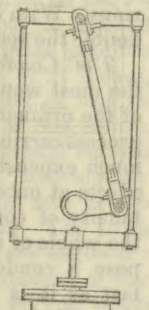


Fig. 16.



Another method of accomplishing the direct connection without encumbering the deck, has twice been patented: in the last instance by Mr Humphreys. It may be called the trunk-engine. The axis is placed at the height of half the stroke, or more, above the cylinder, and a connecting rod unites immediately the crank-pin with the centre of the piston. In this way the connecting rod, passing through the top of the cylinder, would allow the steam to escape but for a large trunk or casing with which it is surrounded, and which, passing through a chasm of large area conceived to be steam-tight, rises and falls with the piston to which it is attached. In fig 17, A A is the cylinder: to its piston is attached a trunk B, which works through a stuffing-box in the cylinder cover; to the piston the connecting rod *c c* is attached. Fig. 18 represents the top of the cylinder A A, with its stuffing-box and the trunk B.

Fig. 17.

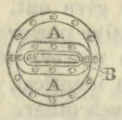
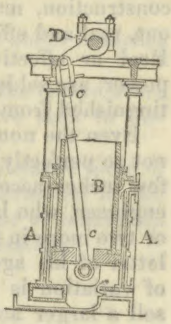


Fig. 18.



Humphrey's Engine.

For a like purpose, oscillating cylinders have been used with some measure of success. Rotatory engines have been unsuccessfully tried. The reader may now examine the vertical engines in the plates.

In short, it does not appear that any vessel, either on a large or small scale, constructed with an engine different from the ordinary side lever engine, has been found to be practically superior to it; and therefore we shall for the future speak of the lever-engine of the ordinary construction, when we treat of the marine steam-engine, unless when another species is expressly mentioned. The lever-engine possesses three advantages of an important nature:—first, its parts are nearly in equilibrio; secondly, its basis embraces a large part of the vessel's bottom for strength; thirdly, the lever presents great facility for working its appendages.

Cylinder of the Marine Engine.

The Cylinder of the Marine Steam-Engine.—The cylinder of the steam-engine being that portion of its apparatus, by means of which the elastic force of the steam is directly applied to the mechanical arrangements by which the force of the machine is developed, is therefore the principal member of the engine, on the size of which its powers and the dimensions of the other parts depend.

It is according to the dimensions of the cylinder that an engine receives its denomination, and is bought or sold. An engine is called a 10, 20, 50, or 100 horse-power engine, according to the number of inches in the diameter of the cylinder. It is not to be expected, however, that every steam-engine will develope the power of a given number of horses, simply because it has a cylinder of a given number of inches. This depends equally on the proper proportion, construction, and condition of all the other parts, without which the engine will be incapable of doing its proper duty. The engines of some makers will develope double the power of those made by inferior engineers, even although in name and dimensions identical. Hence, the dimension of cylinder is taken according to a rule somewhat arbitrary, of the value both dynamical and pecuniary of the engine under the term nominal power; and the actual efficiency of the engine under given circumstances, is called the real or effective power. Hence an ambiguity is incurred in speaking of the relative powers of engines, when it is not determined whether the real or nominal power is referred to. An engine of 100 horse power, which ought to be capable of giving out an effective power of 100 horses, may, from bad workmanship, bad arrangements, or modified circumstances, only give out the real power of 50 horses; and an engine of the same dimension of

Cylinder of the Marine Engine.

cylinder, and of the same nominal power, but of better construction, may give out, and frequently does give out, real and effective power equal to that of 150 horses. Real or effective power, and nominal or mercantile power, are seldom identical, and should always be distinguished from each other.

Even the nominal or mercantile standard of power is not so perfectly invariable as may be desired. It varies a few inches according to the practice or policy of the engineer, who is frequently called upon to give an inch or two more in his mercantile dimensions, than the strict letter of his agreement might demand. Another cause of variation is this, that some engineers will prefer to sell a larger actual dimension under the name of a less number of horse power, that their engines of a given nominal power may apparently do more work than those of other people. It is a third cause of variation, that some engine-makers give more than the actual dimension belonging to the power, in order that, under even the most unfavourable circumstances, the possessors of the engine may derive from it more than the full measure of the actual effective power which they require.

The following table has been constructed from a comparison of the practice of the most eminent marine steam-engine makers, with the principles of their construction. But under the dimensions given, the engines of best construction will give out from one-fourth to one-third more than their nominal power. We know, for example, that a cylinder of 74 inches diameter has been constructed under the designation of 200 horses, whereas its proper nominal power is above 225 horses, and its actual effective power, as given out in the ship, was more than 300 horses. The contraction H.P. is generally used instead of the words horse power.

Table of the Dimensions of the Cylinder of a Marine Steam-Engine of given Horse power.

Nominal Power.	Dimensions of Cylinder.	
	Diameter (within.)	Length of Stroke.
10 H.P.	20 Inches.	2 Feet 0 In.
15 „	24 „	2 „ 2 „
20 „	27 „	2 „ 6 „
25 „	30 „	2 „ 10 „
30 „	32 „	3 „ 2 „
35 „	34 „	3 „ 3 „
40 „	36 „	3 „ 6 „
45 „	38 „	3 „ 9 „
50 „	40 „	4 „ 0 „
60 „	43 „	4 „ 3 „
70 „	46 „	4 „ 6 „
80 „	49 „	4 „ 9 „
90 „	52 „	5 „ 0 „
100 „	55 „	5 „ 6 „
110 „	57 „	5 „ 6 „
115 „	57 „	5 „ 9 „
125 „	59 „	6 „ 0 „
130 „	60 „	6 „ 0 „
150 „	62 „	6 „ 3 „
165 „	65 „	6 „ 6 „
175 „	66 „	6 „ 6 „
200 „	70 „	7 „ 0 „
225 „	73 „	7 „ 3 „
250 „	76 „	7 „ 6 „
275 „	79 „	7 „ 9 „
300 „	82 „	8 „ 0 „
350 „	87 „	8 „ 6 „
400 „	92 „	9 „ 2 „
500 „	100 „	10 „ 0 „

This table shows that the power of the steam-engine increases more rapidly than the area of the cylinder or the square of the diameter. By the rule of the square of the diameter, the power of an engine of 74 inches would be about 200 instead of about 225; and 100 inches diameter would give only 333 horse power; but the same rule would give too small a diameter for the lower powers. We believe that engines of the dimensions of this table will all work to more than their nominal power.

The best proportion between the diameter of the cylinder and the length of the stroke, has been the subject of much dispute, and of opposite practice. In America, a diameter of 40 inches is sometimes combined with a stroke of 10 or 11 feet, being more than double the length given in this country. On the Clyde, we have seen the opposite extreme, a diameter of 60 inches with a stroke of only 4 feet. For sea-going ships, the proportions we have given are the most convenient. In deviating from this proportion, a longer stroke will be preferable to a shorter; and with the necessary alterations required for high velocities of piston, a longer stroke working the steam expansively is likely to be attended with many advantages.

By means of a long stroke or great velocity of piston, considerable advantages are gained. The pressure upon the journals and working parts of the engine, and the consequent strain, is lessened in proportion to a given power. All the parts of the engine might be lighter than with a shorter stroke and a greater diameter of cylinder. A short stroke has however this advantage, that with a given length of lever and connecting rod, the angles of oblique pressure are smaller, and the intervals of time between maximum and minimum pressure are shorter. There are other peculiarities of smaller importance. On the whole, a longer stroke than that of the present British engine, as given in the table, is to be reckoned considerably preferable to a shorter one.

The velocity of the piston in the cylinder of a steam-engine is generally reckoned in this country at 220 feet a-minute, and all the arrangements of the engine and its work are made on that principle. We can find no better reason for this than that a horse going at that speed, viz. two miles an hour, can draw 150 lbs. eight hours a-day, all the year round. Tredgold finds it to be a law of nature. It is strange how much this arbitrary dogma, transmitted without question, has retarded the improvement of steam navigation. It is a rule as universal in its acceptation as it is groundless and injurious. With large condensers, and large ports and valves, double the speed may be employed with great advantage.

The Condenser and Air-Pump.—The condenser is the most wonderful part of the marine-engine, as indeed of the ordinary steam-engine. It is here that the whole process carried on in the boiler in so great bulk, and at so much expense, is instantly reversed, and all its laborious effects at once, as it were, annihilated. It is the instantaneity of condensation that is its virtue: without this the whole of its virtue in the steam-engine is lost. Suppose a condenser capable of condensing the steam as fast as it is generated by the boiler, and given off in the cylinder, and no faster, what would be the consequence? The power of the engine would cease, the elastic force of the steam above the atmosphere would alone act, the steam being only condensed as the piston carried it out of the cylinder; the engine would become nothing else in power but a high-pressure engine, whose steam is merely condensed before going out into the atmosphere. It is by forming a perfect vacuum in the cylinder on the moment when the steam is about to enter on the opposite side, that the full power of the steam can alone be obtained in useful effect. A perfect condenser must, therefore, have much greater capability than that of merely condensing the steam as fast as the boiler is capable of evacuating it, or the engine of passing it through.

We have insisted the more strongly on this point, inasmuch as it is here principally that power is to be gained at smallest expense. Many other modes of condensation have been tried besides condensation by jet, and without effect. Newcomen tried to condense by cold water outside his condenser; so did Savary, so did Watt, so did Cartwright, so did Napier on the Clyde, so did Stevens of Hoboken in America, so did Trevithic, Symington, Mills, and many others; but without success: for though they all succeeded so far as, by having cold water on the outside of the vessels, to condense the steam in the inside, yet this condensation by contact, however perfect in quantity, has always been slower in time than condensation by jet, and has consequently failed in developing the full power of the engine. In this list we have not mentioned the name of the ingenious and enterprising Mr Hall of Basford, as he still continues to persevere against the difficulty of introducing successfully into use the system which has baffled the efforts of his predecessors; and perhaps his attempt may be attended with a higher degree of success than theirs.

It appears difficult to assign a volume to the condenser which shall give it most efficiency. We have seen efficient condensers from one-fourth of the volume of the cylinder up to its full size. One-half the volume of the cylinder appears to be a size sufficiently convenient and effective.

The proper distribution of the water forming the jet, throughout the whole volume of the condenser, seems the most important point of efficacy in the condenser. Some engineers accomplish this by allowing the water to rise from the bottom of the condenser in a *jet d'eau*, which striking the top, falls down in a shower, filling the whole condenser; others make this shower radiate in all directions from a perforated horizontal pipe; and a third most effective method is, to spread out the jet in a thin film or sheet, like a waterfall, through which the steam is compelled to pass. In marine engines, the water is permitted to flow into the condenser through a pipe in the ship's side, regulated by a cock.

Much has been said regarding the perfection of the vacuum found in the condenser of a steam-engine, especially a marine engine. It does not appear to be known that a vacuum may be too good. We hear it boasted every day by rival engineers that their engines have the best vacuum. Some boast their vacuum at 27 inches, others at 28, others at 29, some at 30, and at last an engineer appears who boasts a vacuum of 30½ inches. It is to be regretted that time and talent should be thus wasted. It is a fact of great importance, confirmed by experiment and by practice, that a vacuum may be too good, and become a loss instead of a gain. The truth is simply this, and should be known to every engineer: *If the barometer stand at 29½ inches, the standard of this country, the vacuum* IN THE CONDENSER *is* TOO GOOD *if it raise in the barometer more than 28 inches of mercury.* This important truth is incontrovertible, and is practically exhibited every day.

The following is a simple proof of this doctrine, divested as far as possible of a technical form, and put in the shape of an enquiry into the best state of a condenser.

Let $t =$ the caloric of water of 1°.
$c =$ the constituent caloric of water in the state of steam.
$e =$ the total force of steam in the boiler in inches of mercury;
and $x =$ the elastic force of steam at the temperature of best condensation which we seek to discover.

Then from the law which connects the elastic force of steam with temperature, as already determined in the article STEAM, it follows, that in the case of maximum effect, or the temperature of best condensation,

$$\frac{t}{c} = \frac{x}{e} \text{ that is } x = \frac{et}{c}$$

now $c = 1000$, and if the steam in the boiler be at 5 lbs. above the atmosphere, or if $e = 40$ inches of mercury, and $t = 1$,

$$x = \frac{40}{1000} = 0.04$$

Again, if the steam be at 7½ lbs. = 45 inches,

$$x = \frac{45}{1000} = 0.045$$

Again, if the steam be at 10 lbs. = 50 inches,

$$x = \frac{50}{1000} = 0.05$$

Hence, we find that the best elasticity or temperature in the condenser depends on the elastic force of the steam in the boiler.

With steam of 5 lbs. in the boiler, the elasticity of maximum effect in the condenser is at 93° of Fahrenheit, and the best vacuum in the barometer is 28. With steam of 7½ lbs. in the boiler, the elasticity of maximum effect in the condenser is 95° of Fahrenheit, and the best vacuum in the barometer is 27.8. With steam of 10 lbs. in the boiler, the elasticity of maximum effect in the condenser is 97°, and the best vacuum in the barometer is 27.5. In like manner it would be found that with steam of 50 lbs. in the boiler, worked expansively, as in Cornwall, the best vacuum in the condenser would be about 26° on the barometer.

It is hoped, therefore, that engineers will not in future distress themselves, at finding the vacuum of their condenser much less perfect than the vacuum of others who have obtained 30, and 30½ inches, at so great a loss of fuel and power. To obtain a vacuum of 29½ with the weather-glass at 29.75, and steam at 7½ lbs., would be to sacrifice four horse power out of every hundred. In a day when the barometer is as low as 28½ inches, the vacuum in the condenser should indicate 26.8.

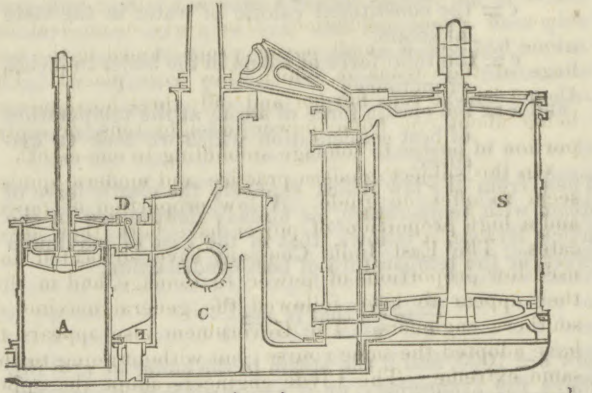
In speaking of the vacuum in the condenser, it would save much ambiguity to indicate the elasticity merely of the gas in the condenser. Thus, if the barometer stands without at 29½, and the barometer of the condenser at 28, it might be stated that the steam in the condenser stands at 1½, being the point of maximum effect; and the indication would at all times convey more precise information.

Air-pump of marine engines.

An air-pump is an appendage rendered necessary by the condenser, and especially by condensation by *jet d'eau*. Ordinary water contains about 5 per cent. of air and other gases, which become disengaged in the condenser, and must be withdrawn, to maintain the vacuum. Hence the air-pump, which is also used to withdraw the water which accumulates in the condenser. A valve between it and the condenser is called the foot valve; and a valve at the exit from the top of the air-pump is called the discharge valve. They are thus arranged: S the cylinder, C the condenser, A the air-pump, F the foot valve, and D the discharge valve.

Steam Navigation.

Fig. 19.



The dimensions of the air-pump seem to vary much, from $\frac{1}{8}$ to $\frac{1}{5}$ of the volume of the steam-cylinder. I do not know any disadvantage of importance in having a large air-pump; as, if properly constructed, the force which is required to work it will be nearly in the proportion of the elasticity of the gas which it has to remove from the condenser. To give the air-pump half the stroke of the cylinder and $\frac{1}{3}$ of the area of the cylinder, or $\frac{1}{5}$ of the stroke of the cylinder and $\frac{1}{2}$ the area of the cylinder, are common proportions.

Area of the valves and valve passages.

The Valves and Valve Passages.—The notion that because a horse can do most work at the rate of $2\frac{1}{4}$ miles an hour, or 220 feet a minute, therefore a steam-engine should also move at that rate, is a prescriptive error almost ridiculous; but from which it will nevertheless be difficult for us to escape, especially as the proportions generally in use are derived from this absurd dogma. There is no doubt that the passages and valves should simply be as large as possible, and those valves should be used which can be most enlarged with least inconvenience. Such valves we possess in the class of equilibrium valves. These valves may have an area as large as the tenth-part of the cylinder without disadvantage, and the velocity of the piston may thus be increased, and consequently the power of the engine, with great advantage, especially in steam navigation. We have the best possible means of knowing, that with proper valves and passages, the speed of the piston may very advantageously be increased to 250, 300, 400, and 500 feet a minute. The pistons of the swiftest vessels in the world move at that rate.

Various kinds of valves used in marine engines.

The kind of valve most commonly in use in steam-vessels is the long D-slide, as it is called; and next to that is the short D-slide. There are scarcely any other kinds in use in Britain. A valve called the four-port slide valve has been used to a limited extent, as have also conical valves, and equilibrium valves, or double heat valves in this country, the latter very extensively in America. The following are diagrams of the long and short D-slides.

The D-slide valve.

Fig. 20.

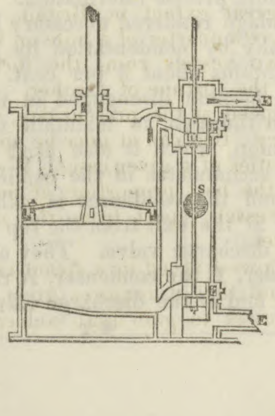
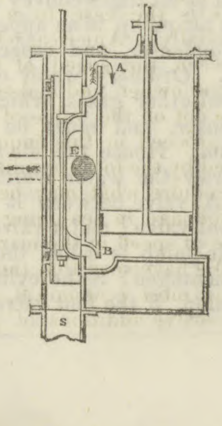


Fig. 21.



The

port

valve

The four-port slide valve is a recent invention, having been the subject of a patent so lately as 1833. Since that time they have been used to a considerable extent in one part of Scotland. The same kind of valve was subsequently patented by another party in England, and these valves were put on board of some of her Majesty's frigates. The following figures represent the four-port slide valve, in two positions. A the cylinder; *pp* the piston; S the steam-pipe; VVVV the slide valves. The arrows show the direction of the steam.

Fig. 22.

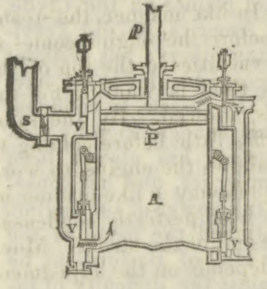
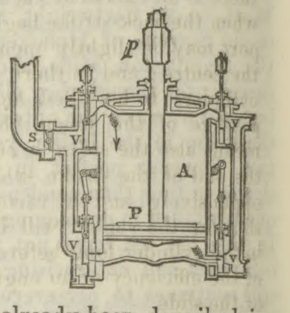


Fig. 23.



The equilibrium valve has already been described in the article STEAM-ENGINE.

The size of the valves is a matter of some consequence. That the valves, passages, and ports by which the steam enters the cylinder should allow a free passage of $\frac{1}{25}$ of the area of the cylinder, is an old and pretty general rule. It is equally certain, however, that the eduction valves, ports, and passages by which the steam enters the condenser should be much larger. They have been made $\frac{1}{12}$th and $\frac{1}{10}$th of the area of the cylinder with advantage, in the case of high velocity of the piston.

The Ecce

The Eccentric.—The valves, by means of which the steam is alternately admitted to the cylinder on one side, and educted from the other side, into the condenser, are moved by the machine itself; and the very simple and beautiful automatic contrivance for that purpose is called the eccentric.

Its p
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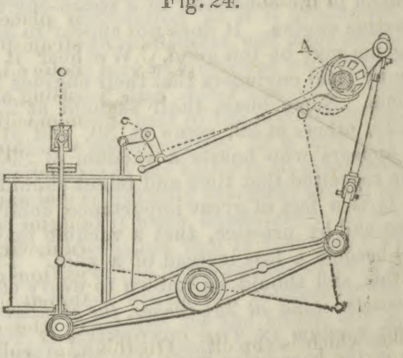
engin

We have already described the actions of the eccentric in the article STEAM-ENGINE. In the marine engine it is placed on the axis of the paddle wheels. In fig. 24 its usual arrangement is shown, and in the Plates many examples will be found.

Fig. 24.



As the shaft A moves round, it is plain that the projection of the eccentric, first on one side of the shaft and then on the other side, will draw the eccentric rod in opposite directions; and the distance of the centre of the eccentric from the centre of the shaft, will be placed now on one side and now on another side of the axis. The motion thus produced is called the throw of the eccentric; and half the throw is equal to the eccentricity.

n Na- tion.

T ad of th alves.

An important point in setting the valves is what is called the lead on the centres. What is the best instant of time at which to allow the steam to enter or escape from the cylinder? At first sight we should say, precisely at the instant of reversing the direction of the motion. This is not the case. Great advantage is gained by letting the steam out of the condenser before the end of the stroke. A little of the force of the steam in the cylinder may thus be sacrificed; but it is a very little, say $\frac{1}{50}$th of the stroke, and is much more than compensated by this, that the steam escaping thus early into the condenser, time is allowed for effectual condensation, and there is an excellent vacuum in the cylinder by the time when the back-stroke begins. In like manner, the steam-port may be slightly opened before the engine comes to the centre; and as there are vacuities at the top of the cylinders to be filled, and as time is wanting for the passage of the steam, this is allowed. By the same means also the steam is cut off a little before coming to the end of the stroke, which allows the engine to work expansively; and the vacuum port may in like manner be shut, as the vapour will have been perfectly condensed in the cylinder long before the end of the stroke. Much of the efficiency of an engine depends on the adjustment of the slide.

Ec tric in rine en es ge ally loo on the aft.

The eccentric of the marine engine is generally a loose eccentric, capable of turning the valves either so as to give the engine motion forwards or backwards. By placing the eccentric loose upon the axis, only with a projection on one side, which is carried round by a corresponding projection on the axis, it is left free, except when this check comes in contact with the projection at either end of the stroke. To effect this, it is necessary to open the valves by hand through at least one half-stroke.

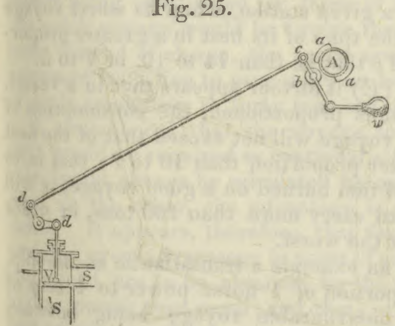
Ha Ge

The Hand-Gear.—The hand-gear is generally a lever or series of levers, which enables the engineer to shut and open the valves by hand before placing them in connexion with the eccentric. By this means he places the machine either in the condition to keep moving forwards or backwards. For examples see the Plates.

Ex sive Va s.

The Expansive Valves.—It is of advantage to cut off a part of the steam which would be required to fill the cylinder, so as to allow that quantity which has partly filled it to expand with its elastic force, and fill the rest of the cylinder without further supply from the boiler. The advantage of doing this, especially in long voyages, has now become pretty generally known. A stop-valve V, fig. 25, is placed on the steam-pipe S S′, before it joins the casing of the common valves, which are applied as usual. The principal axis A of the engine carries a cam, with two projections *aa* proportioned in breadth to the extent of the stroke which is cut off. On this cam rolls a small pulley *b*, pressed close by a weight *w*; and by a simple connecting rod the cam opens and shuts the valve with great velocity twice in each revolution. On this cam there may be various grades at which the steam may be cut off in the stroke of the engine. This apparatus is used in all vessels calculated for long voyages.

Fig. 25.



Steam Navigation.

Proportion of power to tonnage.

The Proportion of Power to Tonnage.—Large power or small power has always been one of the *vexatæ quæstiones* of steam navigation. The early steam-boat engines had but a small power proportioned to the tonnage of the vessels in which they were placed. The Comet had 25 tons burden and only three horse power; being about one horse power to eight tons, or a proportion of power to tonnage amounting to one-eighth.

On this subject modern practice and modern opinion seem to offer no guide. A low proportion of power and a high proportion of power have both their advocates. The East India Company have advocated and used low proportions of power to tonnage, and in this they appear to have followed the general maxims of southern engineers. The Government also appears to have adopted the same course; but without going to the same extreme. The Clyde engineers adopt the opposite maxim, and place as much power in their vessels as can be conveniently applied. There appears at the present moment to be a strong feeling in favour of a high proportion of power to tonnage. It has been found by some of the best mercantile companies, that a high proportion is not only better for expedition, but also more economical of fuel and of capital than a smaller proportion; and instances are frequent of an increase in the power of a steam-vessel, producing a diminution in the consumption of fuel.

As this question is becoming every day of greater importance, it is proper to examine it carefully. In the first place, it is well known that the proportion of power must be very much increased to gain a given increase of speed. Thus, if 120 horse power propel a vessel through water five miles an hour, it will require forty horse-power to propel the same vessel ten miles an hour, or it will require a quadruple power to obtain a double speed; and, in like manner, it will require a ninefold power to triple the speed. In fact, the increased speed requires an increased power in a duplicate ratio of the increased speed; or if the speeds be as the numbers 1, 2, 3, 4, 5, 9, 10, &c., the power required to attain those speeds must be 1, 4, 9, 15, 25, 81, 100 horses; or according to the well known law of the resistance of fluids, the resistance which the water opposes to increased speed is nearly in the duplicate proportion of the speed. Thus, to increase the speed in a given proportion, the fire of the engine and the consumption of fuel, which is nearly as the power of the engine, must be increased in a very high proportion. Hence the seeming great economy of a low power of engine and a small consumption of fuel.

Thus a large power of engine occupies much of the useful space of the vessel, which might have been filled with cargo. It consumes much coal, and the speed is by no means proportioned to the expense of fuel and machinery. But this is a very limited view of the subject. If time as an element, and a very important one in the value of mercantile conveyance, be calculated, then it will in many cases be found, that high speed at any expense of fuel will compensate for that expense. This is the case to a great extent in Britain, and especially in America, where a quarter of a mile an hour between the speed of two vessels ruins the fortune of one owner, and makes the fortune of another. But it is not on the value of speed at the present day, that we proceed in this enquiry; that can at once be appreciated by the local peculiarities of a given case. We are to enquire what may be the best proportion of power to tonnage in sea-going vessels, apart from the mere price of speed in the market.

We have seen that the lowest speed in a steam-vessel is the most economical, and that it requires great and expensive additions of power to gain high velocities.

Steam Navigation.

Proportion of power to tonnage in steam-vessels.

But in arriving at this conclusion, we have taken only the case of smooth and still water. Here it is obvious that the slowest rate and smallest power will be most economical; but it should be remembered that the great purposes of steam are generally of a different nature from the mere generation of motion through a quiescent fluid. The force of adverse winds and waves is to be opposed, stream-tides and currents are to be stemmed; and it is the success of steam in conquering those obstacles, and obtaining regularity and speed in spite of them, which constitutes its superiority over wind or animal power in navigation.

Now, if we take a simple case of one of these, we shall soon find that a higher proportion of power to tonnage may be essential, not only to speed, but even to economy. Suppose a steam-boat with a small proportion of power, capable of propelling the vessel at the velocity of three miles an hour through still water, to be applied to stem a current of three miles an hour, is it not plain that the vessel would make no head way, and thus a low proportion of power would burn an immense quantity of coal in doing nothing but standing still?

Let us again suppose that the same vessel, capable of steaming three miles an hour, meets with a moderately strong breeze opposed to her, such as prevents her from making any progress at all against it; then it is plain that by the continuation of this breeze, the vessel burning a continual supply of fuel would consume an indefinite quantity of coal in standing still. This extreme case of too little power, shows that there is at least one proportion of power, which is too small for economy of fuel; viz., that proportion which, being very economical of fuel in fine weather, is brought up altogether by adverse winds. In this case, the consumption of fuel is rendered indefinite, and the useful effect of fuel completely annihilated by too small a proportion of power.

As, then, we have plainly established the existence of a limit to diminution of power, in the vicinity of which it must be followed by extravagant consumption of fuel, we may now proceed to investigate the question of best proportion, or the point where the attainment of high speed is accompanied by absolute saving of fuel as compared to lower velocity. For this purpose, we merely take it for granted that the speed through the water will be nearly as the square root of the power, according to the general law of the resistance of fluids; that the resistance offered by bad weather or adverse winds has been ascertained and is determined on a particular station: that is, that it is known that on a given station a given vessel with a given power makes a voyage in adverse circumstances in, suppose, double the time of her most prosperous voyage; say her most prosperous voyage is in fourteen days, and her adverse voyage in twenty-four days, being a retarding power of ten days out of twenty-four; we take this retardation of ten days as the measure of the retarding power of adverse weather in the given circumstances. And further, let the following quantities be thus represented:—

Let h be the power, v the velocity, f the fuel consumed, t the time in good weather,
Let h' be the power, v' the velocity, f' the fuel consumed, t' the time in bad weather,
} In a given vessel, on a given station.

Let h'' be the power, v'' the velocity, f'' the fuel consumed, t'' the time in good weather,
Let h''' be the power, v''' the velocity, f''' the fuel consumed, t''' the time in bad weather,
} In another vessel of greater power on the same station.

Also, let k represent the consumption of fuel per horse-power per hour, and s the length of the voyage or distance performed. Then

$$f = k\,h\,\frac{s}{v} \qquad v = \text{a given quantity,}$$

$$f' = k\,h\,\frac{s}{v'} \qquad v' = \text{a given quantity.}$$

and

$$f'' = k\,h'\,\frac{s}{v''} \qquad v'' = v\,\frac{h'^{\frac{1}{2}}}{h^{\frac{1}{2}}}$$

$$f''' = k\,h'\,\frac{s}{v'''} \qquad v''' = \left\{\left(v\frac{h'^{\frac{1}{2}}}{h^{\frac{1}{2}}}\right)^2 - v^2 + v'^2\right\}^{\frac{1}{2}}$$

$$\text{hence } f''' = \frac{k\,h'\,s}{v''} = k\,h'\,s\left\{\left(\frac{h'^{\frac{1}{2}}}{h^{\frac{1}{2}}}\right)^2 - v^2 + v'^2\right\}^{-\frac{1}{2}}$$

Putting $f''' = u$, $h' = x$, and differentiating, we get

$$\frac{du}{dx} = \left(v^2\frac{h'}{h} - v^2 + v'^2\right) - \frac{1}{2}\,v^2\frac{h'}{h}\left(v^2\frac{h'}{h} - v^2 + v'^2\right)^{-\frac{3}{2}}$$

whence by reduction, in the case of a minimum, we obtain the value

$$x\ 2\,h = \frac{v^2 - v'^2}{v^2} \text{............(A.)}$$

Whence we obtain the very simple rule for finding the best proportion of power to tonnage: *From the square of the velocity of any given vessel in good weather, subtract the square of the velocity of the same vessel in the worst weather, divide the difference by the square of the velocity in good weather, and the quotient multiplied into double the horse-power of the said vessel will give the power which would propel the same vessel in the same circumstances with the smallest quantity of fuel.*

We have also from (A) $h' = 2\,h\,\frac{v^2 - v'^2}{v^2}$

$$\text{(B)}\ v'' = \surd 2\,(v^2 - v'^2)^{\frac{1}{2}}$$

$$\text{(C)}\ v''' = (v^2 - v'^2)^{\frac{1}{2}}$$

$$\text{(D)}\ f'' = \surd 2\,\frac{k\,h\,s}{v^2}(v^2 - v'^2)^{\frac{1}{2}}$$

$$\text{(E)}\ f''' = \frac{2\,k\,h\,s}{v^2}(v^2 - v'^2)^{\frac{1}{2}}$$

$$\text{(F)}\ t'' = \frac{s}{\surd\, 2\,(v^2 - v'^2)}$$

$$\text{(G)}\ t' = \frac{s}{\surd\, v^2 - v'^2}$$

It appears from the comparison of (B) with (C), that a vessel has its power in the most economical proportion to its tonnage on a given station, when its worst voyage does not exceed the time of its best in a greater proportion than $\surd 2$ to 1; that is, than 14 to 10, or 7 to 5.

From (D) and (E) it further appears that in a vessel, whose power is thus proportioned, the consumption of fuel in the worst voyage will not exceed that of the best voyage in a greater proportion than 10 to 7; that is to say, for 70 tons of fuel burned on a good voyage, it will not be necessary to carry more than 100 tons, in order to provide against the worst.

Let us take as an example a transatlantic steam-ship, which has a proportion of 1 horse power to 4 tons of capacity. Her unfavourable voyage being between England and America twenty-two days, and her favourable voyage fourteen days, being a comparative velocity of 7 and 11, then

$$h' = 2h\frac{v^2 - v'^2}{v^2} = 2.\,\frac{121 - 49}{121.} = 2.\,\frac{72}{121}$$

$$= \frac{12.}{10.}\text{nearly.}$$

Hence, the power of such a vessel should be increased in the ratio of six to five; that is to say, the engines at present capable of exerting a power of 500 horses, should have been capable of exerting a power of 600 horses, and would in this case have consumed less fuel, as well as have produced greater regularity and a higher velocity.

The following results are obtained :—

The vessel of less power burns thirty tons per day, performs the distance in fourteen days, consuming 420 tons of coals in fair weather.

The vessel of less power burns thirty tons per day, performs the distance in twenty-two days, consuming 660 tons of coals, in foul weather.

The vessel of greater power burns thirty-six tons per day, performs the distance in twelve and one-half days, consuming 468 tons of coals, in fair weather.

The vessel of greater power burns thirty-six tons per day, performs the distance in seventeen days, consuming 630 tons of coals, in foul weather; being a consumption of sixty-four tons less fuel, and performing the voyage in four and a half days less than the other.

It is manifest that the store of fuel carried in the vessel with less power, must on all occasions be equal to the greatest consumption of fuel, that is, to at least 660 tons, whereas 630 tons will be sufficient for the vessel of greater power: and as in all vessels for long voyages, coals carried are much more costly than the mere price of coals, or as the freight of the vessel is more costly than the fuel, coals carried are to be reckoned at least as expensive as coals burned. Moreover, as the gain in time and in capital is four one-half out of twenty-two, being twenty-five per cent, it is plain that the vessel may be calculated to perform the distance oftener in a year; because as the times of starting must always be regulated, not by the shorter but by the longest period of a voyage, seventeen one-half days in the one case, stand in the place of twenty-two days in the other.

As another example, let us take the case of a vessel calculated to stem the monsoon in the Indian seas. A vessel of 600 tons and 200 horse power, steaming in fair weather at the rate of eleven miles an hour, has been found to have her speed diminished by the monsoon to five miles an hour. What would be the best proportion of power in such circumstances?

$$h' = 2\,h\,\frac{v^2 - v'^2}{v^2} = 2\,\frac{11^2 - 5^2}{11^2} = \frac{16}{10} \text{ nearly.}$$

Hence we see that the power being increased in the ratio of sixteen to ten, that is, engines of 320 horse-power being substituted for those of 200, the speed on the quick voyage would be twelve three-fourth miles an hour, instead of eleven, the speed against the monsoon increased from five to nine miles an hour, with a saving of coals amounting to forty tons out of 320; and when it is remembered that the voyage for which eighteen days would be required as continual allowance in the one case, might always be calculated on as performed in ten days in the other, the advantage is placed beyond all doubt. It appears, therefore, that for long voyages especially, great advantages in point of economy, certainty, and speed, are to be obtained by the use of vessels of a higher power than usual; and that, in a given case, the best proportion of power to tonnage may readily be determined from the rules already given.

In regard to absolute or definite proportion, it may be stated as the result of the best vessels, that the proportion of power to tonnage should not be greater than one horse power to two tons; the greater proportion holding in the smaller, and the less proportion of power in the greater vessel.

Proportions, form, and structure of steam-ships.

The Proportions, Form, and Mechanical Structure of Steam-Ships.—In the article SHIPBUILDING, the reader will find the elements of construction of ships developed and applied in a satisfactory and lucid manner. There he will also learn, that naval architecture is scarcely recognised as a science in England. The reader will therefore be prepared for the announcement that the proportions and structure of steam-vessels is an enquiry which has hardly as yet systematically commenced; and it is with much hesitation that we set the example of endeavouring to eliminate from the rude mass of practical truth and practical error, some general results worthy of confidence. We may premise, that the drawing and finding the displacement, centres of gravity, and buoyancy, and the calculations of stability, &c., may be performed for steam-ships by the methods, and on the principles developed in the article to which the reader has already been referred.

The proportions of steam-vessels were originally taken from sailing vessels; the length being three or four times the breadth. Six breadths to the length is now a common proportion. The proportion of depth varies with dimension, being about one-half the breadth in vessels of 100 tons, two-thirds of the breadth in vessels of about 600 tons, and three-fourths of the breadth in vessels of 1500 tons. The qualities of a vessel depending much on its form, it is not possible to deduce a very precise rule for proportion abstracted from shape; but the following list of dimensions is deduced from a comparison of the dimensions of the best vessels, and will serve as a standard of reference for the existing state of practice. The following are dimensions of flush-decked vessels without poops or forecastle. Where these exist, the depth must be diminished so as to leave the mean depth the same. Thus, in the table, a vessel of 180 feet long by thirty feet beam, has twenty feet depth; but with a half-poop she would require to be only about eighteen one-half feet deep.

Table of Dimensions of Sea-going Steam-Vessels of the best proportions, in conformity with the best practice in Britain.

Length between the perpendiculars.	Breadth between the paddles.	Depth, hold, and midships.	Tonnage. Old law.
90 feet,	16 feet,	7 feet,	110 tons.
96	16½	7½	118
102	17	8	140
108	18	9	168
114	19	10	197
120	20	11	230
126	21	12	266
132	22	13	306
138	23	14	350
144	24	15	397
150	25	16	450
156	26	17	505
162	27	18	565
168	28	19	630
174	29	20	700
180	30	21	776
186	31	22	856
192	32	23	941
200	33	24	1044
205	34	25	1136
210	35	26	1231
216	36	27	1240
222	37	28	1455
228	38	29	1576
235	39	30	1712
240	40	30	1838
250	40	30	1923
300	50	40	3590

Proportions, form, and structure of steam-ships.

The form of the ship, of course, affects very materially its qualities, and the choice of proportions to produce those qualities. The dimensions in this table apply to vessels of fine proportions, having a fine entrance and run, and a side nearly upright. If however the area of the load-water line be very large, the vessel will be uneasy even with these extreme dimensions; and in such a case the beam in the table is rather excessive, while the height might probably be augmented without inconvenience. Again, if the midship section of the vessel be very square, or merely rectangular, these dimensions will suffice. If however the bilges be round, and the sides slope outwards, more breadth may be usefully employed, so as to leave the breadth at the load-water line nearly equal to, or rather greater than, the beam given in the table.

River steam-vessels are, in this country, and especially on the Thames, made of great length in proportion to beam. Some of the swiftest river boats have their length equal to seven, eight, nine, and even ten times their beam, with advantage. In America they often have twelve times more length than breadth.

The Form of Steam-Vessels.—To determine the best form of a steam-ship may appear to be a much simpler case of the great problem of naval construction, than the formation of a sailing vessel. The principal desideratum in a steam-ship being the power of going fast through the water in the single direction of the propelling power, this case of the problem appears to approach much more closely to the construction of a solid that shall receive the least resistance in passing through the water, than to the case of the sailing vessel, which has to work with a propelling power which is generally in some other direction than that in which the vessel is designed to make way. In this point of view, the problem of the steam-ship is really a simpler case of the general problem than that of the sailing vessel. If, however, the steam-ship is also to be a good sea boat, and to work on some occasions under canvass alone, as well as under steam alone at other times, the problem at once assumes an aspect more complex than that of either problem taken by itself.

There is, however, a single fact which is important, as it very much simplifies the subject. Vessels built expressly for the purpose of steaming, and adapted for that purpose in the best possible way, have been found, when under canvass, to equal the fastest ships in sailing qualities. Their great length and fine ends prevent them from falling to leeward; their fast formation adapts them for going through the water; their boilers and machinery form a well placed and well distributed ballast; their fine ends and flaring bows render them lively as sea boats; and the small amount of their midship section, and small resistance, give them great speed under comparatively little canvass. This practical fact, that a vessel formed exclusively for steaming, and adapted for that alone, in the best possible manner, is found to be a good and fast ship under canvass, greatly facilitates the enquiry concerning the best form of a steam-ship. To this we now add another confirmatory fact, that the fastest schooners, cutters, smugglers, yachts, and slavers, approach more nearly to the form of the best steamers than any other class of sailing vessels. The problem of the best form of a steam-ship becomes thus not only simpler, but doubly interesting, from the reflex influence it may be expected to produce on sailing ships.

It is difficult, without going into minute technical details, to explain the peculiarities in the shape of the best steam-ships. The present state of practice shows that systems perfectly opposite are adopted by different builders. It is at all times difficult to convert into verbal statistics forms so delicate and complex as the surfaces of double curvature formed by the bottom of a ship; but the following considerations of a general nature may probably be intelligible.

In the formation of steam-ships, it has been stated that there are opposite schools. One adopts and advocates a sharp bottom, a great rise of floor, great beam, extensive bearings on the surface, round sides, round water-lines, adopting altogether the formation of a full, capacious, stable, sea-going ship, only employing such dimensions and proportions as are given in the table of dimensions already produced. Another school adopts a flat bottom, long floor, more angular bilge, upright sides, straight entrance, clean run, sharp ends, comparatively small moment of stability, formed with the idea of going directly through the water in all weathers with the least proportion of resistance, and the smallest change of position. A third school, of recent origin, adopts the hollow wave lines and new formation, of which the principles have been established by the writer of this article. The fastest steam-vessels of the present day are built on this principle.

The question of form may be taken up under several heads.

The Transverse Section, or Midships.—The simplest and one of the earliest sections of a steam-vessel is the rectangle, fig. 26. the bottom being flat, the sides vertical, and the bilges almost angular. This form is rendered necessary when the breadth of the vessel over the paddles is to be rendered as small as possible. But this form, although it gives the greatest capacity when the breadth and depth of water are limited, is at once weak at the bilges, liable to crankness, and uneasy at sea. To remedy these evils, the bilges have been rounded, and the floor sharpened, in order to give more easy lines on the bottom, and an easier bilge, as in fig. 27.

Fig. 26.

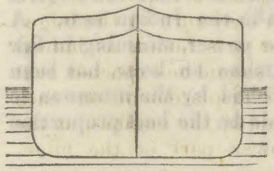
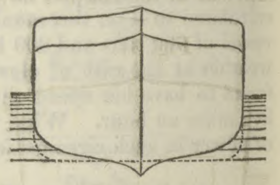
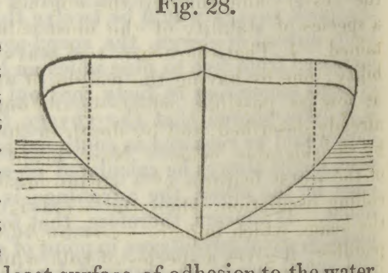


Fig. 27.



And again, this method has been carried to an extreme, or with the intention of producing the best possible sea boat, by making the floor very sharp, and the sides extremely round, thus:

Fig. 28.



But such boats are both unstable at sea, and pitch most violently. The next modes of construction have had for their object to produce the greatest capacity with the least material, and least surface of adhesion to the water. For this purpose semicircular and elliptical bottoms have been tried, thus:

Fig. 29.

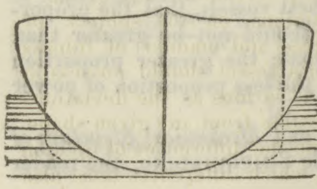
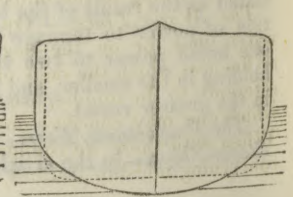


Fig. 30.

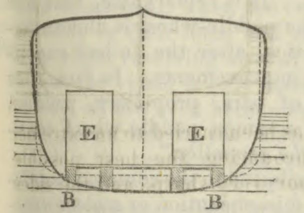


But both of these, and especially the former, although well suited for fast steamers, have a great tendency to oscillate continually, and roll with great latitude at sea.

It appears from experience, that there is great difficulty in determining that section of vessel best suited to a steam-vessel. The rectangular figure first given is, as we have said, at once weak, and crank, and uneasy. The sharpening of the bottom, as in the figures which follow it, removes the engines up from the floor, and effectively diminishes the height of the engine-room, as well as renders the vessel crank, by raising the centre of weight, and of the engines, &c., too high; and if, to counteract this evil, the beam at the surface of the water be increased as in the third section, the vessel is rendered laborious, uneasy, and ineffective at sea by the excessive beam. Again, in the round bilges the vessel swings like a pendulum, and it seems as if her oscillating would never stop. From the multitude of practical experiments which have come under our notice, we are led to the following conclusions.

1. That the existence of a fixed mass in the shape of engine and boilers, renders the usual mode of determining the midship section of a ship inapplicable to steam-ships; and that the form must be determined with immediate reference to these. 2. That the engines of a vessel of 300 horse power occupy a space of about $\frac{2}{3}$ of the beam of a ship, which necessarily is perfectly flat; and that the engine can only be firmly connected with this floor of the ship by being placed as directly in contact with it as possible; and further, that the weight of the said engine must be placed as low as possible, on account of the place of the paddle-wheel; all of which desiderata can only be obtained by making the floor of the vessel parallel to the bottom of the engine. Hence the bottom of the ship should be nearly flat across about $\frac{2}{3}$ of her beam, thus:—B to B, fig. 31, nearly flat, E E the engines. 3. That no displacement is desirable on each side of the engines beyond what is required to give an easy turn to the bilge; for it is found, as indeed it should be expected, that all displacement on each side of the engines, at the lower part of the bilge, being vacant space, or very inefficient stowage-room, is not only wasted, but tends to impair the stability and sea-worthiness of the vessel; and, further, the engines being placed low, a species of stability of the most valuable nature is obtained. 4. That there are two ways of obtaining stability; one by having the weight of engines and boilers as low as possible, which is obtained by the means already described, and by depth in the water; the other by considerable beam. Now, beam in excess is one of the worst features of a steam-vessel. It produces a rolling oscillation, when the wind is in any degree on the beam, which impairs exceedingly the action of the paddles; it gives a species of roll, which is at the same time most distressing to passengers, and most injurious to the ship. All these bad effects are diminished, and can alone be corrected, by obtaining stability as far as possible from depth of the centre of weight rather than beam, according to the midship section already given.

Fig. 31.



Water lines.

The Water Lines.—Opinions on the subject of water lines, or on the degree and manner of fulness or fineness which the ends of a vessel should possess in reference to the middle, are as various as the deviations which one may conceive possible from any given shape. When with these we combine the differences of opinion concerning midship sections, which differences must also affect very materially the form of water line, we get into a labyrinth of difficulties, in the intricacies of which the good qualities of a steam-ship are so often lost.

Form of steam-ships. Water lines.

Full round ends, convex outwardly at the bow, full above at the stern, and fine enough below to steer well, so rendering the form as like as possible to an American cotton ship, with a long straight narrow body in the middle; such a form has been introduced for steam-vessels, in the hope that the vessels, by having a small midship section and great buoyancy, might be easily propelled through the water. Even when they are made seven times as long as broad, we have seen vessels of this class turn out failures. They have, in the first place, been crank, in the second place wet, in the third place slow, and in the fourth place weak; for, by having too much bearing at the ends, and too little where the chief weight is to be supported, viz. in the middle, they have invariably bent down in the middle, and risen up at the ends.

Full round ends, combined with a full round midship section, are a modification from which much has been expected, as forming a ship of large capacity. This has been one of the worst and most extensive errors perpetrated in the construction of large steam-ships. The great breadth along the whole water line, arising from the full lines, gives an excess of superficial stability, which, with a cross sea, causes the vessel to roll violently, with an extent and abruptness of motion which the round form of the section has no tendency to prevent or retard. Then the full ends of the vessel prevent her speed through the water, and increase her motion in a heavy sea, by increasing to excess her longitudinal stability. In the next place, if the ends of the ship be used for stowage, it is plain that the great mass of matter at the two ends must render the ship laboursome, or the reverse of lively, according to the nautical phrase; and the ship will less readily obey the helm. Such are some of the evils which, in many instances, and those especially in steam-ships of the largest class, have been seen to result, and which necessarily must result, from the full and round-bodied vessel used in steam navigation.

These are not all the evils of the full form. The stowage of such vessels is by no means effective in proportion to the weight, capacity, and displacement of the ship. In the first place, by giving much space on both sides of the engine-room, a very inferior species of stowage is obtained to that which results from additional length of hold. Next, the stowage-room in the end of the ship, for which so much speed is sacrificed, cannot be made effective without rendering the ship unseaworthy and unmanageable; for it is notorious, that in order to rectify the erroneous fulness for which so much is sacrificed, the ends of the ship are bulkheaded off to obtain the valuable quality of liveliness. First, then, fulness is obtained at a sacrifice of speed and seaworthiness for some supposed advantage in capacity, &c.; then, that very capacity is rendered ineffectual by the injudicious mode of its application.

An opposite school from this recommends the long straight centre body of a ship, with rectangular sections and sharp, fine, wedgelike ends. This form possesses the advantage of small transverse sections, and gives great stowage: it is an easy sea boat, and is lively from its fine ends. The principal fault in this form of vessel is its liability to crankness—its weakness at the bilge. Many of the finest steam-ships belong to this class.

The last class to which it is necessary to make a particular reference, are the steam-ships recently constructed on the wave-lines, or the hollow entrance line—on the principle which the writer of this article, by experiment and by example, has laboured to introduce. The

Form of steam-ships. Water lines.

first vessel of this form was an experimental one of 75 feet keel, laid down in 1834. The next was a steam-vessel of 100 feet keel, constructed in 1835. The next were two pleasure yachts of Mr Ashton Smith, a wealthy proprietor in Wales, whose observation on vessels had independently led him to the conclusion that hollow lines and a peculiar midship section gave the easiest and best sea steamers; and both of these vessels, of 1838-39, though merely approximations to the true wave-lines, were remarkable for their speed and other excellent qualities. The fourth vessel of this class was the Shandon steam-vessel, altered from the old to the new lines, 1840, with a gain from the same engine of from two to three miles an hour in speed. This vessel is the property of Mr Robert Napier. The next and last vessel is the Flambeau, built in 1840, on the wave principle, by Mr Duncan of Greenock, with the co-operation of the present writer. This vessel, with the smallest proportion of power to tonnage, and with the smallest supply of steam, is, nevertheless, by far the swiftest vessel on the Clyde. The Fire-king, the largest of this new class of vessels, is 660 tons, and has engines of 220 horse power. The Flambeau has only 70 horse power to 280 tons measurement. Vessels of this class have been found at sea to be both easy, stiff, dry, and lively; while they are by far the fastest vessels of their power. The speed of the Fire-king, now the property of Mr Robert Napier, is fifteen miles an hour in still water. The speed of the smaller vessel, the Flambeau, with very deficient steam, is fourteen miles an hour; a velocity which, with her small proportion of steam-power, is only to be attributed to her superior form, and the slight degree of resistance which she encounters from the water.

The principle on which these wave-ships are constructed is, that the hollow lines forming the entrance are to correspond, as nearly as may be consistent with the form of a ship, to the form of a certain wave capable of moving with the same velocity as the vessel. The analogy between the displacement of the water by a wave of the first order, and its displacement by a vessel moving with the same velocity, being so very close as to approach to identity, rendered it probable that the same mode of displacement would be followed in both cases with the same result, viz. the production of minimum resistance. It was further to be anticipated, that as a wave, when allowed to follow the usual mode of displacing the particles of water over which it passes, presents a smooth and unbroken swelling surface, so the vessel, if of the proper shape, according to these wave-lines, would divide the water at the bow in a smooth, unbroken sheet, instead of showing the usual head of water or surge exhibited at the bow of ordinary vessels at high velocities. On the other hand, when a wave encounters a shapeless rock, or breaks on a rugged coast, it exhibits the same violent surges which are presented on the bow of vessels of the usual form. Thus, then, the analogy leads us to suppose, that the smooth, continuous, resisting displacement of a wave, would be the best method of displacement for a vessel. On submitting the question of least resistance to the elementary calculation, it appeared that the form of least resistance was very close indeed to that of the wave. The science of hydrodynamics is not, however, sufficiently matured to enable us to place implicit dependence on all the results of its calculations, unless where they are supported by actual observation; and it therefore became necessary to make the experiment.

For the purpose of determining whether this form were that of least resistance, an experimental vessel, about seventy-five feet long, was constructed on a hypothetical form of least resistance, with the wave water lines. When this vessel was propelled at the rate of seventeen miles an hour through the water, it was found, that instead of the usual surge exhibited at the bow of other vessels, the water was parted so smoothly and quietly, that no white spray nor other symptoms of high speed and great resistance were visible, and the parted water returned peaceably to the place it had occupied previous to the transit of the boat, with only a slight translation forwards. It appeared, therefore, from the experiment, that no greater quantity of motion was communicated to the water than was necessary to permit the vessel to pass through, and with no greater velocity than the speed of the vessel demanded. It was then presumed that this form was that of least resistance; and all subsequent experiment appears to demonstrate the truth of this inference from fact, as predicted by analogy and calculation.

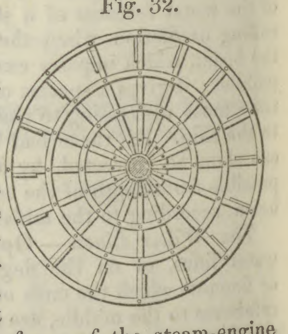
It is also worthy of remark, that this form is capable of being combined with all the good qualities of a steam-ship, such as strength, dryness, easiness, as well as great speed; but as the construction of such vessels may still be deemed an experiment in progress, the writer will not occupy more space with observations on his own researches. Thus much he felt it his duty to communicate, in order to adapt this article to the most recent condition of steam-navigation.

The immediate Mechanism of Propulsion.—The paddle-wheel of the ordinary form (as given in the plates) seems to be the most perfect, as it is the most simple means of propelling vessels through the water. The idea soon occurred, that as the steam-engine is calculated to turn round wheels, it is only necessary to place, on a wheel on the outside of a boat, large teeth or paddle-boards to take hold of the water, and so drive the vessel forward by simply turning the wheel. It was this plan that was adopted by Jonathan Hulls, in the first plan of a steam-vessel. But there is no piece of mechanism (if we except, perhaps, the crank of the steam-engine,) which has been more despised, or which more strenuous and frequent attempts have been made to improve or supersede, than the common paddle-wheel. It is remarkable, that like the crank steam-engine, the paddle-wheel is almost universally employed in practice, after the fullest experiment of many diversified improvements. In fact, after experiments of all sorts of oars, propellers, paddles, chaplets, screws, &c., the common paddle-wheel continues to predominate as "*the* propeller."

The numerous faults attributed to the common paddle-wheel, are chiefly faults of misconception or malconstruction. It is easy to account for both.

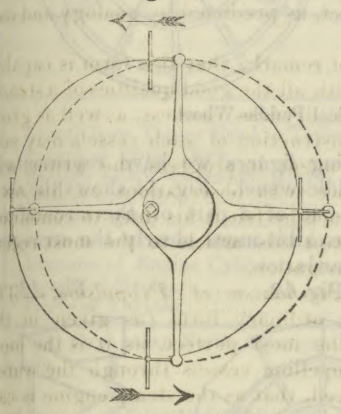
When a steam-vessel is at rest in a harbour, and prevented from moving, or when in the act of setting out into motion after having been at rest, the defects of the common paddle-wheel appear to be very great. The paddle-boards, fig. 32. on entering the water, press obliquely down into it, tending to raise or lift the vessel up out of the water with a force which produces no useful effect. Again, when the paddle is rising out of the water behind, it seems to do little more than raise or drive the water upwards in the form of back water. It is only, therefore, in the middle of its path that the propulsion of the paddle seems exerted in forwarding the boat, and that only for a very short time. A large part of the force of the steam-engine seems thus to be expended in raising up the vessel, and

Fig. 32.



in elevating back water, and only a small portion in carrying forward the ship. But this is the case of a vessel at rest or not in rapid motion. Now it is argued from this view of the case, that the only way in which a paddle-wheel could be made efficiently to perform its propelling duty, would be, by giving the paddle-boards such a motion upon themselves as to keep them always in a vertical position, both on entering the water and on emerging from it. This was effected about the commencement of steam navigation by Mr Buchanan of Glasgow, in what may be designated the parallel paddle-wheel.

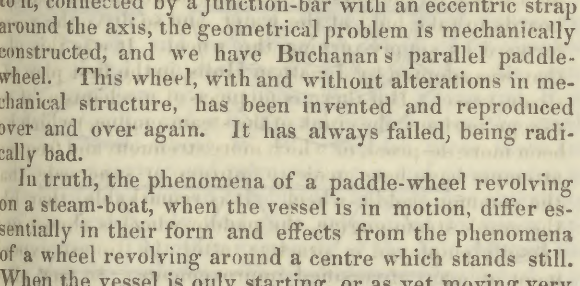
Fig. 33.



The parallel wheel, fig. 33 is constructed on this principle, "that if two equal circles be equally divided, and so placed, that the distance between two of the points of division is equal to the distance between the centres of the circles, then will all the other points of division be also equidistant, and all the straight lines joining them be parallel." By giving to each paddle-board revolution on an axis, and placing an arm at right angles to it, connected by a junction-bar with an eccentric strap around the axis, the geometrical problem is mechanically constructed, and we have Buchanan's parallel paddle-wheel. This wheel, with and without alterations in mechanical structure, has been invented and reproduced over and over again. It has always failed, being radically bad.

In truth, the phenomena of a paddle-wheel revolving on a steam-boat, when the vessel is in motion, differ essentially in their form and effects from the phenomena of a wheel revolving around a centre which stands still. When the vessel is only starting, or as yet moving very slowly, all the evils here mentioned do in some degree take place; but by the motion of the vessel forwards, which is the result of the revolution of the paddles, the evils complained of are at once remedied, and the paddle of a common wheel in a quick vessel is actually "feathered," according to the most dexterous toss of the practised rower. A little study of the geometrical conditions of a paddle moving forwards and in a circle at the same time, will make this plain. Let us trace for this purpose the motion of a single paddle. At the point *o*, the paddle-board O′ being in the position O′, the wheel, turning on a stationary axle, would bring the board *o* successively into the positions *a′*, *b′*, *c′*, *d′*, *e′*, *f′*, *g′*, &c.; but the axle being advanced by the motion of the boat into the places *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *l*, *m*, *n*, *o*, *p*, *q*, in the same intervals of time, and these motions being simultaneous, the paddle-board describes a path in reference to the water which is the result of both, and the successive positions of the paddle-board are *a*A, *b*B, *c*C, *d*D, *e*E, *f*F, *g*G, &c. The paths described by the boards are trachoidal curves, being of the family of the cycloid. Now, from the study of the actual motion thus performed by the paddle-board of the common wheel, it is plain, first of all, that the paddle is inserted into the water in an angular position resembling closely the entrance of an oar into the water; that it is then made to act horizontally on the water during a short interval; after which it is withdrawn from the water, edgeways, in an easy and elegant manner, which the dexterous rower might envy and try to equal, but which he could hardly excel.

Fig. 34.



All this, however, takes for granted that the paddle and the boat are well proportioned and placed; otherwise all this perfection may be impaired or lost. To this exposition of the subject, it may be added, that the common paddle-wheel is in practice, as it ought to be in theory, exempt from the faults generally attributed to it; and that experiment has shown that its action presents as much perfection in operation, as its simple form and mechanical arrangements do in enabling the artist to give it durability and strength.

When the paddle-wheel is badly proportioned, badly placed, attached to a very slow or full boat, or immersed too deep in the water, its action becomes impaired or impeded. Hence much attention has been devoted to the construction of a paddle that should be more effective in these unfavourable circumstances than the common wheel; in short, to construct a paddle-wheel that should be an effective propeller, even when immersed to its axis, or wholly placed under water. This may be properly enough called the radiating paddle, as distinguished from the parallel paddle.

Radiating Paddle

The radiating paddle is not constructed on the fallacious view of the subject which gave rise to the invention of the parallel paddle-wheel. On the contrary, it proceeds on the hypothesis, that the actual motion of a paddle-wheel on a moving ship is cycloidal; and its intention is to adapt the wheel with greater perfection to that cycloidal motion. The theorem on which it is founded is as follows. Let the circle in the following diagrams, figs. 35, 36, represent that circle in a paddle-wheel which is described by a point moving in the common cycloid, that is, where velocity in the circle is equal to the velocity of the vessel, *o* being the centre of the paddle-wheel, then, by the property of the cycloid, all lines drawn from the point M at the superior extremity of the vertical diameter of that circle to A, B, C, D, E, F, &c., points in its circumference, will be parallel to the cycloid of progression, or rather to its tangents, at the points of its periphery which correspond to A, B, C, D, E, &c., when in motion. If it were possible to construct this

Fig. 35.

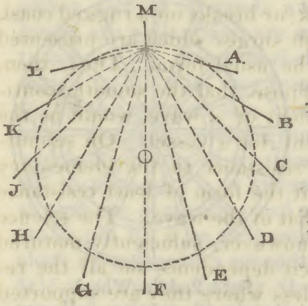
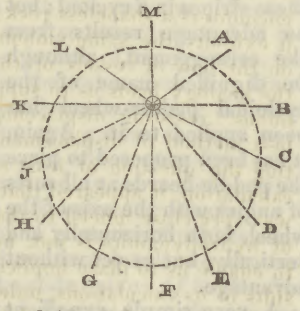


Fig. 36.



geometrical problem in a mechanical apparatus, this paddle-wheel would have great efficacy even when very deeply immersed. It is, however, difficult to make this motion perfect at M. But this species of mechanism has been very beautifully combined and arranged by Morgan, Seaward, Cave, and others, whose geometrical apparatus is very beautiful. Unhappily the apparatus, even in its most perfect state, is only correct for a single velocity of vessel and of wheel: for a different velocity, the point of radiation of the paddles must be changed, or loss is at once incurred. Hence it is found that this apparatus, like the common paddle, is liable to imperfections of action, with every change of immersion and velocity. When to this there are added the complexity, friction, cost, wear and tear, liability to accident, of this moving mechanism, introduced for obtaining the partial remedy or slight amelioration of an evil which by proper arrangement is but slightly felt under the old method, it becomes manifest, that the general abandonment of the radiating paddle-wheel, and the return to the common one, has not been without sound practical reason.

Divided Paddle.

Split Paddle.

The last species of paddle-wheel is that with the fixed float; in other words, the simple paddle-wheel with boards placed around its rim. Of this there are various modifications. A very simple modification is that mentioned by Mr David Stevenson, in his excellent work on the civil engineering of America. The paddle-board of the usual wheel is, as it were, cut in two, one-half being placed half an interval in advance of the other, as in figs. 37 and 38. This may be called the divided paddle-wheel. The concussion of a paddle-wheel striking the water is much lessened by this means, and the propelling force is rendered more nearly uniform. Another form of this wheel may be named the split paddle-wheel, from having the paddle-board, as it were, split into two or more horizontal slips, by which the same advantage is obtained as from the divided paddle-wheel. It has been proposed to place these stripes in a cycloid; but no advantage results from the arrangement, although the dignified name of the cycloidal paddle-wheel has been applied to it. Again, it has been proposed to place the paddle-boards at all sorts of angles with the axis of the wheel, both horizontally and vertically, but as yet without advantage.

Fig. 37.

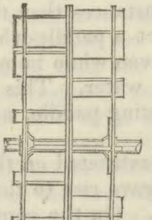


Fig. 38.

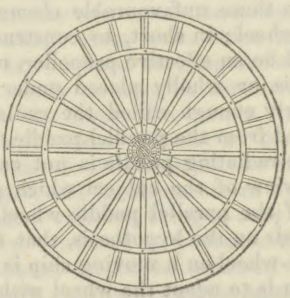
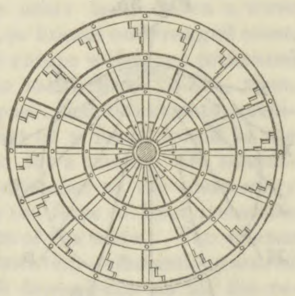


Fig. 39.



Split Paddle-Wheel.

A very simple expedient tends to remove all considerable irregularity or concussion from the common paddle-wheel. It is to allow the extremity of the paddle-board nearest the side of the boat, to descend from six to twelve inches deeper in the water than the outer extremity. This plan was carried into effect by the writer on a steam-vessel in 1836. The desired object was attained without any sacrifice of power or speed. For distinction we may call this the conical paddle-wheel. It is shown in figs. 40, 41.

Fig. 40.

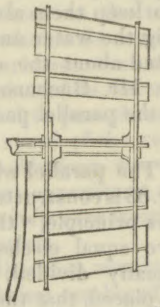
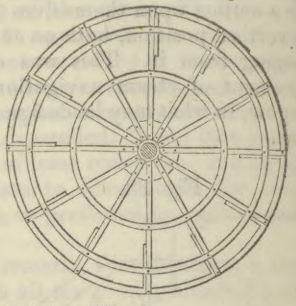


Fig. 41.



Conical Paddle-Wheel.

In the three following figures we have represented the single oblique paddle-wheel. Fig. 44 shows the development or stretch-out of a part of the circumference of the wheel, to exhibit more clearly the arrangement of he paddle-boards.

Fig. 42.

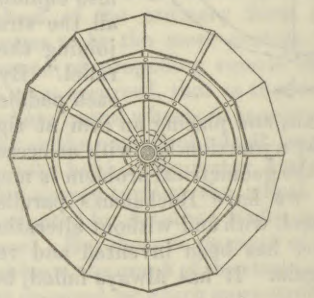


Fig .43.

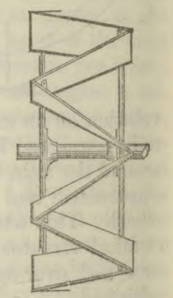
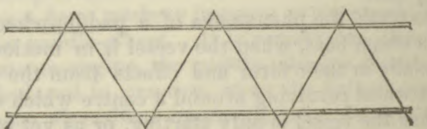


Fig. 44.



Single Oblique Paddle-Wheel.

In figs. 45, 46, the double oblique paddle-wheel is represented; and in figure 47 the development of a portion of its circumference is given.

Fig. 45.

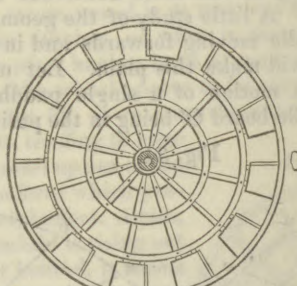


Fig. 46.

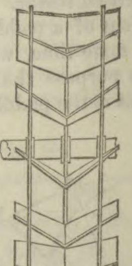
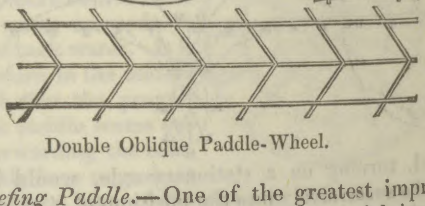


Fig. 47.



Double Oblique Paddle-Wheel.

The Reefing Paddle.—One of the greatest improvemens on paddle-wheels, and one of especial importance to steam navigation, still remains to be innvented

We mean such a mechanism as shall enable the steam commander to set out on a long voyage deeply laden, with a small diameter of paddle-wheel; that is, with the paddle boards near to the axis, and to increase the (effective) diameter of the paddle, that is, to remove the paddle-boards farther from the axis, as the vessel proceeds on her voyage and is lightened by the consumption of coal. The invention of a durable, economical, and safe apparatus still remains to be made. In the infancy of steam-navigation, Mr Buchanan of Glasgow published an account and drawing of a reefing paddle; Messrs Bolton and Watt are also in possession of a very old method of reefing paddles; the Society of Arts in Scotland offered a prize several years ago for the invention, without obtaining, out of many plans, one to be recommended for practice; and, finally, the indefatigable inventor, Mr Hall of Basford, has patented a very elegant mechanism for the same purpose. It still, however, remains to introduce and establish a perfect reefing apparatus, and the author of such a system will render the common paddle-wheel a perfect propeller.

The following Table exhibits a comparative view of the Size and Power of six of the largest of the recently constructed Vessels for Transatlantic navigation.

	NAME OF VESSELS.											
	British Queen		President.		New York.		Great Western.		Liverpool.		Acadia.*	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft	In.	Ft	In.	Ft.	In.
Length from Figure Head to Taffrail,......	275	0	273	0	235	0	240	0	234	0	228	0
Length of Upper Deck,..........................	245	0	243	0	0	0	0	0	212	0	206	0
Breadth within the Paddle-Boxes,..........	40	0	41	0	36	6	0	0	35	4	34	4
Breadth over all,..................................	61	0	68	0	60	0	57	0	58	4	56	0
Depth of Hold,......................................	27	0	30	0	22	0	20	0	23	3	22	6
Diameter of Paddle-Wheels,...................	31	0	30	0	0	0	0	0	28	0	28	0
Diameter of Engine Cylinder,................	6	5½	7	6	0	0	0	0	6	1	6	0
Length of Stroke,..................................	7	0	7	6	0	0	0	0	7	0	6	10
Power of Engines,..................................	500 h p.		600 h. p.		0	0	460 h. p.		450 h p.			

* The three other North American Royal mail steam-ships Britannia, Caledonia, and Columbus, are of the same dimensions as the Acadia.

DESCRIPTION OF THE PLATES ON STEAM-ENGINE AND STEAM NAVIGATION.

Plate CCCCLXVIII. Figs. 1 and 2. These figures exhibit a front and side elevation of one of the simplest forms of the non-condensing steam-engine. Its principal parts are the cylinder A, the piston-rod P *p*, and connecting rod *p* K, acting directly upon the crank K X, and fly-wheel W W. Besides these there are only an eccentric and valve-rod *x x x*, and governor *w w*. Two columns and an entablature support one extremity of the crank axle, and give attachment to minor appendages. The other extremity of the axle rests on the wall of the building. To the columns is attached *g g*, a guide for the top of the piston-rod. The feed-pump *f f f*, is worked by an eccentric on the crank-shaft.

Figs. 3 and 4. The form of engine here exhibited, is of still greater mathematical simplicity than the last, although its mechanical arrangements are probably more intricate. In this engine no member intervenes between the piston-rod and the crank. A cross-head carried by the piston-rod, open in the centre, permits the crank-pin, in its circle of rotation, to oscillate freely on alternate sides of the piston; and being itself powerfully confined to motion in the vertical direction only, by the slides on the columns of the framing, the vertical motion of the piston-rod is precluded from the production of any other dynamical effect than the most direct of all possible conversions of rectilineal into rotatory motion. The cross-head is marked H H in the figure, the columns being marked *m m*. The other letters refer to the same parts as in the last figure.

Figs. 5 and 6. In these figures the high-pressure engine is represented in its most improved form for stationary purposes. It is analogous, in the arrangement of its principal parts, to the usual construction of Bolton and Watt's condensing-engine. A cast-iron base supporting six columns and an entablature, forms a framing upon which the parts of the engine are distributed, so as to form what is called a Portable Engine, being entirely independent of the building in which it may happen to be placed. At one extremity of the base is placed the cylinder A A, and at the other the crank-axle X, and fly-wheel W W. The motion is transferred from the piston P *p*, through the great lever L L L, and connecting rod or crank-rod L K. The feed-pump *f f* is in this instance worked from the point *m* of the parallel motion, in the way generally adopted in condensing engines for working the air-pump, whose place in fact it here occupies. The valve is a short D-slide, worked by eccentric gear, *x x x x*. S is the steam-pipe. The eduction pipes E are seen descending on both sides of the valve-casing; they unite in a common chamber beneath the cylinder, whence a pipe conveys the educted steam to the chimney, or to serve some other purpose, as the case may be. The governor acts as in the previous case. This drawing is taken from the form of engine manufactured by Messrs Caird and Company.

Figs. 7 and 8 is a form of the upright condensing engine manufactured by Messrs Carmichael of Dundee, and successfully applied by them to various purposes. It is compact and has been found to work well.

The cylinder A A is placed upon the floor, and on either side of it stands a cast-iron column. These columns are hollow and are used as steam-pipes, S S S S, to convey the steam to the jacket of the cylinder, from which it finds its way into the valve-chest D. On the top of the columns is a cross-beam sustaining the crank axle, and the columns support guides *m m m m*, on which, by means of wheels *g g*, and a cross-head *g p g*, the piston-rod P *p* is maintained in its vertical position, so that the connecting rod *p* K is directly attached to the crank-pin K. The air-pump G is worked from the crank-shaft by means of a second crank or bend, and an eccentric *x x* works directly the slide valve; *f f* is the feed-pump for the boiler, worked directly from the air-pump cross-head; *w w w w* is the governor, with its appendages; C is the condenser; N the cold well.

Plate CCCCLXIX. In fig. 1. of this plate we have given a sectional elevation of a land-engine of twenty-five inch cylinder and five feet stroke. In fig. 2. we have given its horizontal section at the level of the base of the cylinder, and in the remaining figures the details of its different parts. In figs. 1 and 2 AA is the cylinder, P the piston, P*p* the piston rod, B*b* the parallel motion, LLL the great lever. The pillow blocks L*l*, in which the centre of the great lever works, rest on the spring beam UU, whose ends are secured to the walls of the building in the manner shown on the next plate. The centre of the spring beam is sustained by the columns VV and their entablature *u*, which crosses the building and has its ends secured to the walls like those of the spring beams. At the other end of the great lever are the connecting rod LK, the crank KX, and fly-wheel WW. Returning to the cylinder we have, DD the slide-valves and their casing; *dd* the packing ports. The valve-casing terminates below in EE the eduction-pipe leading into the condenser C. G is the air-pump, F the place of the foot-valve, *h* the air-pump piston-rod. The condenser and air-pump with their appendages are placed in the cold well N. M is the hot well into which the contents of the air-pump are discharged, and from which the hot water pump *m* draws its supply by the pipe *m*′. The pipe *oo* leads from the hot water pump for the supply of the boiler. The cold well is supplied from the cold water pump *n* by the pipe *n n*′. The rods for working the hot and cold water pumps hang from a stud at either side of the lever at *m*. The governor *ww* is supported on a bracket *tt*, which bridges across the main shaft. The influence of the governor is conveyed to the throttle-valve by the levers and connecting rods *wwww*. The valves are worked by the eccentric *xxxx*. *ff* is the eccentric shaft which carries the gab-lever *f*′ on which the eccentric rod acts; it also carries the levers for working the side rods of the valves, the levers which carry the counterbalance weight, and the socket for the starting lever. The small pillars TT, which surround the cylinder, are surmounted by an entablature which serves as a support for a gangway round the cylinder.

The remaining figures on the plate represent in detail the different parts of the engine which we have just described, separated from each other, in order more clearly to exhibit their construction. Figs. A A′ *a a*′ show the details of the cylinder. In A A′ is shown the upper and lower ports of the cylinder at 1 and 2, and the steam port at 3. In A′, 4 is the cylinder cover, and 5 the stuffing box. *a* is a horizontal section of the cylinder, and *a*′ a plan of the cylinder cover.

Figs. DD′ *dd*′ show the slide-valve casing; D a front view, D′ a side view. 1 and 1 are the packing ports, 2 and 2 the packing-port covers, 3 the eduction-pipe, *d* the cover of the slide-valve casing, 4 its stuffing-box, *d*′ a section of the casing. Figs. C, G, F, show a side elevation of the condenser, foot-valve, and air-pump; C,′ G′, F′, a section of these; and *c*, *g*, *f*, a plan of them. 1 is the cover of the foot-valve, 2 and 3 a section and front view of the valve. Fig. L shows a side view of the great lever, L 1 a top view, and L 2 a transverse section through the centre of it. Figs. KK′ show a front view and section of the crank. Figs. XX*x* show a side view, an end view, and a plan, of the crank shaft pillow block. Figs. *l*, *l* 1, *l* 2, show a side view, an end view, and a plan of the pillow block for the main centre of the great lever. Figs. *mm*′ show a vertical and horizontal section of the hot water pump, and figs. *nn*′ of the cold water pump. Figs. B 1, 2, 3 are the details of the main links of the parallel motion; *b* 4, 5, 6, 7, 8 details of its air-pump links; 9, 10, 11, 12 side and top views of its radius and parallel bars. 13, 14 is the clutch for the top of piston-rod; 15, 16, gudgeon and clutch for the top of air-pump rod; 17, 18, top and side views of the ring gudgeon to which the parallel rods are attached; P piston-rod, H air-pump piston-rod, *h* air-pump rod, *gg* cold water pump-rod and piston-rod, and *g*′*g*′ hot water pump-rod and piston-rod; *x* the eccentric, WW, 1, 2, 3, 4 details of the fly wheel, O main centre or gudgeon for the great lever. PP 1 plan and section of the piston, *w w*′ 1, 2, 3, 4, 5 details of the governor, *w* the spindle, *w*′ the slide, 1 1 the radius arms to which the balls 5 5 are attached, 2 2 the radius arms which cause the balls to act on the sliding collar *w*′, 3 and 4 the stay for confining the motion of the balls. *t* 1 2 is the slide-valve rod and side rods, *t* 3 is the slide-valve cross-head, R R′ a side and front view of the connecting rod.

Plate CCCCLXX exhibits a Sectional Elevation of a Condensing Engine. This description of house engine is the design of Mr M‘Naught of Glasgow, and has been extensively applied by him to cotton, silk, and saw-mills. The principal peculiarity in its structure is the arrangement by which no further masonry is required for its foundation than the building in which it stands, the usual cold well being dispensed with, and the whole structure connected by cast-iron beams with the walls of the house. The cylinder AA is attached immediately to TT, the cast-iron beams of the floor, which are deeply bedded in the wall at T and T, and rests directly upon the large vessel C, which forms the condenser, and is supported likewise by beams YY, which are bedded in the walls. The condensation is effected by injection alone, without the usual accompaniment of a cold well around the condenser, an appendage that may safely be regarded as by no means indispensable to the practical perfection of the vacuum—when the vessel itself is formed with few joints. The transverse beams of the buildings are supported by two pillars directly under the centre of the great lever LLL, so as to support the main centre L; and the crank-axle X and the axis Z of the fly-wheel W, are supported on UU, another beam of cast iron.

The steam enters the house through the pipe SS, passes round the cylinder to SS, around the long slide-valve DD, being confined to the middle of it by the valve packing *hh*, and after performing its duty in the cylinder, passes out at EEE into the condenser C, where it is finally condensed into water. Hence it is drawn off at the foot-valve F by the piston H of the air-pump G, and delivered by the discharge-valve M into N, the hot well. The slide-valve DD is worked by the eccentric gear *xxxx* and the rod *d*D through a moveable stuffing-box *dx*.

Plates CCCCLXXI, CCCCLXXII. These plates represent the high-pressure engines which are employed to work the inclined plane at the Liverpool station on the Liverpool and Manchester Railway. They are beautiful and in many respects highly judicious; they are the work of Messrs Mather, Dixon & Co., Liverpool.

WWW, Plate CCCCLXXII, is the great wheel which works the rope that draws the railway train up the inclined plane; the rope is contained in a groove in the edge of the wheel. A clutch *kk* connects or disconnects the crank-axle XXX with the wheel WW; the cranks KX, KX, KX are placed at right angles, so that when one is on the centre the other is at the furthest distance from it. K*k*, the connecting rod, hangs down from LL, the ends of the levers. The centre of the side levers, IV., rests on a truss at no greater height than three feet above the floor of the engine-room. L*p* is a side rod by which the levers are united to the cross-head *rpr*. The steam in this instance comes about a quarter of a mile from the boilers to the cylinders AA by the steam-pipe SSS. Fig. 2 is a section of the steam-valves and cylinder. The valves DD are short D-slides, surrounded by steam, and by the underside of the valves the escape takes place through the space E; *d*D is the valve-rod moved by the usual valve-gear *xxx*. The eccentric *xxx*, Plate CCCCLXXI., is placed on a long shaft from the crank-axle at X, which shaft is also employed to work the governor-balls *ww*. The whole foundations are solid red sandstone rock, in which excavations are made for the shafts and ropes.

Plates CCCCLXXIII, CCCCLXXIV, CCCCLXXV. This very beautiful pair of engines was constructed by Mr Fairbairn of Manchester; and they are the property of Messrs Bailey and Co. of Staley Bridge, near Manchester. They are employed to drive a cotton-mill, and possess many excellent adaptations to this purpose.

These engines are of a similar form to those employed in large steam-vessels, and will serve very well to conduct the student from the common to the marine engine. The working beam or great lever LLL is, as it were, split in two, one of the halves being placed on each side of the engine, but united at the middle by a large gudgeon or main-centre, LL, and at the one end by a cross-head, L*p*L, and side rods, RL and RL, and at the other end by a cross-tail of similar form, and the connecting rod KL, which turns the crank KX. The moving mass is thus placed lower, and the whole rendered more compact, than the common house-engine.

This double marine engine is reckoned preferable in the manufacture of cotton to an engine of the common kind. The double engine gives a considerable degree of uniformity to the velocity produced; and the approximation to uniformity is rendered still more perfect by the short stroke, in which the variations of force recur at shorter intervals than with a long stroke. A striking peculiarity in this pair of engines is the large fly-wheel, WWW, formed of toothed segments, which receives the moving force of both engines, and gives it out directly, and with a high velocity, to the mill-shafts, YY. Not only is the requisite speed of revolution attained very readily and quickly by this means, but the momentum of the wheel is immediately conveyed to the shaft, instead of passing through a series of wheel and axle work. The durability and excellence of this arrangement are unquestionable.

The section, fig. 1, plate CCCCLXXIV, shows the details of many of the parts. The steam-pipe SSS from the boiler conducts the steam into a space SS, forming a jacket round the cylinder AA. The piston P has metallic rings on its periphery as packing; U and V, the upper and lower steam-ports, are wholly formed in the cover and bottom plate of the cylinder, and are closed and opened alternately by two short D-slides in two separate valve-chests above and below. The steam enters the upper chest from the jacket at S, where the throttle valve is inserted, and passes through the valve. The packing on the back of the valve is screwed down from above by a vertical spindle, and the eduction takes place through E by a hollow vertical column on one side of the valve-chest, while the steam passes down to the lower port through another column. The condenser C is a single casting, placed immediately below the valve-chest, and is entered by the injection pipe *cc* at *c*, of which the aperture is regulated by a slide-valve and vertical spindle ending in a screw. F is the foot-valve, governing the communication between the condenser and air-pump G; H is the air-pump piston, with common clack-valves; and M is the delivery-valve, opening outwards into the hot well. The waste-pipe is immediately below M; and the feed-pump and pipe *f* are in the masonry below the lever, so as to draw the feed-water from the waste-pipe.

The valves DD receive motion by an apparatus somewhat peculiar. A stud in the crank-pin K carries round a small radius rod *x x* on an axis, concentric with the crank; a smaller crank on this axis or shaft has a length equal to half the throw of the valve, or equal to that which would be given to the usual eccentric, and by a bar *x x* similar to the eccentric rod, the valve is moved by this lesser crank, just as by an eccentric. This gearing has the advantage of lightness and precision. *m m m* are the usual links of the parallel motion; *d* is a counterpoise to the weight of the valve, *w w* are the weights of the governor.

Plate CCCCXXLVI. This is one of that class called the rotatory steam-engine; a class comprehending many varieties, of which we hear much and see but little. The engine is here given as an illustration of this very unsuccessful class of engines, by one of its least exceptionable examples. It has actually been in use for some years, being frequently employed to turn the machinery of a large establishment. We have seen it working smoothly and well. Yet we have not been able to recognize in it any reason for giving it an equality, much less a preference, in comparison with the common engine. It can be reversed in the same way as a common engine. It was invented by Mr Yule of Glasgow, by whom it was patented, and is still in the works of Thomas Edington, Esq., at Glasgow.

SSS is a double steam-pipe, either branch of which may be employed according as the engine is to go forward or backward. AA is the cylinder firmly fixed on a stone foundation, and in its centre is an axis XX, upon one side of which and eccentric to the cylinder is an inner cylinder or barrel turned quite true, and fixed to revolve with the axis X, and so to form the piston P, which is to receive and give out the force of the steam. RR furnishes the *point d'appui*, the surface of reaction, which resists the force of the steam and forms a fixed obstacle. It is a flat slide or sluice, (see fig. 5,) resting on the barrel piston P, and maintained by guides always in a vertical position. It passes into the cylinder through a rectangular stuffing box, and is raised and depressed by a small eccentric pin *x x*, so as to remain always upon the surface of the piston drum. All the working surfaces are rendered steam-tight by metallic packings. EEE is the eduction passage into the condenser or the open air, DD are slide-valves to be reversed when the engine is to go backwards. On the revolving axis of the piston X are toothed wheels, *gg*, working other two, *gg*, which have a common axis *zz*, carrying a fly-wheel, and driving the machinery to be worked by the engine. Fig 6. shows the ports at DD. Fig. 7 shows the guides of the slide RR.

Plates CCCCLXXVII, CCCCLXXVIII, CCCCLXXIX exhibit views of a pair of beautiful marine engines, constructed by Mr Napier, for the four British and North American royal mail steam-ships Britannia, Acadia, Caledonia, and Columbia, plying between Liverpool, Halifax, (Nova Scotia) and Boston, (U. S.) The following are the general dimensions of the vessel and engines.

	Ft.	in.
Length from figure-head to taffrail, .	228	
Length of keel and fore-rake, . .	206	
Breadth of beam between paddles, .	34	6
Depth of hold, ...	22	6
Diameter of paddle-wheel, . .	28	
Length of floats, . . .	26	
Diameter of cylinder, . . .	6	
Length of stroke, . .	6	10

The power of the engines is about 240 horse power. The paddle shafts make 16 revolutions per minute. The tonnage of the vessel by the old law is about 1200 tons.

Plate CCCCLXXVII is a side elevation of one of the engines.

Plate CCCCLXXVIII is the elevation of the crank end of the engines, and Plate CCCCLXXIX the elevation of the cylinder end. By an inspection of these engravings it will be seen, that the parts of the engines are sustained by an elegant and rigid Gothic framing, rendering them, notwithstanding the ponderosity of their different parts, entirely independent of the vessel on which they are placed. A A are the cylinders, B the slide-valve casing, C the condenser, D the hot well and air-vessel placed on the top of the condenser. E the air-pump, FF the feed-pumps. The moving parts of the engine are as follow:—K the cylinder piston-rod, I the cross-head, H the cylinder side rods descending to the great side levers GGG. Connected with the parts last described are the radius rods of the parallel motion L, the motion side rod L′, and the parallel motion shaft *l*, V the valve or weigh-shaft on which is fixed the valve lever W, whose other end is inserted into a clutch on the slide-valve link *c*. On either side of the centre of the great lever depends a side rod *ff*, to work the bilge and brine pumps, and to its extremitty are attached the links of the cross-tail of the connecting rods, P the links, Q the cross-tail, R the connecting rod. To the upper end of the connecting rod is attached the crank S; T is the intermediate or crank-shaft, T′T′ the paddle-wheel shafts. On the crank-shaft is placed the eccentric U; and *uu* is the eccentric rod working the eccentric gab-lever *v* on the valve or weigh-shaft $t\ t^2$. Y *y y* the expansion valve apparatus, *h h* escape valves at top and bottom of cylinders, X paddle wheels, *k* lever for starting the engines, 1 1 steam-pipes, 2 2 waste water pipes from hot well, 3 double force-pump for filling boilers, extinguishing fires, and washing decks, 4 4, engine beams, 5 5 5 5 midship section of vessel, 6 6 thick planks checked in upon and bolted through the timbers thus:—

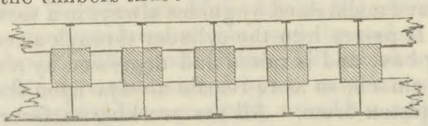


Plate CCCCLXXX. Side and end elevation of one of the engines of her Majesty's mail packet, Urgent, and also of the Actæon, built by Messrs Caird and Company of Greenock. The Urgent plies between Liverpool and Dublin; the Actæon between Liverpool and Glasgow. Both vessels have been very successful: they are swift boats, and consume a small amount of fuel. Their general dimensions are here noted.

	Urgent.		Actæon.	
	Ft.	in.	Ft.	in.
Length of keel and fore-rake,	172	1	171	
Breadth within paddle space,	26		25	10
Depth of hold,	17	5	17	3
Diameter of paddle-wheel,	24	6		
Length of floats, which in the Urgent are of Galloway's patent, in 3 breadths of about 9 inches each,	8	10		
Diameter of cylinder,	5	2	5	2
Length of stroke,	5	9	5	9

The power of each of the engines is 140 horse power. The paddle-shaft makes about twenty revolutions per minute. The tonnage of the Urgent, by the old law, is $562\frac{63}{94}$—of the Actæon $551\frac{92}{94}$. A A is the cylinder, C the condenser, E the air-pump, H the cylinder side rods, I the cylinder cross-head, B the valve-casing, W the valve lever, W′ W the back balance, G G G the side levers, P the cross-tail links, Q the cross-tail, R the connecting rod, S the crank, U the eccentric, N the air-pump side rods, M the air-pump cross-head.

Plates CCCCLXXXI, CCCCLXXXII, CCCCLXXXIII, represent the engines of the Achilles, also built by Messrs Caird and Company, to ply between Liverpool and Glasgow. Plates CCCCLXXXI, CCCCLXXXII, show the two side elevations of one of the engines; and plate CCCCLXXXIII a section of the vessel to a lesser scale, with the engines, paddle-wheels, &c., *in situ*. The arrangement of the framing of these engines is highly beautiful. The entablature supported by the columns, uniting both engines in one design, gives massiness of appearance, as well as great strength to the structure. In plate CCCCLXXXII is seen the apparatus for working the engines expansively. On the crank-axle T is placed a series of cams, *t t t*, which act upon the roller of the expansion-valve tumbler. Y *y y y* are the expansion-valve connecting rods and levers. Z is the valve-chest, and the valve is of the kind called equilibrium valves, or crown valves. The other parts are A the cylinder, B the valve-chest, C the condenser, D the hot well, E the air-pump, F the feed and bilge pumps, GG the great lever, G′ its main gudgeon, H the cylinder side rods, I the cross head, K the piston-rod, L L the parallel motion, M the air-pump cross-head, N the air-pump side rods, O the air-pump piston-rod, P the connecting rod cross-tail links, Q the cross-tail, R the connecting rod, S the crank, U the eccentric pulley or cam, *u u u* the eccentric rod, V the valve-shaft, W W the valve-lever and counter balance lever.

Plates CCCCLXXXIV, CCCCLXXXV, CCCCLXXXVI. The engines exhibited in these plates are a pair of 110 horse power each, constructed by Messrs Fawcett, Preston & Co. of Liverpool.

Plate CCCCLXXXIV shows the side elevation of one of these engines. Plate CCCCLXXXV shows the elevation of the crank end of both engines; and plate CCCCLXXXVI the cylinder end of the engines, drawn to a somewhat smaller scale. The letters refer to the same parts as in the engines already described, and it is unnecessary here to repeat the description.

Plate CCCCLXXXVII. In this plate is given a representation of a single marine engine of 65 horse power, with a stroke of four feet. Fig. 1 is a side elevation; fig. 2 a plan or bird's-eye view; fig. 3 an elevation of the cylinder end; and fig. 4 an elevation of the crank end. The same letters indicate the same parts as in the former figures.

Plate CCCCLXXXVIII, fig. 1. is an end view, and fig. 2 a side view, of a double towing-engine of forty-five horse power and three feet six inches' stroke. The most striking peculiarity of this engine is, that the paddle-wheel shaft is separate from the crank-shaft, and driven by it through the intervention of toothed wheels. T is the crank shaft, with its spur wheel driving the spur wheel of the paddle-shaft T^2. The other letters refer to the same parts as before.

Plate CCCCLXXXIX. In this plate are represented two engines of direct connexion, constructed by Messrs Tod and M'Gregor, Glasgow.

In figs. 1 and 2 of this plate, the crank S of the engine is placed directly above the cylinder A; the piston-rod K carries a cross-head I, which is guided to move in the vertical direction by two cross guides *gg*, one at each extremity, whose ends slide upon the vertical pillars *pp*, which sustain the framing for the support of the crank-axle. From each end of the piston cross-head depends a side rod HH, whose lower extremity, together with the ends of the side rods PP, which depend from the cross-tail Q of the connecting rod R, are attached to the end of a side lever GG. To the opposite end of the side levers are attached the side rods N of the air-pump, and on either side of its centre the side rods of the feed and bilge pumps F. The parts not already described are *aa* the slide-valve, C the condenser, E the air-pump, S the crank, U the eccentric, and *uuu* the eccentric rod and valve-gear.

In the engine represented in figs. 3 and 4, the piston-rod K terminates in a triangular frame III, from the apex of which the connecting rod R descends to the crank S; and to the extremities of its base are attached the piston-rods OO of the air-pumps EE, which are in this case two in number, and situated one on each side of the cylinder. The triangular frame III is confined to move in a vertical direction, by its cross-head *gg* being guided in the slide *pp*. The remaining parts are, A the cylinder, CC the condensers, *aa* the valve-chest, F the feed-pumps, worked by an eccentric *ff*, U*u* the eccentric and valve-gear, and *eeee* the framing of the engine.

Plate ccccxc. Fig. 1 of this plate is a side-elevation, and fig. 2 an elevation of the cylinder end, of a pair of marine engines constructed by Messrs Seaward of the Canal Ironworks, Limehouse, for H. M. steam-frigates Gorgon, Cyclops, Prometheus, and Electo. These engines are of a peculiar construction; the crank, as in the engines of the last plate, being directly above the cylinder, the connecting rod only intervening between it and the piston-rod. They are of the class of the vibrating pillar-engines, the pillar which supports the beam turning upon a centre at its lower end. A is the cylinder, B the valve-chest, C the condenser, E the air-pump, K the piston-rod, R the connecting rod, S the crank, GGG the beam, *g* the vibrating pillar, L the radius rod, N the air-pump side rod, M the air-pump cross-head.

STEEL.—As good iron is the basis of good steel, all that has been said under the articles IRON and SMELTING in reference to the sources and means of procuring that metal in a state of purity, may be advantageously referred to as a preliminary to the present.

Steel is a carburet of iron, with probably a slight mixture of other substances which are more or less essential to its perfection, and certainly in most cases with some alloy which is not essential, but which, on the contrary, is to some extent injurious. This description would equally apply to cast-iron, which differs from steel as to its ingredients principally in the quantity of carbon, cast-iron having sometimes one-fifteenth part, and good steel seldom more than one two-hundredth part of that substance. The difference between the proportions of the carbon does little, however, to explain the difference between cast-iron and steel; for, while the condition of cast-iron is retained, it is found that diminishing the quantity of carbon renders it still less like good steel. It appears, in short, that the good qualities of steel—and they are very various—depend upon circumstances partly chemical and partly mechanical, which have hitherto defied analysis. It is not even precisely known whether the union of the iron and carbon is a chemical or mechanical union: perhaps it may be partly one and partly the other, for reasons which will presently be given.

In consequence of this ignorance as to what constitutes the essential qualities of good steel, the processes by which favourable results have been obtained have in nearly all cases been empirical, and in many instances have been real or pretended secrets. The processes are of a nature to forbid any very nice calculations, and they are liable to great and unappreciable modifications in the execution. For example, steel being, as before stated, a carburet of iron, and having generally a slight admixture of oxyde of iron, must be subject to many incalculable changes during its successive exposures to violent heat in contact with carbonaceous fuel and atmospheric air. Moreover, the hammering, on which many of its good properties depend, is obviously an operation which cannot be meted out with very scrupulous nicety, and is besides liable to be very much influenced by the temperature of the metal and by the direction of the blows in reference to the mechanical structure of the mass.

A good practical essay on steel, it is therefore evident, would consist in an exceedingly minute detail of the actual operations applied to a certain description of ore, or to a known specimen of manufactured iron, which, with certain sorts of fuel, had been found uniformly to produce steel peculiarly adapted to certain purposes. Such an essay would form a volume, and it would still convey imperfectly what it professed to teach, because in all the processes there are certain stages of the conversion whose advent is judged of by the experienced eye and hand of the skilful workman, from symptoms which can be explained only to the sight and touch. Here we only propose to describe, in very general terms, some of the principal processes, so as to convey a knowledge of the *theory* of steel-making without professing to give the actual practice. We must premise, that the destination of the steel is of great importance in estimating even the theory of those processes, as may be well supposed when it is recollected that a lancet will fracture almost like glass, while a bricklayer's trowel is required to cut the most refractory lump of semi-vitrified clay in the shape of a brick. These two instruments are perhaps at the extremities of the scale, the perfect hardness and brittleness of the lancet contrasting with the extraordinary toughness and tenacity of the trowel.

It was at one time, indeed, thought so difficult to combine these last-mentioned qualities with sufficient hardness to sever a good stock-brick, that trowels were made of a plate of iron to supply the toughness, and an edge of steel to give the hardness. Even at the present time it is supposed that the peculiar qualities of certain sword-blades result from their being combinations of hard steel with soft tenacious iron fibre; and that the variegated or *damasked* surface of such blades is owing to the different appearances presented by the iron and steel. By some this effect has been supposed to result from chemical changes acting partially upon the original carburet, depositing the carbon more profusely in some parts of the iron than in others. It may arise, as already hinted, from some portions of the carburet being in a chemical, and others only in a mechanical state of union. According to other authorities, the structure in question has been manufactured expressly by binding up portions of soft iron wire with ingots of steel, and hammering the whole into a mass at a high temperature. Such a process will, it is known, produce very similar appearances. Whatever be the truth in regard to the sword-blades, certain combinations of iron and steel in parallel laminæ are advantageously employed for some purposes. The carpenter's *plane-iron*, for example, consists of a very thin hard steel face on an iron back; because this instrument requires to unite a cutting edge nearly equal to that of the lancet with a tenacity which shall encounter uninjured the hardest knots; a trial almost as severe as that applied to the trowel.

One great cause of the uncertainty and obscurity attending the practice of steel-making, is the importance of the hammering or other mechanical parts of the operation. If the distinction between good and bad steel were principally chemical, the production of the former would long since have been rendered easy and determinate. How little this is the case may be inferred from the fact, that the elaborate series of experiments conducted a few years since by Dr Faraday and Mr Stodart have scarcely added a new fact to the science of steel-making; while, on the other hand, the immense value of mechanical action is shown, among numerous instances, by the increased strength of *drawn* iron wire as compared with *rolled* iron of equal size, a difference amounting sometimes to sixty or seventy per cent.

The remarkable qualities of the trowels for which a Mr. Walby was celebrated about forty years since, resulted in a great measure, if not entirely, from good and rapid hammering at a moderate temperature. The object of hammering being to condense the steel, it is evident that when at a white heat, in a state approaching to fusion, the mass is so plastic, it yields so freely, that hammering is perfectly inoperative, except to change the external form; while, on the other hand, if the mass be cold, it is so unsusceptible of what may be called intestinal movement among its particles that the most violent hammering can do little more than dislocate portions of the surface, which will accordingly crack or scale off. Between these extremes a medium may be found, and was, we believe, found by Mr Walby. His hammering was principally performed at a low cherry-red heat; and, by means of a peculiar and ingeniously mounted hammer of considerable weight, he was enabled to do all that was required before the temperature was sensibly lowered. But, as we are informed, he did more than this. It is quite certain that in hammering any mass, and especially in a thin plate, the central cannot be under the same circumstances as the exterior portions. Not only will the centre retain its heat somewhat longer, but, what is of more consequence, the tendency of the central portions to spread laterally under the hammer, is resisted by the marginal parts; while these latter not being so protected by a belt, spread freely, and perhaps separate into detached pieces. If, for example, a circular disc of steel at a low temperature were violently beaten under a flat hammer, it would be very much condensed in the middle, while the circumference would gradually separate, showing radial splits or cracks. The most perfect way to condense a circular disc of metal would obviously be to confine it in a very strongly defended cavity, whose walls should prevent all lateral spreading, and thus the full effect of each blow would be felt in condensation. Such a process is, however, inapplicable to trowel making, and perhaps to all other purposes except the striking of medals, where we see it employed; but Mr Walby obtained nearly all the effect of such an arrangement by forging each trowel considerably larger than it was ultimately intended to be, and cutting off about an inch of superfluous metal after the hammering was completed; cutting off, that is to say, the wall which had acted to restrain the spreading of the central portion of the blade, and which had probably become loose and spongy itself for want of such restraint, thus leaving only the close compact metal in the finished trowel.

Having thus endeavoured to direct the reader's attention to some of the qualities demanded in steel, and to the causes which affect their production, we shall briefly describe some of the operations.

Steel is most frequently made from rolled bars of *good*, by which we mean *pure* iron. To communicate to these bars the desired quantity of carbon, they are formed into bundles, and are placed in a large stove or furnace alternating with layers of carbon, (hard-wood charcoal is preferred,) and a high temperature being maintained for a week or ten days, the iron gradually absorbs the required quantity of carbon, and becomes converted into steel. The completeness of this conversion is judged of from time to time by the examination of certain of the bars, which are so disposed as to be accessible for this purpose. If the carbon has not penetrated to the centre of the metal, this will be evident on breaking the bar transversely, as the section will exhibit a colour in the centre different from that near the surface: it will show what the workmen call a pith. Towards the end of the process, the watching requires to be skilful and constant, because, if the absorption of carbon becomes very excessive, the metal may be rendered so fusible as suddenly to melt; and though this would be of little consequence in a sound crucible, it would be attended with great loss in a large stove or hearth. The surface of the bars becomes so nearly in this condition that it is always blistered by the escape or rarefaction of air or gas from the interior of the metal; and hence bars so prepared have acquired the name of blister or blistered steel. The process itself is called cementation.

The bars thus prepared do not differ very greatly from cast-iron, except in the smaller quantity of carbon which they contain, and in their freedom from impurities. They have somewhat more malleability and tenacity than cast-iron, but not so much as is imparted to that substance during its conversion to bar-iron, and which must now, except for very coarse purposes, be communicated to these bars of cementation—without, however, depriving them of their carbon. With this view the bars so prepared are broken up into short lengths, are made into bundles, heated almost to a white heat, hammered, welded together, re-broken and re-hammered till they are reduced as nearly as possible to a compact homogeneous mass of greater specific gravity than in their former state. In all these weldings, care is required to preserve the surfaces clean and unoxydized, as upon this depends the perfect union of the two surfaces.

This care is dispensed with in the processes for making cast-steel, the nature of which has been already indicated in describing that of cementation. The pure iron and a certain proportion of carbon are fused together in a crucible, and being cast into ingots, these are treated, somewhat like the bundles of the cemented bars. They are hammered at a high temperature till they are rendered malleable and dense, and till a certain portion of the carbon is displaced, that substance being generally in excess. Various modes of applying the carbon have been proposed; but it is very difficult to determine in the abstract which of these is the best. One mode of application is, by the introduction of a stream of gas. Cast-steel is free from the defects which are liable to attend the imperfect welding of the bars, and is likely to supersede all others for the finer purposes of cutlery. It requires, however, the most skilful manipulation as the point of sufficient fusion is reached, and this must be performed under the most severe exposure to heat; so severe as to demand that the workmen should be protected, by clothing of wetted sackcloth, from the joint effects of the opened furnace and the glowing crucible. This combination of skill and severe labour secures high wages, and enhances the price of the article.

The experiments of Faraday and Stodart, before alluded to, were undertaken not so much to improve the mode of manufacture as to determine the effect of various alloys; it having been inferred, partly from the condensation which frequently accompanies chemical unions, and partly from the examination of certain specimens of steel which were known to possess good qualities, that a small portion of foreign matter might be beneficially introduced. With this view, alloys of steel with gold, silver, platinum, and many other metals, in various proportions and combinations, were made, without however producing any very definite results. One of the best was a mixture of 500 parts of steel with one part of silver. While the silver was in this small proportion, it appeared to diffuse itself equally throughout the mass, and the union appeared to be chemical. No remarkable increase of specific gravity accompanied the union; and the opinion formed at the time, that the steel was improved by the addition, is beginning to be shaken. It is worth mentioning, that if the quantity of silver much exceeded the five-hundredth part, the excess was distributed in small distinct fibrous masses, in such a manner as to unfit the steel for most purposes of utility.

Having by any of the means now mentioned manufactured a good steel or a good alloy, it is found to have acquired a property on which its great value in the arts entirely depends: we mean the property of becoming very hard when *suddenly* cooled from a high temperature. If heated to whiteness, and then plunged into water, instead of the malleable tenacious substance which had been produced under the welding hammers, it has become nearly as hard as a diamond and as brittle as glass. The sudden cooling from a white heat would, however, be found to have damaged considerably the compactness of the steel; and practically it is known, that the lower the temperature on which the sudden cooling can be made to act with effect, the better will be the quality of the metal. It is also supposed that the lower the temperature at which the steel is manufactured—that is to say, hammered into compactness and malleability—the lower will be the temperature necessary to give it hardness. When all these points have been determined to the greatest exactness, there remains another consideration which has been well pointed out by a recent writer on the subject. Since the perfection of every steel instrument depends upon its receiving a hardness very exactly proportioned to its intended use, and as the subsequent operations will equally affect every part of the hardened steel, it is most important that the hardening be equal in every part, in order that the hardness of the whole, when reduced, shall be equal. If then the heated steel, at the moment of its plunge into the water, be in some parts coated with an oxyde of iron while in other parts it is clean, the rapidity of the cooling in the various parts will be so different as to affect seriously the uniformity of the result. In this way, among others, we can understand how it happens that one part of a razor or other instrument shall be much harder than another. To avoid this inequality, it has been proposed that the instrument shall be perfectly cleansed upon a stone previously to hardening, and then heated with the utmost care to prevent the formation, or at least the unequal formation, of oxyde upon the surface. Various opinions and practices prevail as to the mode of cooling. Besides water at various temperatures, saline solutions, mercury, and a current of air, have been suggested; but it is doubtful whether any of them is preferable to water at a moderate temperature.

The steel having now been made indefinitely hard, too hard generally for any practical purposes, it requires to be tempered or softened down more or less, according to the nature and uses of the intended instrument. This is done by the application of a moderate heat, varying from 430° to 600° of Fahrenheit; the higher temperatures softening the metal proportionally more than the lower.

Formerly the heat applied in tempering was judged of by the colour assumed by the steel, a portion being always ground clean, to enable the operator to observe exactly when the required shade of colour was obtained. These colours, it may be stated, are produced by the action of the oxygen in the air upon the heated metal; and though their indications are sufficiently accurate for most purposes, it has been found desirable in some cases to substitute a fusible metallic bath, by which a regulated temperature may with certainty be communicated.

The following table, showing the temperatures according to Fahrenheit which correspond with various colours, was drawn up by the late Mr Stodart:—

1. Very pale straw yellow,......................	430°
2. A shade of darker yellow,..................	450
3. Darker straw yellow,........................	470
4. Still darker straw yellow,..................	490
5. A browner yellow,............................	500
6. Yellow slightly tinged with purple,.......	520
7. Light purple,....................................	530
8. Dark purple,......................................	550
9. Deep blue,..	570
10. Paler blue,.......................................	590
11. Still paler blue,................................	610
12. Still paler blue, with a tinge of green,...	630

When the hardened steel is heated only within the limits here specified, it matters not how it is cooled; the softening or tempering equally takes place, and is proportioned to the temperature. The knowledge of the proper degrees of heat or colour adapted to various instruments, is obtained wholly by experience. The following table, extracted from the work before mentioned, is perhaps as accurate as any:—

INSTRUMENTS.	COLOURS.	TEMPERATURES.
1. Razors and instruments with a stout back and fine edge,	Straw colour.	430° to 450°
2. Scalpels and penknives,	Full yellow.	470°
3. Scissors and small shears,	Brown yellow.	490°
4. Pocket and pruning knives,	First tinge of purple.	510°
5. Watch-springs, swords, &c.	Purple.	550° to 560°

After the operation of tempering, nothing is required but the final grinding, fashioning, and polishing of the article, which it is not here requisite to discuss. (C. K.)

STEEL-YARD. See WEIGHING-MACHINES.

STEELE, SIR RICHARD, was born in Dublin about the year 1676. One branch of the family was possessed of a considerable estate in the county of Wexford. His father, a counsellor at law in Dublin, was private secretary to James, Duke of Ormond; but he was of English extraction; and his son, while very young, being carried to London, he put him to school at the Charter-house, whence he was removed to Merton College in Oxford. He left the university without taking any degree, in the full resolution to enter into the army. This step was highly displeasing to his friends; but the ardour of his passion for a military life rendered him deaf to any other proposal. Not being able to procure a better station, he entered as a private gentleman in the horse guards, notwithstanding he thus lost the succession to his Irish estate. However, as he had a flow of good nature, a generous openness and frankness of spirit, and a sparkling vivacity of wit, these qualities rendered him the delight of the soldiery, and procured him an ensign's commission in the guards. In the mean time, as he had made choice of a profession

Steele.

which set him free from all the ordinary restraints in youth, he spared not to indulge his inclinations in the wildest excesses. Yet his gayeties and revels did not pass without some cool hours of reflection; it was in these that he drew up his little treatise entitled *The Christian Hero*, with a design, if we may believe himself, to be a check upon his passions. For this purpose it had lain for some time by him, when he printed it in 1701, with a dedication to Lord Cutts, who had not only appointed him his private secretary, but procured for him a company in Lord Lucas's regiment of fusiliers.

During the same year he brought out his comedy, called *The Funeral, or Grief à la Mode.* This play procured him the notice of King William, who resolved to give him some essential marks of his favour; and though, upon that prince's death, his hopes were disappointed, yet, in the beginning of Queen Anne's reign, he was appointed to the profitable place of gazetteer. This post he owed to the friendship of Lord Halifax and the Earl of Sunderland, to whom he had been recommended by his schoolfellow Mr Addison. That gentleman also lent him a helping hand in promoting the comedy called *The Tender Husband*, which was acted in 1704 with great success. But his next play, *The Lying Lover*, had a very different fate. Upon this rebuff from the stage, he turned the same humorous current into another channel; and early in the year 1709, he began to publish the Tatler; which admirable paper was undertaken in concert with Dr Swift. His reputation was perfectly established by this work; and, during the course of it, he was made a commissioner of the stamp-duties in 1710. Upon the change of the ministry the same year, he joined the Duke of Marlborough, who had several years entertained a friendship for him; and upon his Grace's dismission from all employments in 1711, Mr Steele addressed a letter of thanks to him for the services which he had rendered to his country. As, however, he still continued to hold his place in the stamp-office under the new administration, he wisely declined the discussion of political subjects; and, adhering more closely to Addison, he dropped the Tatler, and afterwards, by the assistance chiefly of that steady friend, he carried on the same plan, much improved, under the title of the Spectator. The success of this paper was equal to that of the former; and, before the close of it, he was thus encouraged to proceed upon the same design in the character of the Guardian. This was opened in the beginning of the year 1713, and was laid down in October the same year. But in the course of it his thoughts took a stronger turn to politics: he engaged with great warmth against the ministry; and being determined to prosecute his views by procuring a seat in the House of Commons, he immediately removed all the obstacles that stood in his way. For that purpose he took care to prevent a forcible dismission from his post in the stamp-office, by a timely resignation of it to the Earl of Oxford; and at the same time gave up a pension, which had hitherto been paid to him by the Queen as a servant to the late Prince George of Denmark. He now wrote the famous Guardian upon the demolition of Dunkirk. It was published August 7, 1613; and the parliament being dissolved next day, the Guardian was soon followed by several other warm political tracts against the administration. Upon the meeting of the new parliament, Steele having been returned a member for the borough of Stockbridge in Hampshire, took his seat accordingly in the House of Commons; but was expelled in the course of a few days, for writing the close of the paper called the *Englishman*, and one of his political pieces entitled the *Crisis*. Presently after his expulsion, he published proposals for writing the history of the Duke of Marlborough. At the same time he also wrote the *Spinster*; and, in opposition to the *Examiner*, he set up a paper called the *Reader*, and continued publishing several other papers and tracts in the same spirit till the death of the queen. As a reward for these services, he was immediately taken into favour by her successor to the throne, King George I.; was appointed surveyor of the royal stables at Hampton Court, and governor of the royal company of comedians was put into the commission of the peace for the county of Middlesex, and in 1715 received the honour of knighthood. In the first parliament of that king, he was chosen member for Boroughbridge in Yorkshire; and, after the suppression of the rebellion in the north, was appointed one of the commissioners of the forfeited estates in Scotland. In 1718, he buried his second wife, who had brought him a handsome fortune with a good estate in Wales; but neither this, nor the ample addition lately made to his income, was sufficient to answer his demands. The thoughtless vivacity of his spirit often reduced him to little shifts of wit for its support; and the project of the fish-pool this year, owed its birth chiefly to the projector's necessities. This vessel was intended to carry fish alive, and without wasting, to any part of the kingdom; but notwithstanding all his towering hopes, the scheme proved very ruinous to him; for after he had been at an immense expence in contriving and building his vessel, besides the charge of the patent, which he had procured, it turned out upon trial to be a mere project. His plan was to bring salmon alive from the coast of Ireland; but these fish, though supplied by this contrivance with a continual stream of water while at sea, yet uneasy at their confinement, shattered themselves to pieces against the sides of the pool; so that when they were brought to market they were worth very little.

The following year he opposed the remarkable peerage bill in the House of Commons; and, during the course of this opposition to the court, his license for acting plays was revoked, and his patent rendered ineffectual at the instance of the Lord Chamberlain. He did his utmost to prevent so great a loss; and finding every direct avenue of approach to his royal master effectually barred against him by his powerful adversary, he had recourse to the method of applying to the public, in hopes that his complaints would reach the ears of his sovereign, though in an indirect course, by that channel. In this spirit he formed the plan of a periodical paper, to be published twice a-week, under the title of the *Theatre*; the first number of which appeared on the 2d of January 1719-20. In the mean time, the misfortune of being out of favour at court, like other misfortunes, drew after it a train of more. During the course of this paper, in which he had assumed the feigned name of *Sir John Edgar*, he was outrageously attacked by Mr Dennis, the noted critic, in a very abusive pamphlet, entitled *The Character and Conduct of Sir John Edgar.* To this insult he made a proper reply in the *Theatre*.

While he was struggling with all his might to save himself from ruin, he found time to turn his pen against the mischievous South Sea scheme, which had nearly brought the nation to ruin in 1720; and the next year he was restored to his office and authority in the playhouse in Drury-Lane. Of this it was not long before he made an additional advantage, by bringing his celebrated comedy called the *Conscious Lovers* upon that stage, where it was acted with prodigious success; so that the receipt there must have been very considerable, besides the profits accruing by the sale of the copy, and a purse of £500 given to him by the king, to whom he dedicated it. Yet notwithstanding these ample supplies, about the year following, being reduced to the utmost extremity, he sold his share in the playhouse; and soon after commenced a lawsuit with the managers, which in 1726, was decided against him. Having now again, for the last time, brought himself by the most heedless profusion into a desperate condition, he was rendered altogether incapable of retrieving the loss, by being seized with a paralytic disorder, which greatly impaired his understanding. In these unhappy circumstances, he retired to his seat at Languanor near Caermarthen in Wales, where he died on the 21st of September 1729, and, according to his own desire, was privately interred in the church of Caermarthen. Among his papers were found the manuscripts of two plays, one called *The Gentlemen*, founded upon the Eunuch of Terence, and the other entitled *The School of Action*, both nearly finished.

Sir Richard was a man of undissembled and extensive benevolence, a friend to the friendless, and, as far as his circumstances would permit, the father of every orphan. His works are chaste and manly. He was a stranger to the most distant appearance of envy or malevolence; never jealous of any man's growing reputation; and so far from arrogating any praise to himself from his conjunction with Mr Addison, that he was the first who desired him to distinguish his papers. His great fault was want of economy; and it has been said of him, he was certainly the most agreeable and the most innocent rake that ever trode the rounds of dissipation.

STEERAGE, on board a ship, that part of the ship next below the quarter-deck, before the bulk-head of the great cabin, where the steersman stands in most ships of war.

STEERING, in *Navigation*, see Seamanship.

STEEVENS, George, the most successful of all the editors and commentators of Shakspeare, was born in the year 1735. We know nothing respecting his parents; but they appear to have been in affluent circumstances. He received the rudiments of his education at Kingston-upon-Thames, and had Gibbon the historian for a companion at that school. From hence he went to Eton, and in a few years was admitted a fellow commoner of King's College, Cambridge; but no mention is made of his peculiar course of studies. It appears however that he had little relish for the mathematics, which lead at Cambridge to academical honours. On the first establishment of the Essex militia, he accepted of a commission; but he spent the concluding years of his life in almost total seclusion from the world, seldom mingling with society but in the shops of booksellers, in the Shakspeare gallery, or in the morning conversations of Sir Joseph Banks.

Although not an original writer, we cannot in justice refuse him a place among the literary characters of the age, when we consider the works which he illustrated, and the learning, sagacity, taste, and general knowledge which he brought to the task. With a versatility of talents, he was eminent both by his pen and his pencil; but his chief excellence lay in his critical knowledge of an author's text; and the best specimen of his abilities is his edition of Shakspeare, in which he has left every competitor far behind him. He had studied the age of Shakspeare, and employed his persevering industry in becoming acquainted with the writings, manners, and laws of that period, as well as the provincial peculiarities, whether of language or customs, which prevailed in different parts of the kingdom; but more particularly in those where Shakspeare passed the early years of his life. He was continually increasing this store of knowledge, by the acquisition of the obsolete publications of a former age, which he spared no expense to obtain. His critical sagacity and observation were constantly employed in calling forth the hidden meanings of the dramatic bard, and of course enlarging the display of his beauties. This advantage is apparent from his last edition of Shakspeare, which contains so large a portion of new, interesting, and accumulated instruction. In preparing it for the press, he gave an instance of activity and perseverance without example. To this work he exclusively devoted a period of eighteen months, during which he left his house at Hampstead every morning at one o'clock, going to his friend Mr Isaac Reed's chambers in Barnard's Inn, without any consideration of the weather or the season, and there he found a sheet of the Shakspeare letterpress ready for correction. Thus, while the printers slept, the editor was awake, by which means he completed, in less than twenty months, his splendid edition of Shakspeare in fifteen volumes octavo; a labour almost incredible, and by which the energy and persevering powers of his mind were fully proved.

He probably rested satisfied with being a commentator from the particular habits of his life, and his devotion to the name of Shakspeare. But at the same time he was a classical scholar of a respectable order, and well acquainted with the polite literature of Europe. He studied ancient and modern history, and particularly that of his own country. His genius was strong and original, his wit abundant, his imagination of every colour; and his sentiments were enlivened with the most brilliant expressions. His eloquence was logical and animated; his descriptions were so true to nature, his figures so curiously selected, and so happily grouped, that he might be regarded as a speaking Hogarth. He scattered his wit and his humour too freely around him, and they were not lost for want of gathering.

Mr Steevens had a very handsome fortune, which he managed with discretion. His generosity was equal to his fortune; and though not profuse of his money to sturdy beggars, few persons distributed with more liberality to truly deserving objects. He possessed all the graces of outward accomplishment, at a period when civility and politeness were characteristics of a gentleman. He bequeathed his valuable Shakspeare, illustrated with about 1500 prints, to Earl Spencer; his Hogarth, perfect, with the exception of one or two pieces, to Mr Windham; and his corrected copy of Shakspeare, with 200 guineas, to his friend Mr Reed. He died in the month of January 1800, about sixty-five years of age.

STEGANOGRAPHY, the art of secret writing, or of writing in ciphers, known only to the persons corresponding.

STELLIONATE, in the civil law, a kind of crime, committed by a fraudulent bargain, where one of the parties sells a thing for what it is not; as if he sells an estate for his own which belongs to another, or conveys a thing as free and clear which is already engaged to another, or puts off copper for gold, &c.

STEMPHILA, a word used by the ancients to express the husks of grapes, or the remains of the pressings of wine. The same word is also used by some to express the remaining mass of the olives, after the oil is pressed out.

STEMPYLITES, a name given by the ancients to a sort of wine pressed hard from the husks.

STEMPLES, in mining, cross bars of wood in the shafts which are sunk to mines.

STENOGRAPHY.[1] The art of stenography, or short writing, was known and practised by most of the ancient civilized nations. The Egyptians, who at an early period were distinguished for learning, at first expressed their words by a delineation of figures called *hieroglyphics*. A more concise mode of writing seems to have been afterwards introduced, in which only a part of the symbol or picture was drawn. This answered the purpose of short-hand in some degree. After them the Hebrews, the Greeks, and the Romans, adopted different methods of abbreviating their words and sentences, suited to their respective languages. The initials, the finals, or radicals, often served for whole words; and various combinations of these sometimes formed a sentence. Arbitrary marks were likewise employed to determine the meaning, and to assist legibility; and it seems probable that every writer and every author of antiquity had some peculiar method of abbreviation, calculated to facilitate the expression of his own sentiments, and intelligible only to himself. It is also probable that some might by these means take down the heads of a discourse or oration; but few, very few, it is presumed, could have followed a speaker through all the meanders of rhetoric, and, in a manner legible even to themselves, could have noted with precision every syllable as it dropt from his mouth. To arrive at such consummate perfection in the art was reserved for more modern times, and is still an acquisition by no means general.

In every language of Europe, till about the close of the sixteenth century, the Roman plan of abbreviating (viz. substituting the initials or radicals, with the help of arbitraries, for words) appears to have been employed. Till then no regular alphabet had been invented expressly for stenography, when an English gentleman of the name of Willis invented and published one.[2] His plan was soon improved, or at least altered. One alteration succeeded another; and at intervals, for a series of years past, some men of ingenuity and application have composed and published systems of stenography, and doubtless have themselves reaped all the advantages that attend it. But among the various methods which have been proposed, and the different plans which have been adopted by individuals, none has yet appeared fortunate enough to gain general approbation, or proved sufficiently simple, clear, and concise, to be universally studied and practised. Some systems are replete with unmeaning symbols, perplexing arbitraries, and ill-judged contractions; which render them so difficult to be attained by a common capacity, or ordinary application, that it is not to be wondered at if they have sunk into neglect, and are now no longer known. Other systems, by being too prolix, by containing a multiplicity of characters, and those characters not simple or easily remembered, become ineffectual to the purpose of expedition, and are only superior in obscurity to a common hand. Some, again, not only reject all arbitraries and contractions, but even prepositions and terminations; which last, if not too lavishly employed and badly devised, highly contribute to promote both expedition and legibility; and though they reduce their characters to fewer than can possibly express the various modifications of sound, yet they make nearly one half of them complex. In the disposition of the vowels there is the greatest perplexity in most systems. A dot is sometimes substituted for all the vowels indiscriminately, and the judgment is left to determine which letter out of six any dot is intended to express; or a minute space is allotted them; so that unless they be arranged with mathematical precision, they cannot be distinguished from one another; but such a minute attention is inconsistent with the nature of short-hand, which should teach us to write down in a short time, as well as in small bounds, what we wish to preserve of what we hear. Nor is the plan of lifting the pen and putting the next consonant in the vowel's place, in the middle of words, less liable to objections; or that of representing all the vowels by distinct characters, being obviously ill calculated for facility and despatch, and consequently inadmissible into any useful system.

It is to be confessed, that the person who first proposed the omission of vowels in the middle of words,[3] which it is obvious are not wanted, and invented letters which could be connected as in a running hand without lifting the pen in the middle of the word, made a real improvement on the works of his predecessors. But, in fine, most systems, either in their plan or execution, labour under some capital defect, attended with circumstances highly discouraging to the learner, and which in a great measure defeat the end of their invention, by being too complicated to be learned with ease and remembered with accuracy, or to be practised with the expedition which is requisite; and so difficult to be deciphered, that a man can scarcely read what he has just written. To obviate these defects, to provide against prolixity and conciseness, which might occasion obscurity, to exhibit a system founded on the simplest principles, which might be easily learned and read, and yet be capable of the utmost expedition, were the motives that gave rise to the present attempt.

This method will be found different from any yet published, and superior to all in the disposition of the vowels and the facility of arranging them; the confusion in placing which seems to detract from the merit of the best performances on the subject; and it may without ostentation be affirmed, that characters simpler in their form, and more perfect in their union, have not been applied to the art of stenography. As well as it could be determined, the simplest characters are appropriated to the letters most usually employed; indeed, as far as possible, those which are complex have been rejected; but as it was an object always kept in view that the writing should be on a line, a few are admitted into the alphabet for that reason. The characters for the double and triple consonants are the easiest that could be invented, consistent with perspicuity; for care has been taken to provide against all obscurity which might arise by adopting letters too similar in their formation; and with respect to the prepositions and terminations, those which occur most frequently are expressed by the simplest characters, which will be found perfectly easy in their application. The arbitraries are few in number, and the arbitrary abbreviations, as they are entirely from the letters of the alphabet, and chosen from some thousands of words in common use, will well repay the learner for an hour's trouble in committing them to memory.

The last section lays down a scheme of abbreviation, comprised in a few rules, perfectly easy to be understood and practised by proficients in this art; and we hope it will answer the expectation of the writer, and will be found free from the perplexity complained of in many systems where abbreviation is admitted. The principal rules are new, are so easy, so extensive in their use, and so consistent with expedition and legibility, if applied with judgment, that they alone might suffice. The learner is however advised by no means to adopt any of them till experience has convinced him that they may be used without error, or injury to legibility. All abbreviating rules are suited to those only who have made some progress in the stenographic art; for although they certainly promote expedition in a wonderful manner, and afford the greatest ease to a proficient, yet a learner, as expedition is not his first, though his ultimate view, should admit of nothing that in the least renders the reading difficult.

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[1] The value of stenography is not unknown to the learned; and the care and success with which it has been lately cultivated in these kingdoms will, in all probability, soon render it an object of general attention. No one, however, appears to us to have simplified and improved the art so much as Dr Mavor, author of *Universal Stenography*.

[2] Mr Locke says, a regular method of short writing seems to be known and practised only in Britain. This is not now the case; and indeed there is no reason to doubt whether characters may not be invented to express the various sounds or letters employed in any language, either ancient or modern.

[3] Mr Byrom rejected vowels entirely in the middle of words, as others before him had only done partially. Without critically examining the executive part of his performance, which is very defective, it must be owned that it is above the reach of human ingenuity to exceed his general plan, which for ever must be the basis of every future rational system.

II. The English alphabet consists of twenty-six letters; six of which are vowels, *a*, *e*, *i*, *o*, *u*, and *y*; and the other twenty consonants, *b*, *c*, *d*, *f*, *g*, *h*, *j*, *k*, *l*, *m*, *n*, *p*, *q*, *r*, *s*, *t*, *v*, *w*, *x*, and *z*. This alphabet, as is observed by the best grammarians that have written on the language, is both defective and redundant in expressing the various modifications of sound.[1] Custom or prejudice has assigned some letters a place, when others would with much more propriety express the same sound; and to this may be added, that several letters, sometimes in one word, seem to be admitted for no other reason than to perplex a young beginner or a foreigner, as an obstruction to true pronunciation, and to add to the apparent length of the word, when they are entirely quiescent and useless. That this is the genius of the orthography of our language, must be perceived by the most superficial observer; but no modern tongue is absolutely free from the same exceptions. In particular, the French has a great number of dormant letters, which, it is obvious, render the pronunciation more difficult and perplexing to learners. In this respect, the Latin and Greek claim a just superiority over the modern tongues. In them no confusion or doubt can arise from the manner of spelling; and the reader can scarcely be wrong, unless in quantity, in sounding all the letters that he sees.

But as it is neither our business nor our intention to propose a mode of spelling different from that in common use, when applied to printing or long-hand writing (since several innovators in orthography have fallen into contempt, and their plans have been only preserved as beacons to warn others of the folly of endeavouring to subvert established principles[2]), we shall only observe, that in stenography, where the most expeditious and concise method is the best, if consistent with perspicuity, the following simple rules are studiously to be regarded and practised.

1. All quiescent consonants in words are to be dropped, and the orthography to be directed only by the pronunciation; which being known to all, will render this art attainable by those who cannot spell with precision in long-hand.

2. When the absence of consonants, not entirely dormant, can be easily known, they may often be omitted without the least obscurity.

3. Two or sometimes more consonants may, to promote greater expedition, be exchanged for a single one of nearly similar sound; and no ambiguity as to the meaning ensue.[3]

4. When two consonants of the same kind or same sound come together, without any vowel between them, only one is to be expressed; but if a vowel or vowels intervene, both are to be written: only observe, if they are perpendicular, horizontal, or oblique lines, they must only be drawn a size longer than usual; and characters with loops must have the size of their heads doubled.

First rule exemplified.

Might is to be written *mit*, fight *fit*, machine *mashin*, enough, *enuf*, laugh *laf*, prophet *profet*, physics *fisiks*, through *thro'*, foreign *foren*, sovereign *soveren*, psalm *sam*, receipt *reset*, write *rite*, wright *rit*, island *iland*, knavery *navery*, temptation *temtation*, knife *nife*, stick *stik*, thigh *thi*, honour *onour*, indictment *inditement*, acquaint *aquaint*, chaos *kaos*, &c.

Second rule exemplified.

Strength *strenth*, length *lenth*, friendship *frenship*, connect *conek*, commandment *comanment*, conjunct *conjunt*, humble *humle*, lumber *lumer*, slumber *slumer*, number *numer*, exemplary *exemlary*, &c.

Third rule exemplified.

Rocks *rox*, acts *aks* or *ax*, facts *faks* or *fax*, districts *distriks* or *distrix*, affects *afeks* or *afex*, afflicts *afliks* or *aflix*, conquer *konkr*, &c.

Fourth rule exemplified.

Letter *leter*, little *litle*, command *comand*, error *eror*, terror *teror*, &c. But in *remember*, *moment*, *sister*, and such like words, where two consonants of the same name have an intervening vowel, both of them must be written.

These four rules, with their examples, being carefully considered by the learner, will leave him in no doubt concerning the disposition and management of the consonants in this scheme of short writing; we shall therefore proceed to lay down rules for the application of the vowels with ease and expedition.

Rules for the vowels.

1. Vowels, being only simple articulate sounds, though they are the connectives of consonants, and employed in every word and every syllable, are not necessary to be inserted in the middle of words; because the consonants, if fully pronounced, with the assistance of connection, will always discover the meaning of a word, and make the writing perfectly legible.

2. If a vowel is not strongly accented in the incipient syllable of a word, or if it is mute in the final, it is likewise to be omitted; because the sound of the incipient vowel is often implied in that of the first consonant, which will consequently supply its place.

3. But if the vowel constitutes the first or last syllable of a word, or is strongly accented at its beginning or end, that vowel is continually to be written.

4. If a word begins or ends with two or more vowels though separated, or when there is a coalition of vowels, as in diphthongs and triphthongs, only one of them is to be expressed, which must be that which agrees best with the pronunciation.

5. In monosyllables, if they begin or end with a vowel, it is always to be inserted, unless the vowel be *e* mute at the end of a word.

Such are the general principles of this art; in vindication and support of which it will be needless to offer any arguments, when it is considered that brevity and expedition are the chief objects, if consistent with legibility; and the subsequent specimens in the orthography recommended will, we hope, be sufficient to show that there is no real deficiency in the last-mentioned particular.

Specimen of the mode of spelling in stenography.

He who md us mst be etrnl, grt, nd mnptnt. It is or dty, as rsnl bngs, to srv, lv, nd oby hm.—A mn tht wd avd blm, shd be srkmspk in al hs axns, nd ndvr wth al hs mt to pls evry bdy.—I wd nt frm any knxns wth a mn who hd no rgrd fr hmslf; nthr wd I blv a mn who hd ons tld me a li.—Onr is of al thngs thre mst dfklt to prsrv ntrnshd; nd whn ons mpchd, lk the chstty of a wmn, nvr shns wth its wntd lstr.—Wth gd mnrs, kmplsns, nd an esy plt adrs, mny mk a fgr in the wrl, whs mnl ablts wd skrsly hv rsd thm abv the rnk of a ftmn.—Idlns is the prnt of a thsnd msfrtns, wch ar nvr flt by the ndstrs: it is a pn nd a pnshmnt of itslf, and brngs wnt nd bgry in its trn.—Vrtu is the frst thng tht shd be rgrdd; it is a rwrd of itslf; mks a man rspktbl hr, nd wl mk hm etrnly hpy hrftr.—Prd is a mst prnss psn, wch yt ws plntd by hvn in ur ntr, to rs ur emlsn to imtt grt nd wrthy krktrs or axns, to xt in us a sl fr wht is rt nd gst, and a ldbl ndgnsn gnst oprsrs nd wrkrs of ny knd of nkyty; in shrt, to mk us st a prpr vlu upn urslvs, nd dsps a wrthls flo, hu evr xltd. Ths fr prd is a vrtu, nd my gstly be kld a grtns of sl. Bt prd, lk othr psns, gnrly fxs upn rng obgks, or is apld in rng prprsns. Hu kmn is it to se a rtch whm evry vs hs rndrd msrbl, nd evry fly kntmbl, vlng hmslf on hs hi brth, nd bstng ths ilstrs nsstrs, of whm he nhrts nthng bt the nm or ttl! nsstrs who, if thy nu hm, wd dsn thr dsndnt wth kntmt. But al prd of ths srt is fly, nd evr to be avdd.

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[1] Lowth's Grammar. Priestley's Grammar. Sheridan's Lectures on Elocution.

[2] Preface to Johnson's Dictionary.

[3] By this rule likewise *q* and *v* in the middle of words, but never in the beginning, may be exchanged for *k* and *f*, when they admit of an easier connecting with the following character, or will make the writing appear neater

III. As the whole of this art depends upon a regular method and a simple alphabet, we have not only endeavoured to establish the former on satisfactory principles, but have been careful to appropriate, according to the comparative frequency of their occurrence, such characters for the letters as, after repeated trials and alterations, were conceived to be the best adapted for despatch.

Stenographic alphabet.

The stenographic alphabet consists of eighteen distinct characters (viz. two for the vowels and the rest for the consonants), taken from lines and semicircular curves; the formation and application of which we shall now explain, beginning with the vowels.

For the three first vowels, *a*, *e*, and *i*, a comma is appropriated in different positions; and for the other three, *o*, *u*, and *y*, a point. The comma and point, when applied to *a*, and *o*, are to be placed at the top of the next character; when for *e* and *u*, opposite to the middle; and when for *i* and *y*, at the bottom.

This arrangement of the vowels is the most simple and distinct that can easily be imagined. Places at the top, the middle, and the bottom of characters, which make three different positions, are as easily distinguished from one another as any three separate characters could be; and a comma is made with the same facility as a point.

Lines.

Simple lines may be drawn four different ways; perpendicular, horizontal, and with an angle of about forty-five degrees to the right and left. An ascending oblique line to the right, which will be perfectly distinct from the rest when joined to any other character, may likewise be admitted. These characters being the simplest in nature, are assigned to those five consonants which most frequently occur, viz. *l*, *r*, *t*, *c* hard or *k*, and *c* soft or *s*.

Circles.

Every circle may be divided with a perpendicular and horizontal line, so as to form likewise four distinct characters. These being the next to lines in the simplicity of their formation, we have appropriated them for *b*, *d*, *n*, and *m*.

Curves and Lines.

The characters expressing nine of the consonants are all perfectly distinct from one another; eight only remain which are needful, viz. *f*, *g* or *j*, *h*, *p*, *q*, *v*, *w*, and *x*; to find characters for which we must have recourse to mixed curves and lines. The characters which we have adopted are the simplest in nature after those already applied, admit of the easiest joining, and tend to preserve lineality and beauty in the writing.

It must be observed, that we have no character for *c* when it has a hard sound, as in *castle*; or soft, as in *city*; for it naturally takes the sound of *k* or *s*, which in all cases will be sufficient to supply its place.

R likewise is represented by the same character as *l*; only with this difference, *r* is written with an ascending stroke,[1] and *l* with a descending; which is always to be known from the manner of its union with the following character; but in a few monosyllables where *r* is the only consonant in the word, and consequently stands alone, it is to be made as is shown in the alphabet, for distinction's sake.

Z, as it is a letter seldom employed in the English language, and only a coarser and harder expression of *s*, must be supplied by *s* whenever it occurs; as for *Zedekiah* write *Sedekiah*, &c.

IV. The prepositions and terminations in this scheme are so simple, that the greatest benefit may be reaped from them, and very little trouble required to attain them; as the incipient letter or the incipient consonant of all the prepositions and of several of the terminations is used to express the whole. But in order to give every assistance, we have subjoined the following directions.

1. The preposition is always to be written without joining, yet so near as plainly to show what word it belongs to; and the best way is to observe the same order as if the whole was to be connected.

2. A preposition, though the same letters that constitute it may be met with in the middle or end of a word, is never to be used, because it would expose to obscurity.

3. Observe that the preposition *omni* is expressed by the vowel *o* in its proper position; and for *anti*, *anta*, *ante*, by the vowel *a*, which the radical part of the word will easily distinguish from being only simple vowels.

The first rule for the prepositions is to be observed for the terminations; and also the second, *mutatis mutandis;* except that whenever *sis*, *sus*, *sys*, *cious*, *tious*, and *ces* occur, they are to be expressed as directed in the fourth rule for the consonants, whether in the beginning, middle, or end of words.

4. The terminative character for *tion*, *sion*, *cion*, *cian*, *tian*, is to be expressed by a small circle joined to the nearest letter, and turned to the right; and the plurals *tions*, *cions*, *cians*, *tians*, by a dot on the same side.

5. The terminative character for *ing* is to be expressed likewise by a small circle, but drawn to the left hand; and its plural *ings* by a dot.[2]

6. The plural sign *s* is to be added to the terminative characters when necessary.

7. The separated terminations are never to be used but in polysyllables, or words of more syllables than one.

These rules duly observed will point out a method as concise and elegant as can be desired, for expressing the most frequent and longest prepositions and terminations in the English language. If it should be thought necessary to increase their number by the addition of others, it will be an easy matter for any one of the least discernment to do so, by proceeding on the principles before laid down.

V. Though a more concise method of writing, or more numerous abbreviations, may not be indispensably necessary, if the foregoing directions be practised for a considerable time, yet contractions will be found extremely useful and convenient to those who have attained a proper knowledge of the subject, and will lead to a greater degree of expedition, at the same time that they diminish the labour of writing. It has been observed in the introduction, that abbreviations are only to be employed by proficients in this art; because expedition is not the first, though the ultimate, object in view; and that an easy legibility is of the utmost consequence to the learner; which however cannot be preserved, if he adopts too soon those very rules which in time will afford him the greatest ease when applied with judgment.

The following short and practical rules will be found, we hope, fully adequate to every purpose for which they were intended, and are far superior in the facility of their application to any which we have seen.

1. The usual abbreviations in long-hand are always to

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[1] The character for *h*, when lineality requires it, may be made from the bottom and inverted. And often *h* may be omitted entirely, or a vowel may be substituted in its stead, without any injury to legibility, it being rather a breathing than a letter.

[2] In horizontal characters, by the left hand is meant the top, and by the right the space below the letter. In all other characters the right and left positions will naturally be known.

be followed; as Mr for Master, M. D. for Doctor of Physic, and Abp. for Archbishop, &c.

2. Substantives, adjectives, verbs, and participles are to be expressed by their initial consonant with distinguishing marks, viz. a substantive must have a dot exactly over its initial consonant; an adjective must have a dot under it; a verb is to be expressed by a comma over its initial consonant; and a participle by a comma under.[1] These, being the four principal parts of speech, will be sufficient; and an adept will never be at a loss to know when he can with safety apply this rule to them.

3. To render the writing more legible, the last letter of the word may be joined to the first, and the proper mark applied.

4. The constituent or radical part of words, especially if they are long, will often serve for the whole or sometimes the first syllable: as we ought to moderate our *ex.* by our *circum.;* a man's *man.* commonly shape his *for.*

5. All long words without exception may have their prepositions or terminations expressed by the incipient consonant of such preposition or termination.

6. When there is a great dependence between the parts of a sentence, the initial letter will often suffice; as *L.* is the capital of Great *B.;* the eldest *S.* of the king of Great *B.* is styled prince of *W.* Every one, it is presumed, will allow this to be perfectly legible in long-hand; then why may it not in stenography?

7. The terminations *ness* and *less* may be omitted; as *faithfulness* is only to be written *faithful; forwardness, forward; heedless, heed; stubbornness, stubborn,* &c.

8. The second and third persons of verbs, ending in *eth* and *est,* may be expressed by *s;* as, he *loves,* thou *teaches;* instead of he *loveth,* thou *teachest:* or even without *s;* as, he *love,* &c.

9. Words may often be entirely omitted, and yet no ambiguity ensue; as, *In beginning God created heaven and earth,* for In *the* beginning God created *the* heaven and *the* earth.

10. When there is an immediate repetition of a sentence or word, a line is to be drawn under the sentence or word to be repeated; as, Amen, Amen, is to be written *Amen;* but if any words intervene before a word or sentence is to be repeated, the line must be drawn as before, and a ∧ or mark of omission placed where the repetition should begin; as, *Is it just the innocent should be* condemned ∧ reviled?

STENTOROPHONIC Tube, a speaking trumpet; thus called from Stentor, a person mentioned by Homer.

STEP, in a ship, a block of wood fixed on the decks or bottom of a ship, and having a hole in its upper side, fitted to receive the heel of a mast or capstern. The steps of the main and fore masts of every ship rest upon the kelson, to which they are firmly secured by knees, bolts, or spike-nails. The step of the mizen-mast usually rests upon the lower deck.

STEPHANO, St, a city of the province of Mazzara, in the island of Sicily. It stands on the sea-shore, in a situation rather unhealthy, on the declivity of Mount Quisquina, and at the distance of forty-eight miles from Palermo. It contains about 6000 inhabitants.

STEPHANOPHORUS, in *Antiquity,* the chief priest of Pallas, who presided over the rest. It was usual for every god to have a chief priest; that of Pallas was the Stephanophorus, and that of Hercules was called Dadouchus. Stephanophorus was also a priest who assisted the women in the celebration of the festival Thesmophoria.

STEPHANUS Byzantinus, a learned grammarian, who flourished about the close of the fifth century. He wrote a large work, in which he made a great number of observations, borrowed from mythology and history, which showed the origin of cities and colonies; of which we have little remaining but an abridgement by Hermolaus the grammarian. Even in this state, it has been found a work of no inconsiderable value. It is alphabetically arranged, and bears the inscription Περὶ Πόλεων, or "Concerning Cities." The first edition was printed by Aldus, Venet. 1502, fol. This was followed by an edition printed by the heirs of P. Junta, Florent. 1521, fol. The text received many emendations in the edition of Xylander, Basil. 1568, fol. All these editions contain the Greek text, without any Latin version. An edition, with a translation, and copious annotations, was published by Thomas de Pinedo, Amst. 1678, fol. Another edition, with a translation and a commentary, was prepared by Berkelius, and after his death was completed by J. Gronovius, Lugd. Bat. 1688, fol. Nor must we here omit the posthumous "Notæ et Castigationes" of Holstenius, Lugd. Bat. 1684, fol.

Stephanus.

Stephanus, *Henry,* the founder of a most remarkable and meritorious family of printers, was born at Paris in the year 1470. The French name is Estienne, which is frequently transformed into the English *Stephens,* although the correct translation would be *Stephen.* He began the business of a printer about the year 1503. This is the date of Boethius's treatise on arithmetic, the first book that is known to have issued from his press. A great proportion of the books which he published were Latin. They are printed in the Roman letter, and are not inelegant, though some of them abound rather too much in contractions. He died about the year 1520, and left behind him three sons, Francis, Robert, and Charles. His widow married Simeon de Colines (*Colinæus* in Latin), who thus got possession of Henry's printing-office, and continued the business till his death.

Of Francis, the eldest son, little more is known than that he carried on business along with Colinæus, and that he died at Paris in 1550.

Robert Stephanus, the second son, was born at Paris in 1503. In his youth he made great proficiency in the Latin, Greek, and Hebrew languages, and at the age of nineteen had acquired so much knowledge that his step-father intrusted him with the management of his press. He soon afterwards began business himself, and married Perrete, the daughter of Jodocus Badius, a printer and an author. She was a woman of learning, and understood Latin, which indeed was the necessary consequence of her situation. Her husband always entertained a number of learned men as correctors of the press. Being foreigners, and of different nations, they made use of no other language but Latin; which Perrete being accustomed to hear, was able in a short time not only to understand, but even to speak with tolerable ease.

In 1531 he published his "Thesaurus Linguæ Latinæ;" a work of great labour, and of great value. The device which he exhibited in all his books was a tree branched, with a man looking upon it, and these words *Noli altum sapere,* to which he sometimes added *sed time.* In 1539, Francis I. made him his printer, and ordered a new set of elegant types to be founded for him. His frequent editions of the New Testament gave great offence to the doctors of the Sorbonne, who accused him of heresy for his annotations, and insisted upon the suppression of some of his books. Although Henry, the French king, in some measure protected him, the persecution of these divines rendered him so unhappy, not to mention the expense and loss of time which an almost constant attendance at court unavoidably occasioned, that in 1552 he abandoned his country and settled at Geneva. Here he embraced the Protestant religion, and thus justified in some measure the suspicions of his theological enemies. It has been affirmed by several writers that he carried along with him the royal types, and the moulds in which they were cast; but it is certain that he never afterwards made use of those types. Besides, is it possible that the author of so daring a theft could have been not only protected in Geneva, but even courted and honoured by the most eminent men of the age? Is it credible that such a crime could have been concealed for sixty years; or that Henry, the son and heir of the perpetrator, would have enjoyed the favour of the French king, if Robert Stephanus had acted such a shameful part? If he was burnt in effigy at Paris, it was not for theft, but for having renounced the popish faith. After his arrival at Geneva, he published an account of the dispute between him and the Paris divines, which does as much honour to his abilities as his *Thesaurus* does to his learning. He died in 1559, after a life of the most extraordinary industry. The books of which he was the editor were not fewer than 360. Many of them were ancient classics in different languages. Several were accompanied with annotations which he collected, and all of them were corrected by the collation of manuscripts. He was so anxious to obtain perfect accuracy, that he used to expose his proofs in public, and reward those who discovered a mistake. His books consequently were very correct. It is said that his New Testament, called *O Mirificam* (because the preface begins with these words), has not a single fault. It was Robert Stephanus who first divided the New Testament into verses, during a journey between Paris and Lyon. The advantages of this improvement are fully counterbalanced by its defects. It has destroyed the unity of the books, and induced many commentators to consider every verse as a distinct and independent aphorism. By his last will his estate was left exclusively to such of his children as should settle at Geneva. He left behind him three sons, Henry, Robert, and Francis.

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[1] The dot or comma being placed thus will never occasion them to be mistaken for vowels, because they should always be on one side or other; whereas the mark for parts of speech may constantly be placed exactly over or under.

Charles Stephanus, the third son of Henry, was, like the rest of his family, familiarly acquainted with the learned languages. This recommended him to Lazarus de Baif, who made him tutor to his son, and in 1540 carried him along with him to Germany. He studied medicine, and took his doctor's degree at Paris. He did not however forsake the profession of his family, but exercised it at Paris, where he became the editor of many books remarkable for neatness and elegance. He wrote above thirty treatises on different subjects, particularly on botany, anatomy, and history. Having been unsuccessful in business, he was imprisoned for debt in the Chatelet in 1561, and died there in 1564.

Robert Stephanus, the son of Robert the first of that name, did not accompany his father to Geneva, but continued to profess the Romish religion, and to reside at Paris. His letter was remarkably beautiful. He was made king's printer, and died about 1589. His brother Francis, who was also a printer, embraced the Protestant religion, and resided at Geneva.

Henry Stephanus, the eldest brother, was born at Paris in 1528. He became the most learned and most celebrated of all his family. From a very early age he gave proofs of uncommon abilities, and displayed an ardent passion for knowledge. The Medea of Euripides, which he saw acted while at school, first kindled his love for poetry, and inspired him with the desire of acquiring the language in which that tragedy is written. He entreated his father not to condemn him to study Latin, which he already understood from conversation, but to initiate him at once in the knowledge of Greek. His father willingly acceded to his request; and Henry applied with such vigour, that in a short time he could repeat the Medea by heart. He afterwards studied Greek under Danesius, who was tutor to the Dauphin, and finally heard the lectures of Tusanus and Turnebus. At an early age he became eager to understand astrology, and accordingly attended a professor of that mysterious art; but he was not long in discovering its absurdity. At the age of nineteen he began his travels, which he undertook in order to examine foreign libraries, and to become acquainted with learned men. He spent two years in Italy, and returned into France completely master of Italian, and bringing along with him copies of several scarce authors, particularly a part of Anacreon, which previously was supposed to be lost. He found his father publishing an edition of the New Testament, to which he prefixed some Greek verses. Soon after, he visited England and the Netherlands, where he met with John Clement, an Englishman, to whom he was indebted for the remaining odes of Anacreon. During this journey he learned the Spanish language, which was very much spoken at that time in the Low Countries.

Whether Henry accompanied his father to Geneva, is uncertain: if he did, he must have returned immediately to France, for we find him soon after established at Paris, and publishing the odes of Anacreon. In 1554 he went to Rome, and thence to Naples. This journey was undertaken at the request, and in the service, of the French government. He was discovered, and would have been arrested as a spy, had he not by his address and skill in the language of the country been able to pass himself for a native of Italy. On his return to France, he assumed the title of printer to Ulric Fugger, a very rich and learned German nobleman, who allowed him a considerable pension.

In 1560 he married a relation, as is generally supposed, of Henry Scrimger, a Scotish scholar and civilian, with whom he was intimately acquainted. She was a woman, as he himself informs us, endowed with the noblest spirit and the most amiable disposition. Her death, which happened in 1586, brought on a disease that had twice attacked him before. It was a disgust at all those pursuits which had formerly charmed him, an aversion to reading and the sight of books. It was probably occasioned by too constant and severe an application to literary pursuits. In 1572 he published, in four vols. folio, his *Thesaurus Linguæ Græcæ*, one of the greatest works, perhaps, that ever was executed by one man, if we consider the wretched materials which more ancient dictionaries could furnish, the size and perfection of the work, and the immense labour and learning which must have been employed in the compilation. In 1573, he added *Glossaria duo, e situ vetustatis eruta*. This work had been carried on at a greater expense than he could well bear. He expected to be reimbursed by the sale of the book, but he was unfortunately disappointed. Scapula, one of his own correctors, extracted from it whatever he thought would be most serviceable to students, and published it beforehand in quarto. By this act of treachery Henry was reduced to poverty.

About this time he was much beloved by Henry III. of France, who treated him so kindly, and made him such flattering promises, that he resided frequently at court. But these promises were never fulfilled, owing to the civil wars which soon after distracted France, and the unfortunate death of Henry himself. During the remainder of his life, his situation was very unsettled. We find him sometimes at Paris, sometimes at Geneva, in Germany, and even in Hungary. He died at Lyon in 1598, at the age of seventy. His temper during the latter part of his life is represented as haughty and severe, owing probably to his disappointments. He was twice married, and by his first wife had a son and two daughters, one of whom was married to the learned Isaac Casaubon.

This most erudite printer was fond of poetry from his very infancy. It was his practice to compose verses on horseback, and even to write them, though he generally rode a very mettlesome steed. His Thesaurus was his great work, but he was also the author of many other treatises in the French and Latin languages. His poems are numerous. His "Apologie pour Herodote" is a very singular performance. It has been illustrated by the annotations of Duchat. The number of books which he published, though fewer than his father, was great, and they were superior in elegance to any thing which the world had then seen. A great proportion of them were Greek. He was the editor, however, of many Latin and even of some oriental writings. His Greek classics are remarkably correct; and many of his editions are accompanied by most learned notes. His Thesaurus still maintains an unrivalled reputation. An edition, with very ample additions, was recently published by Barker and Valpy; and another elaborate edition is now in progress at Paris.

Paul Stephanus, the son of Henry, continued his father's profession at Geneva. He was a man of learning, executed translations of several books, and published a considerable number of the ancient classics; but his editions possess little of his father's elegance. He died in 1627, at the age of sixty, after selling his types to one Chouet, a printer. His son Antony, the last printer of the family, abandoned the Protestant religion, and returned to France, the country of his ancestors. He received letters of naturalization in 1612, and was made printer to the king; but managing his affairs ill, he was reduced to poverty, and obliged to retire into an hospital, where he died in 1674, miserable and blind, at the age of eighty.[1]

Stephen's Island, in Torres Strait, north of Darnley's Island. Long. 143. E. Lat. 9. 0. S.

Stephen's Islands, two small islands in the Eastern Seas, the one about three miles long, and the other about six. The passage between them is three miles broad. Long. 138. 39. E. Lat. 0. 22. S.

STEPNEY, a parish of the county of Middlesex, in the hundred of Ossulton, adjoining to London, and forming one of the suburbs, or rather a part of the metropolis. It was very extensive, and comprehended the districts on the side of the Thames, and extending till it united with Hackney, but has been divided into the distinct parishes of Stratford, Whitechapel, Limehouse, Wapping, Shadwell, Ratcliff Highway, Spitalfields, and Bethnal Green. It is commonly said by seamen, that all children born at sea are parishioners of Stepney, and that all the colonies of England are part and parcel of this parish, so as to make it the largest in the world. The population of the present division, containing four hamlets, Mile End Old Town, Mile End New Town, Poplar with Blackwall, and Ratcliff, amounted in 1801 to 25,260, in 1811 to 37,199, in 1821 to 49,163, and in 1831 to 67,872.

STERCORARIANS, or Stercoranistæ, formed from *stercus*, "dung," a name which those of the Romish church anciently gave to such as held that the host was liable to digestion, and all its consequences, like other food.

STEREOGRAPHIC Projection, is the projection of the circles of the sphere on the plane of some one great circle, the eye being placed in the pole of that circle.

STEREOMETER, an instrument invented in France for measuring the volume of a body, however irregular, without plunging it in any liquid.

STEREOMETRY, Στερεομετρια, formed of στερεος, *solid*, and μετρον, *measure*, that part of geometry which teaches how to measure solid bodies, *i. e.* to find the solidity or solid contents of bodies; as globes, cylinders, cubes, vessels, ships, &c.

STEREOTOMY, formed from στερεος, and τομη, *section*, the art or act of cutting solids, or making sections thereof; as walls and other membranes in the profiles of architecture.

STEREOTYPE Printing, a method of printing, which was introduced into this country by William Ged of Edinburgh, before the middle of the eighteenth century. See Printing.

STERLING, an epithet by which genuine English money is distinguished. It is unnecessary to mention the various conjectures of antiquaries about the origin and meaning of this appellation. The most probable opinion seems to be this, that some artists from Germany, who were called *Esterlings*, from the situation of their country, had been employed in fabricating our money, which consisted chiefly of silver pennies; and that from them the penny was called an *esterling*, and our money *esterling* or *sterling* money.

STERN, the posterior part of a ship. The stern is terminated above by the taffarel, and below by the counters; it is limited on the sides by the quarter-pieces, and the intermediate space comprehends the galleries and windows of the different cabins.

Stern-Fast, a rope used to confine the stern of a ship or boat to any wharf or jetty head, &c.

Stern-Most, in sea language, usually denotes that part of a fleet of ships which is in the rear, or farthest a-stern, as opposed to headmost.

Stern-Post, a long straight piece of timber erected on the extremity of the keel, to sustain the rudder and terminate the ship behind.

Stern-Sheets, that part of a boat which is contained between the stern and the aftmost or hindmost seat of the rowers. It is generally furnished with benches to accommodate the passengers.

STERNE, Laurence, an eccentric writer of fiction, has left behind him a sketch of the principal events of his life, and some particulars of his family history. From that outline it appears that he was born at Clonmell, in the south of Ireland, on the 24th November 1713. His father was a lieutenant in the army, and grandson of Dr Richard Sterne, archbishop of York. When his son was about eight years of age, Lieutenant Sterne placed him at a school in Halifax, to which town he had been conducted by his professional duties. That officer died in 1731, and in the following year, young Sterne, by the bounty of a relation and namesake of his own, was transferred from the school of Halifax to Jesus College, Cambridge.

Having completed his studies at the university, he proceeded to York; and his uncle, Dr Jacques Sterne, prebendary of Durham, and canon residentiary and precentor of York, procured him the living of Sutton, and afterwards a prebend at York. At York he formed an acquaintance with the lady who afterwards became his wife, under circumstances sufficiently romantic. From a friend of hers he obtained the living of Stillington, but continued for twenty years to reside at Sutton, relieving the burden of his double charge, as he informs us, "by books, painting, fiddling, and shooting." In the library of Shelton Castle, the residence of his friend and relation, John Hall Stevenson, author of a licentious production, entitled Crazy Tales, Sterne found among the dross of antiquity many a brilliant gem, which he transferred without scruple to his own pages. In this stolen garb he cut a most imposing figure, until Dr Ferriar of Manchester, twenty years after the death of the celebrated plagiary, restored the pilfered trappings to the rightful owners.[2]

In 1759, Sterne produced the first two volumes of Tristram Shandy, which procured him both money and reputation. In these volumes there was abundance of matter which every one could relish; and what was unintelligible was thought profound. Much ingenious speculation was squandered upon the black leaves and marbled pages, which were long contemplated with wonder, before they were discovered to mean nothing. "The republic of dark authors," says Swift, "have been peculiarly happy in the variety, as well as extent, of their reputation."

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[1] Almeloveen de Vitis Stephanorum. Amst. 1683, 8vo. Maittaire, Historia Stephanorum. Lond. 1709, 8vo. Biographie Universelle, tom. xiii. p. 386.

[2] See Dr Ferriar's Illustrations of Sterne. Lond. 1798, 8vo.

Before this period, Sterne had only printed two sermons. The two volumes of Tristram Shandy were succeeded by two volumes of Sermons. In 1761 appeared the third and fourth volumes of the novel, and the fifth and sixth in the year following. The seventh and eighth volumes were published in 1765; but these monstrous births had by that time ceased to please. Four volumes of Sermons were produced in 1766; and in 1767, these were followed by the ninth and last volume of Tristram Shandy. In 1768 Sterne returned from Italy, whither he had repaired in the hopes of finding relief for a consumptive complaint with which he had long been afflicted. He only survived to prepare for the press the first part of his Sentimental Journey, which was published in 1768. In the month of March of that year he expired at his lodgings in Bond Street, surrounded by strangers; a mode of death which he considered as most desirable.

The English writer to whom the author of Tristram Shandy is most indebted for his matter is Burton; and his manner bears some resemblance to the capricious, whimsical, and digressive Tale of a Tub. He even mimics Swift in sneering at "the great Dryden;" but in the writings of his prototype he might have found many things infinitely more worthy of imitation. In order to make room for his pathos, however, he eschewed the misanthropy of the dean of St Patrick's, and set up for a lover of his species, to which character his claims were less than equivocal, for his philanthropy did not extend so far as to his own mother. That sensibility is worthy only of ridicule that bestows a tear with greater promptitude than a shilling. For the irony of Swift, Sterne substituted buffoonery, which, in conformity with the opinion of Aristotle, the dean regarded as the less liberal species of pleasantry But the strongest objection to much of the satire in Tristram Shandy is, that the author threw away his ridicule upon pedantry that had become altogether obsolete.

It would be harsh justice to conclude, that the beauties of Sterne's writings are drawn from some yet undiscovered source, because he is known to have had confused notions on the subject of literary honesty, and to tear the laurel from his brows, because some of its leaves are purloined from the tombs of the dead. "Every man's wit," he says, "must come from every man's own soul, and no other body's." That he had much wit of his own, there is reason as well as charity in supposing, although his propensity to make free with the wit of others may justify some suspicion on the subject, upon the principle that a rich man, who retains the use of his reason, is seldom guilty of theft. And it cannot be denied, that the world would be indebted to the writer who could produce such another tissue of reproductions, if such it is, as "The Life and Opinions of Tristram Shandy, Gent."

STERNOMANTIS, in *Antiquity*, a designation given to the Delphian priestess, more usually called PYTHIA. Sternomantis is also used for any one that had a prophesying demon within him.

STERNUTATIVE, or STERNUTATORY, a medicine proper to produce sneezing.

STETTIN, one of the governments into which the Prussian province of Pomerania is divided. It extends over 4895 square miles, comprises forty cities and market-towns, and 1510 villages. It is divided into eleven circles. The inhabitants amounted in 1817 to 327,002, and in 1831 to 432,570; the whole of them adhering to the Lutheran church, with the exception of about 3000 Catholics and 1500 Jews. It has been formed out of the whole of the former province of Pomerania and the western part of Hither Pomerania. The capital is the city of the same name, situated on the left bank of the river Oder, from which it has a gradual ascent. It is a well-built city, but some of its streets are steep. It is strongly fortified, has a citadel, and a fine place of arms, and storehouses for munitions of war. From its position near the mouth of such a river, it has facilities for carrying on a very extensive commerce. The productions of foreign countries are conveyed from it to the cities of Kustrin, Frankfurt, Breslau, and even to Cracow; and it is the best shipping port for the productions of the districts which surround those cities. The larger classes of vessels cannot ascend to Stettin, but are loaded or discharged by means of barges at the port of Swinemunde, near the discharge of the Fresh Haff into the Baltic. It contains a fine old royal palace, a Gothic cathedral with two lofty towers, a gymnasium, to which belong an astronomical observatory, a library, and museums. It has considerable manufactories of linen and woollen goods, tobacco and snuff, several sugar refineries, tanneries, soap-boilers' works, and extensive breweries and distilleries. Many vessels are built at Stettin, and more than 200 are owned by the merchants of the city. About 800 ships yearly enter and clear out. The city, with the suburbs, contains 32,191 inhabitants, and the markets are well and cheaply supplied. Long. 14. 50. 25. E. Lat. 52. 25. 36. N.

STEVENAGE, a town of the hundred of Broadwater, in the county of Hertford, thirty-one miles from London. It formerly belonged to the abbot of Westminster. The church, which stands on a hill, is an ancient building, with a large square tower. There is a free grammar-school, and an endowed alms-house. This town has a market on Wednesday. The inhabitants amounted in 1801 to 1254, in 1811 to 1302, in 1821 to 1664, and in 1831 to 1859.

STEWARD (*senescallus*, compounded of the Saxon *steda*, *i. e.* "room" or "stead," and *weard*, "a ward" or "keeper"), an officer appointed in another's stead or place, and always taken for a principal officer within his jurisdiction. Of these there are various kinds. The greatest officer under the crown is the lord high steward of England, whose office was anciently the inheritance of the earls of Leicester, till forfeited by Simon de Montfort to King Henry III. But the power of this officer is so very great, that it has not been judged safe to trust it any longer in the hands of a subject, excepting only for a particular occasion; as to officiate at a coronation, or at the arraignment of a nobleman for high treason or felony. During his office, the steward bears a white staff in his hand; and when the trial is ended, he breaks the staff, and with it his commission expires. There is likewise a lord steward of the king's household, who is the chief officer of the king's court, has the care of the king's house, and authority over all the officers and servants of the household, except such as belong to the chapel, chamber, and stable.

The court of the lord high steward of Great Britain, is a court instituted for the trial of peers indicted for treason or felony, or for misprision of either. When such an indictment is found by a grand jury of freeholders in the king's bench, or at the assizes before the justices of *oyer* and *terminer*, it is to be removed by a writ of *certiorari* into the court of the lord high steward, which has the only power to determine it. A peer may plead a pardon before the court of king's bench, and the judges have power to allow it, in order to prevent the trouble of appointing a high steward merely for the purpose of receiving such plea; but he may not plead in that inferior court any other plea, as guilty or not guilty of the indictment, but only in this court;

because, in consequence of such plea, it is possible that judgment of death might be awarded against him. The king, therefore, in case a peer be indicted of treason, felony, or misprision, creates a lord high steward *pro hac vice* by commission under the great seal; which recites the indictment so found, and gives his Grace power to receive and try it *secundum legem et consuetudinem Angliæ.* During the session of parliament the trial of an indicted peer is not properly in the court of the lord high steward, but before the court of our lord the king in parliament. It is true, a lord high steward is always appointed in that case, to regulate and add weight to the proceedings; but he is rather in the nature of a speaker *pro tempore*, or chairman of the court, than the judge of it; for here the collective body of the peers are the judges both of law and fact, and the high steward has a vote with the rest in right of his peerage. But in the court of the lord high steward, which is held in the recess of parliament, he is the sole judge of matters of law, as the lords triors are in matters of fact; and as they may not interfere with him in regulating the proceedings of the court, so he has no right to intermix with them in giving any vote upon the trial. In the conviction and attainder of a peer for murder in full parliament, it has therefore been held by the judges, that in case the day appointed in the judgment for execution should lapse before execution done, a new time of execution may be appointed by either the high court of parliament during its sitting, though no high steward be existing, or, in the recess of parliament, by the court of king's bench, the record being removed into that court.

STEWART, Matthew, D.D., an eminent mathematician, was in 1717 born at Rothsay in the Isle of Bute, of which parish his father was minister. Being intended for the church, he passed through the usual course of a grammar-school education, and was in 1734 received as a student into the university of Glasgow. There he had the happiness of having for his preceptors in moral science and mathematics the celebrated professors Hutcheson and Simson, by the latter of whom he was instructed in what may not improperly be called the *arcana* of the ancient geometry.

His views making it necessary for him to remove to Edinburgh, he was introduced by Dr Simson to Mr Maclaurin, that his mathematical studies might suffer no interruption; and he attended the lectures of that great master with such advantage as might be expected from eminent abilities, directed by the judgment of him who made the philosophy and geometry of Newton intelligible to ordinary capacities. From his intimacy with Simson he had however acquired such a predilection for the ancient geometry, as the modern analysis, however powerfully recommended, could not lessen; and he kept up a regular correspondence with his old master, giving him an account of his progress and his discoveries in geometry, and receiving in return many curious communications respecting the *Loci Plani*, and the porisms of Euclid.

While the second invention of porisms, to which more genius was perhaps required than to the first discovery of them, employed Dr Simson, his pupil pursued the same subject in a different and new direction. In doing so, he was led to the discovery of those curious and interesting propositions which were published under the title of *General Theorems* in 1746. They were given without the demonstrations, but did not fail to place their discoverer at once among the geometers of the first rank. They are for the most part porisms, though Mr Stewart, careful not to anticipate the discoveries of his friend, gave them no other name than that of theorems.

Before this period he had entered the church, and through the patronage of the Duke of Argyle and the Earl of Bute he obtained the living of Roseneath, a retired country parish in the west of Scotland; but in 1747 he was elected to the mathematical chair in the University of Edinburgh, which had become vacant the year before by the death of Mr Maclaurin. The duties of this office gave a turn somewhat different to his pursuits, and led him to think of the most simple and elegant means of explaining those difficult propositions which were hitherto only accessible to men deeply versed in the modern analysis. In doing this, he was pursuing the object which of all others he most ardently wished to attain, namely, the application of geometry to such problems as the algebraic calculus alone had been thought able to resolve. His solution of Kepler's problem was the first specimen of this kind which he gave to the world; and it was impossible to have produced one more to the credit of the method which he followed, or of the abilities with which he applied it. On this problem the utmost resources of the integral calculus had been employed. But though many excellent solutions had been given, there was none of them at once direct in its method and simple in its principles. Mr Stewart was so happy as to attain both these objects; and his solution appeared in the second volume of the Essays of the Philosophical Society of Edinburgh for the year 1756. In the first volume of the same collection there are some other propositions of Mr Stewart's, which are an extension of a curious theorem in the fourth book of Pappus. They have a relation to the subject of porisms, and one of them forms the ninety-first of Dr Simson's Restoration. They are besides very beautiful propositions, and are demonstrated with all the elegance and simplicity of the ancient analysis.

The prosecution of the plan which he had formed of introducing into the higher parts of mixed mathematics the strict and simple form of ancient demonstration, produced the Tracts Physical and Mathematical, which were published in 1761, and the Essay on the Sun's Distance, which was published in 1763. In this last work it is acknowledged that he employed geometry on a task which geometry cannot perform; but while it is granted that this determination of the sun's distance is by no means free from error, we may venture to affirm that it contains a great deal which will always interest geometers, and will always be admired by them. Few errors in science are redeemed by the display of so much ingenuity, and, what is more singular, of so much sound reasoning. The investigation is everywhere elegant, and will probably be long regarded as a specimen of the most arduous inquiry which has been attempted by mere geometry.

The Sun's Distance was the last work which Dr Stewart published; and though he lived to see several animadversions on it made public, he declined entering into any controversy. His disposition was far from polemical; and he knew the value of that quiet which a literary man should rarely suffer his antagonists to interrupt. He used to say, that the decision of the point in question was now before the public; that if his investigation was right it would never be overturned, and that if it was wrong it ought not to be defended. A few months before he published the essay just mentioned, he gave to the world another work, entitled *Propositiones Geometricæ more Veterum demonstratæ.* This title, it is said, was given to it by Dr Simson, who rejoiced in the publication of a work so well calculated to promote the study of the ancient geometry. It consists of a series of geometrical theorems, for the most part new; investigated first by an analysis, and afterwards synthetically demonstrated by the inversion of the same analysis. Dr Stewart's constant use of the geometrical analysis had put him in possession of many valuable propositions which did not enter into the plan of any of the works that have been enumerated. Of these not a few have found a place in the writings of Dr Simson, where they will for ever remain to mark the friendship of these two mathematicians, and to evince the esteem which Simson entertained for the abilities of his pupil.

Soon after the publication of the Sun's Distance, Dr

Stewart, Dugald.

Stewart's health began to decline, and the duties of his office became burdensome to him. In the year 1772 he retired to a small demesne which he possessed in Ayrshire, where he afterwards spent the greater part of his life, and never resumed his labours in the university. But though mathematics had now ceased to be his business, they continued to be his amusement till a very few years before his death, which happened on the 23d of January 1785, at the age of sixty-eight.

The habits of study, in a man of original genius, are objects of curiosity, and deserve to be remembered. Concerning those of Dr Stewart, his writings have made it necessary to remark, that from his youth he had been accustomed to the most intense and continued application. In consequence of this application, added to the natural vigour of his mind, he retained the memory of his discoveries in a manner that will hardly be believed. He rarely wrote down any of his investigations till it became necessary to do so for the purpose of publication. When he discovered any proposition, he would put down the enunciation with great accuracy, and on the same piece of paper would construct very neatly the figure to which it referred. To these he trusted for recalling to his mind at any future period the demonstration or the analysis, however complicated it might be. Experience had taught him that he might place this confidence in himself without any danger of disappointment; and for this singular power he was probably more indebted to the activity of his invention than the mere tenaciousness of his memory. Though he was extremely studious, he read few books, and verified the observations of M. d'Alembert, that of all men of letters, mathematicians read least of the writings of one another. His own investigations occupied him sufficiently; and indeed the world would have had reason to regret the misapplication of his talents, had he employed in the mere acquisition of knowledge that time which he could dedicate to works of invention.

Stewart, *Dugald*, the illustrious son of the eminent mathematician whose merits are recorded in the preceding article, was born at Edinburgh on the 22d of November 1753. As a pupil in the High School of his native city, he was remarkable for the command of language exhibited in his exercises; and at college his turn for mental science began unequivocally to develop itself. In his nineteenth year he attended at Glasgow a course of lectures delivered by Dr Reid, of whose doctrines he was destined to be the most distinguished amender and expounder. In the course of that winter he composed, and read in a literary association, an essay on Dreaming, which afterwards took its place as an interesting section in his principal work.

But his youthful talents and acquirements were speedily subjected to a much more decisive test. Soon after the period of his studies in Glasgow, he assumed, on the decline of his father's health, the sole charge of his classes in the university of Edinburgh, and on the completion of his twenty-first year was appointed to the mathematical professorship, as assistant and successor. His popularity as a teacher in this department was remarkable; but when he was just twenty-five years old, an opportunity was fortunately afforded him of proving his qualifications for communicating knowledge in his favourite branch of philosophy. Dr Ferguson, the professor of moral philosophy, having gone to America on a public mission, Mr Stewart undertook to fill his place during the session of 1778–9: he entered on the duties of the situation within a week after having promised to discharge them; and for six months, besides teaching his two mathematical classes and a new class of astronomy, he delivered a course of lectures on ethics, thinking over every morning the subject of lecture for the day, and addressed his pupils without having written the discourse or made any further preparation. Those who then heard him considered his extemporaneous lectures as possessing an energy and liveliness even exceeding that which distinguished his later addresses. He was soon transferred permanently to the post which he thus had temporarily filled; Dr Ferguson retiring in 1785, and Mr Stewart, then thirty-two years old, being appointed to the chair of moral philosophy in his room. While his fame as a lecturer rapidly spread all over Great Britain, he long abstained from communicating his speculations to the world in any more durable form. His earliest published work, the first volume of his Elements of the Philosophy of the Human Mind, did not appear till 1792. In 1793 he published his Outlines of Moral Philosophy, an unpretending text-book, but which exhibits his powers of generalization in the most favourable point of view. During several subsequent years his only publications were, the life of Dr Smith in 1793, that of Dr Robertson in 1796, and that of Dr Reid in 1802. These lives appeared in the Transactions of the Royal Society of Edinburgh. But, in the mean time, among his pupils he numbered many of those young men whose talents have since illustrated the northern division of the island; and, without naming those who have shone in political or professional life, it is enough to say that his Elements and his Lectures were the spark that first kindled the metaphysical genius of his own successor. As early likewise as 1780, before his first marriage, he had begun to receive into his family a few private pupils of rank; and some years after his second marriage in 1790, he again opened his house for the same purpose, and superintended the education of several who have occupied a prominent place as British statesmen. His ready command over his own mind was shown, not only by the ease with which he discharged the duties involved in these various avocations, but by his adding to his former course of instruction, in 1800, a series of lectures on Political Economy, which however were not continued. Nor is it unimportant to add, that on several occasions when his colleagues were incapacitated from acting, he temporarily gave lectures on natural philosophy, logic, and rhetoric.

In the winter of 1808–9, Mr Stewart, still in the zenith of his fame, but suffering under ill health, and dejected by the recent loss of his younger son, found himself obliged for a time to discharge the duties of his chair by deputy. In the following session his indisposition was more prolonged; and, strongly attached to private study, and sensitively alive to his reputation as a public teacher, he resolved to retire altogether from active life. In May 1810, Dr Thomas Brown, his late assistant, was in consequence conjoined with him as the acting professor.

After his retirement he lived constantly, as he had formerly done occasionally, at Kinneill House, situated on the Firth of Forth, about twenty miles west from Edinburgh. In this retreat he finished his volume of Philosophical Essays, which was published in 1810, and attained very extensive popularity. The second volume of his Elements of the Philosophy of the Human Mind appeared in 1813; and in the end of 1815 that Dissertation on the Progress of Metaphysical and Ethical Philosophy, which, originally written for the Supplement to this Encyclopædia, has now its place as the opening treatise of the present edition. He published nothing further between that time and the year 1822, when he suffered a severe stroke of palsy. But his mind was unshaken and untouched; and his compositions after this time were as vigorous in every respect as those which had preceded. The third volume of the Elements was published in 1827; and in 1828, a few weeks only before his death, his view of the Active and Moral Powers of Man was given to the world, in two volumes octavo. On the 11th of June 1828, he died at Edinburgh, in the seventy-fifth year of his age, and was buried in the Canongate churchyard. A monument to his memory, erected by his friends and admirers, and successfully imitated from one of the most beautiful structures of Athens, forms a prominent object on the Calton Hill.[1] (B. L.)

STEWART'S *Islands*, a cluster of small, low islands, in the South Pacific Ocean, discovered by Captain Hunter in 1791. They are five in number. Long. 163. 18. E. Lat. 8. 26. S.

STEYER, a city of Austria, in the province of the Upper Ens, the capital of the circle of Traun. It stands at the junction of the two rivers Steyer and Traun, which, when united, flow into the Danube. It is a place of great industry, and contains various manufactories. There are some of cotton and of linen goods; but the chief occupation is that of preparing cutlery and arms of various kinds, the latter chiefly for the imperial armies. The other necessaries for the equipment of armies are also extensively fabricated. The city contains 10,640 inhabitants, having of late years greatly increased. Long. 14. 14. 45. E. Lat. 48. 4. 45. N.

STEYERMARK, or STEIERMARK, one of the provinces of the Austrian empire. Its name is derived from an ancient palace at the junction of the Steyer with the Ens, which in the twelfth century was inhabited by a Count Trungau, who was ruler over a part of Carinthia, then an independent duchy. It extends in north latitude from 45° 54′ to 47° 50′, and in east longitude from 13° 26′ to 16° 19″, being an extent of 8600 square miles. It comprehends twenty cities, ninety-six market-towns, and 3540 villages, with a population, according to the last census, of 869,000 persons, all adhering to the Catholic church, with the exception of four Lutheran congregations and a few Jews. It is bounded on the north by the province of Lower Ens, on the east by Hungary, on the south by the Illyrian province of Laybach, and on the west by that province and the Upper Ens. The northern and western divisions of the province are covered with the lofty mountains of the Julian Alps, divided into two branches. These mountains in no case reach the line of perpetual snow, the highest of them, called the Grossenberg, being but 8380 feet, and the others from 3250 to 7600 feet. The southern and eastern parts of the province are less elevated, consisting of plains and undulating hills. The mountains give rise to numerous rivulets, which form within it large rivers, all of which terminate in the Danube. The principal of these are the Mur, the Drave, the Ens, and the Raab. There are no extensive lakes, but many of small extent, and some of them in very elevated situations. It abounds in mineral springs, both warm and cold, and containing various combinations of iron, salt, and sulphur; but they are not much repaired to by invalids. One half of the province is covered with woods, which yield fuel and timber for building, and contain abundance of game both of the larger and smaller kind. Of the former kind are roebucks, wild swine, gemsen, and bears, as well as beasts of prey, especially wolves and lynxes. The land in the valleys is fertile and well cultivated, and produces good corn, a great proportion of which is maize, forming the chief food of the labouring classes. More than 60,000 acres are cultivated with vines, which produce tolerable wine. Hemp and flax are sufficiently raised to provide clothing, with the aid of the wool of about 150,000 sheep. The mineral productions are various. Salt is the most considerable in quantity. Iron is produced, and is converted into utensils for internal use, but not for exportation. Silver is raised to the extent of about 60,000 ounces yearly, and likewise some copper, cobalt, alum, vitriol, and sulphur. The commerce is not extensive, except between the upper and lower parts of the province, though some is carried on both with other parts of Germany and with Austrian Italy. One of the great roads to Lombardy passes through this province. It still retains some privileges respecting the assembling of the states, but they are of little practical efficacy. The capital is Gratz, a city of 40,000 inhabitants.

STEYNING, a town of the hundred of that name, in the rape of Bramber and county of Sussex, fifty-one miles from London. It is ill built, but has a curious church, of Norman architecture, and was the burial-place of some of the Saxon kings. It returned two members to the House of Commons, but was disfranchised by the act of 1832. It has a market on Wednesday, and several fairs at which great numbers of sheep are sold. The inhabitants amounted in 1801 to 1174, in 1811 to 1210, in 1821 to 1324, and in 1831 to 1436.

STIBADIUM, among the Romans, a low kind of table, couch, or bed, of a circular form, which succeeded to the triclinia, and was of different sizes according to the number of guests for which it was designed. Tables of this kind were called *hexaclina*, *octaclina*, or *enneaclina*, according as they held six, eight, or nine guests, and so of any other number.

STICCATO (*Ital.*), a rude musical instrument, formed of a number of sticks of hard wood of different lengths, generally attached to each other by strings at the ends, but so as to hang separate from one another when suspended by the top. It is played upon by striking the sticks with rods of cane or whalebone tipped with ivory balls. Mersenne, in his *Harmonia Universalis*, calls this instrument *ligneum psalterium*.

STICHOS, a name given by the old writers to a pectoral confection, the principal ingredient of which was the herb *marrubium* or horehound.

STIGMATA, in *Natural History*, the apertures in different parts of the bodies of insects, communicating with the tracheæ or air-vessels, and serving for the office of respiration.

STIGMATA, in *Antiquity*, certain marks impressed on the left shoulder of the soldiers when listed.

STIGMATA were also a kind of notes or abbreviations, consisting only of points disposed various ways; as in triangles, squares, crosses, &c.

STIGMATA is likewise a term used among the Franciscans, to express the marks or prints of our Saviour's wounds, said to have been miraculously impressed by him on the body of their seraphic father St Francis.

STIGMATIZING, among the ancients, was inflicted upon slaves as a punishment, but more frequently as a mark to distinguish them: in which case it was done by applying a red-hot iron marked with certain letters to their foreheads, till a fair impression was made; and then pouring ink into their furrows, that the inscription might be the more conspicuous. It was customary to stigmatize the worshippers and votaries of some of the gods. The marks used on these occasions were various; sometimes they contained the name of the god, sometimes his particular ensign, as the thunderbolt of Jupiter, the trident of Neptune, the ivy of Bacchus; or they marked themselves with some mystical number, by which the god's name was described. To these three ways of stigmatizing St John is supposed to refer (Rev. chap. xiii. ver. 16, 17). Theodoret is of opinion that the Jews were forbidden to brand themselves with stigmata, because the idolaters, by that ceremony, used to consecrate themselves to their false gods. Among some nations, stigmatizing was considered as a distinguishing mark of honour and nobility. In Thrace, as Herodotus informs us, it was practised by none but persons of credit, nor omitted by any but persons of the meanest rank. The ancient Britons are also said to have

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[1] The Editor had hoped to have the gratification of introducing into this work, so deeply indebted to this great and good man, a more detailed account of his life and writings; but circumstances induced him to abandon the design, and to give a place only to the above brief notice contributed by one of his literary assistants.

Stillingfleet.

imprinted on the bodies of their infants the figures of animals, and other marks, with hot irons.

STILLINGFLEET, Edward, bishop of Worcester, was the son of Samuel Stillingfleet, gentleman, and was born at Cranborn in Dorsetshire in 1635. He was educated at St John's College, Cambridge; and having received holy orders, was, in 1657, presented to the rectory of Sutton in Nottinghamshire. By publishing his *Origines Sacræ*, one of the ablest defences of revealed religion that has ever been written, he soon acquired such reputation, that he was appointed preacher of the Rolls Chapel; and in January 1665 was presented to the rectory of St Andrews, Holborn. He was afterwards chosen lecturer at the Temple, and appointed chaplain in ordinary to King Charles II. In 1668 he took the degree of D.D.; and was soon after engaged in a dispute with those of the Romish religion, by publishing his discourse concerning the idolatry and fanaticism of the church of Rome, which discourse he afterwards defended against several antagonists. In 1680 he preached at Guildhall chapel a sermon on Phil. iii. 26, which he published under the title of "The Mischief of Separation;" and this being immediately attacked by several writers, he in 1683 published his Unreasonableness of Separation. In 1685 appeared his *Origines Britannicæ*, or the Antiquities of the British Churches, in folio. During the reign of King James II. he wrote several tracts against popery, and was prolocutor of the convocation, as he had likewise been under Charles II. After the revolution he was advanced to the bishopric of Worcester, and was engaged in a dispute with the Socinians, and also with Mr Locke; in which last contest he is generally thought to have been unsuccessful. He died at Westminster in 1699, and was interred in the cathedral of Worcester, where a monument was erected to his memory by his son. Dr Stillingfleet wrote other works besides those here mentioned, which, with the above, have been reprinted in 6 vols. folio.

Stillingfleet, *Benjamin*, an ingenious naturalist, born in 1702, was the bishop's grandson. His father, Edward Stillingfleet, M.D., was fellow of St John's College, Cambridge, and Gresham professor of physic: but marrying in 1692, he lost his lucrative offices and his father's favour; a misfortune that affected both himself and his posterity. Having however entered the church, he obtained, by his father's means, the living of Newington-Butts, which he immediately exchanged for those of Wood-Norton and Swanton in Norfolk. He died in 1708. Benjamin, his only son, was educated at Norwich school, which he left in 1720, with the character of an excellent scholar. He then went to Trinity College in Cambridge, at the request of Dr Bentley, the master, who had been private tutor to his father, domestic chaplain to his grandfather, and much indebted to the family. Here he was a candidate for a fellowship, but was rejected by the master's influence. This was a severe and unexpected disappointment, and but little alleviated afterwards by Bentley's apology, that it was a pity that a gentleman of Mr Stillingfleet's parts should be buried within the walls of a college.

Perhaps, however, this ingratitude of Dr Bentley was not of any real disservice to Mr Stillingfleet. By being thrown into the world, he formed many honourable and valuable connections. He dedicated some translations of Linnæus to the late Lord Lyttelton, partly, he says, from motives of private respect and honour. Lord Barrington gave him, in a very polite manner, the place of master of the barracks at Kensington; a favour to which Mr Stillingfleet, in the dedication of his Calendar of Flora to that nobleman, alludes with the greatest politeness, as well as the warmest gratitude. His Calendar of Flora was formed at Stratton in Norfolk in the year 1755, at the hospitable seat of his very worthy and ingenious friend Mr Marsham, who had made several observations of that kind, and had communicated to the public his curious observations on the growth of trees. But it was to Mr Wyndham of Felbrig in Norfolk that he appears to have had the greatest obligation: he travelled abroad with him, spent much of his time at his house, and was appointed one of his executors (Mr Garrick being another), with a considerable addition to an annuity which that gentleman had settled upon him in his lifetime.

Mr Stillingfleet's genius seems, if we may judge from his works, to have led him principally to the study of natural history; which he prosecuted as an ingenious philosopher, an useful citizen, and a good man. In this walk of learning he mentions as his friends, Dr Watson, Dr Solander, Mr Hudson, Mr Price of Foxley, and some others; to whom may be added the ingenious Mr Pennant. Nor can we omit the flattering mention which Mr Gray makes of him in one of his letters, dated from London in 1761: "I have lately made an acquaintance with this philosopher, who lives in a garret here in the winter, that he may support some near relations who depend upon him. He is always employed, consequently (according to my old maxim) always happy, always cheerful, and seems to me a very worthy, honest man. His present scheme is to send some persons, properly qualified, to reside a year or two in Attica, to make themselves acquainted with the climate, productions, and natural history of the country, that we may understand Aristotle, Theophrastus, &c. who have been heathen Greek to us for so many ages; and this he has got proposed to Lord Bute, no unlikely person to put it in execution, as he is himself a botanist."

Mr Stillingfleet published a volume of Miscellaneous Tracts, which is in much esteem, and does great honour to his head and heart. They are chiefly translations of some essays in the *Amœnitates Academicæ*, published by Linnæus, interspersed with some observations and additions of his own. In this volume he shows also a taste for classical learning, and entertains us with some elegant poetical effusions of his own. But his Essay on Conversation, published in the first volume of Dodsley's Collection of Poems, entitles him to a respectable station among our English poets. This poem is addressed to Mr Wyndham, with all that warmth of friendship which distinguishes Mr Stillingfleet. As it is chiefly didactic, it does not admit of so many ornaments as some compositions of other kinds. However, it contains much good sense, shows a considerable knowledge of mankind, and has several passages that, in point of harmony and easy versification, would not disgrace the writings of our most admired poets. Here more than once Mr Stillingfleet shows himself still sore for Dr Bentley's cruel treatment of him; and towards the beautiful and moral close of it, where it is supposed he gives us a sketch of himself, seems to hint at a mortification of a more delicate nature, which he is said to have suffered from the other sex. To these disappointments it was perhaps owing that Mr Stillingfleet neither married nor went into orders. His London residence was in lodgings in Piccadilly, where he died in 1771, at the age of sixty-nine, leaving several valuable papers behind him. He was buried in St James's church, without the slightest monument to his memory.

STILPO, a celebrated philosopher of Megara, flourished under the reign of Ptolemy Euergetes. In his youth he had been addicted to licentious pleasures, from which he religiously refrained from the moment when he ranked himself among philosophers. When Ptolemy Soter, at the taking of Megara, offered him a large sum of money, and requested that he would accompany him into Egypt, he accepted but a small part of the offer, and retired to the island of Ægina, whence, on Ptolemy's departure, he returned to Megara. That city being again taken by Demetrius the son of Antigonus, and the philosopher required to give an account of any effects which he had lost during the hurry of the plunder, he replied that he had lost nothing;

for no one could take from him his learning and eloquence. So great was the fame of Stilpo, that the most eminent philosophers of Athens took pleasure in attending upon his discourses. His peculiar doctrines were, that species or universals have no real existence, and that one thing cannot be predicated of another. With respect to the former of these opinions, he seems to have taught the same doctrine with the sect afterwards known by the appellation of *Nominalists.* To prove that one thing cannot be predicated of another, he said, that *goodness* and *man*, for instance, are different things, which cannot be confounded by asserting the one to be the other. He argued further, that goodness is a universal, and universals have no real existence; consequently, since nothing cannot be predicated of any thing, goodness cannot be predicated of man. Thus, while the subtile logician was, through his whole argument, predicating one thing of another, he denied that any one thing could be the accident or predicate of another. If Stilpo was serious in this reasoning, if he meant any thing more than to expose the sophistry of the schools, he must be confessed to have been an eminent master of the art of wrangling; and it was not wholly without reason that Glycera, a celebrated courtezan, when she was reproved by him as a corrupter of youth, replied, that the charge might be justly retorted upon himself, who spent his time in filling their heads with sophistical quibbles and useless subtleties. In ethics he seems to have been a Stoic, and in religion he had a public and a private doctrine, the former for the multitude, and the latter for his friends. He admitted the existence of a Supreme Divinity, but had no reverence for the Grecian superstitions.

STILOBATUM, in *Architecture*, denotes the body of the pedestal of any column.

STILTON, a town of the hundred of Normancross, in the county of Huntingdon, seventy-four miles from London. It stands on the great north road, and has many good inns, with post-horses. It has long been celebrated for the excellence of its cheese. The inhabitants amounted in 1801 to 509, in 1811 to 663, in 1821 to 710, and in 1831 to 793.

STIMULANTS, in *Medicine*, substances which increase the action of certain parts of the body. In particular, they quicken the motion of the blood, increase the action of the muscular fibres, and affect the nervous system.

STING, an apparatus in the bodies of certain insects, in the form of a little spear, serving them as a weapon of offence.

STIPULATION, in the civil law, the act of stipulating, that is, of treating and concluding terms and conditions to be inserted in a contract. Stipulations were anciently performed at Rome, with abundance of ceremonies; the first of which was, that one party should interrogate, and the other answer, to give his consent, and oblige himself. By the ancient Roman law, nobody could stipulate but for himself; but as the tabelliones were public servants, they were allowed to stipulate for their masters; and the notaries succeeding the tabelliones, have inherited the same privilege.

STIRLING, one of the most ancient towns in Scotland, and capital of the county of the same name, is situated in 3° 45′ west longitude, and 56° 6′ north latitude, in a plain called the Carse, watered by the river Forth, and on the sloping ridge of a rock, at the western and precipitous extremity of which the castle is built. The town is very irregular, the street upon the crest of the hill being broad and spacious, but the other streets narrow and inconvenient. Within the last few years great improvements have been undertaken. The pavement of the streets, which was of the worst description, has been rendered equal to that of almost any other place in the kingdom; and the opening of the town at its lower extremity is affording scope for the most marked improvements. Many elegant houses and fine shops have been erected. In the suburbs there are many handsome villas; in Southfield, Melville Terrace, Allan Park, Wellington Place, and Dunbarton Road. Stirling is a most convenient place for the residence of people of small but easy fortune. House-rents are low; and ground for gardens may be procured upon easy terms. There are no local public burdens of any kind; the streets being lighted and cleaned, and water brought to the town, at the expense of the corporation. The situation of Stirling is very convenient in other respects. The steam-boats supply an easy and cheap conveyance to and from Edinburgh; and many coaches pass through the town in different directions. "In point of extent, variety, and magnificence, the view from Stirling Castle is perhaps unequalled by any other in Britain."[1]

Stirling.

The public buildings are the two parish churches, both in the Gothic style, with a modern erection between them, which adds nothing to their beauty: they are called the East and West Churches. The former is a fine building, erected in the year 1494. In the two churches there are three clergymen, and in one of the United Secession churches two. The town council has the patronage of the churches, and two of the ministers are entirely supported by the corporation. It also bears the whole expenses of the jail for the counties of Stirling, Clackmannan, and Kinross, except a part of the jailer's salary, paid by the counties. Besides two chapels belonging to the United Associate Synod, there is an Old Light church, the minister of which, and a majority of the congregation, have within a few weeks joined the established church. There are likewise an Episcopal and a Roman Catholic chapel, the latter a neat building, erected within the last two years; a Cameronian, a Congregational, and several Baptist places of worship. The town-house, with a spire, in which there is a set of music-bells, which play a tune before the striking of each hour, and the jail behind, which is very insecure, form two sides of a quadrangle, the third side of which is finely fitted up as a court-room, in which the circuit court sits twice a year, and also frequently the sheriff court. The fourth side of the quadrangle is private property, which is very inconvenient. In the town-house are still kept the pint jug, the ancient legal standard for liquid measure in Scotland, and two silver keys, representative of the keys of the two ancient gates of the town; and in the circuit court-room about a dozen of the fine ancient carvings known by the name of the Stirling heads. In the narrow lane leading to the castle, there is a military hospital. The building was once the property of the Argyle family, and is still called Argyle House. Near it, and close beside the two churches, is situated a ruin, called Mar's Work. It is an unfinished house, begun, but never completed, by the regent Mar. The Athenæum is a handsome house in King Street, with a spire 120 feet high. In the ground-floor there are shops, but the two upper stories contain, the first a public reading-room, to which respectable strangers have access at all times, and the second a subscription library, containing about 5000 volumes. Close beside the Athenæum is the corn-market, for the accommodation of which a splendid hall has been erected within the last twelvemonths. There are three public school-houses in the town. The parish school has four departments, viz. a grammar-school, a mathematical, and two English schools. In addition to their fees, the teachers have each a salary of fifty pounds from the town council; and the master of the grammar-school has twenty pounds more for an assistant. Education is cheap and good. In the town there are four charitable endowments, commonly called hospitals, in full operation, two for the support of the aged poor, and two for educating the young. One of the former has an income approaching to L.3000 annually, wholly arising from land; but when public burdens are paid, with necessary repairs, there remains scarcely one half for the support of the poor, who receive from 8s. to 1s. 6d. per week, according to circumstances. Two of the others have incomes of about L.700 each, derived in the same way, and bearing the same burdens. The fourth has the interest of L.4000. The two latter educate, clothe, and allow 2s. 6d. a week to between forty and fifty boys. The funds of the whole of these are distributed to parties designated by the founders; all having their operation according to the old constitution of the borough. They are, like every thing else in the town, under the patronage and management of the town council, with the addition in one case of the first, and in another of the second, minister. In addition to these, the late Mr John Maclaren of Liverpool, a native of Stirling, has bequeathed a sum, the amount of which is not yet fully known, for the purpose of founding and endowing schools upon a most liberal scale, for the instruction, not wholly gratuitous, but at a very low rate, of children from four to sixteen years of age. A clause in his will provides that no clergyman shall have any control or management of his fund. One of the above charities had an hospital built for the accommodation of twelve decayed members of the incorporation of guildry, but nobody could be persuaded to inhabit it, although pleasantly situated. The consequence was, that the funds accumulated, until what was originally L.2222 sterling, has now increased to about L.3000 yearly. As in these circumstances the intentions of John Cowane, the founder, could not be carried into effect, the town council and the first minister, who are the governors, have for a long period been in the habit, and latterly with the consent of the Court of Session, of dividing the funds among the poor belonging to the incorporation, so that now upwards of 180 persons are deriving benefit to the amount of from 8s. to 1s 6d. a week, from a fund which was intended for the support of only twelve. The hospital stands near the East and West Churches, ornamented with a small spire and a statue of Cowane; and its hall is now used for the meetings of the guildry. The other charity had also an hospital, which is still standing, without however being the property of the charity; and the funds are divided in a similar manner among the poor of the seven incorporated trades. They are all at present in a thriving condition. Besides the above charities, the general poor of the town are supported by the kirk-session, the various churches to which they belong, and by a voluntary subscription denominated the poor-scheme; the people preferring this mode to a regular assessment, of which they have a salutary dread. There is also a public dispensary, which affords relief to many. Notwithstanding all these provisions, public mendicancy is exceedingly common; nor do the authorities, from false notions of humanity, exert themselves to put a stop to this practice, so degrading to the poor, and annoying to the public.

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[1] M'Culloch's Statistical Account of the British Empire, vol. i. p. 299.

The literature of the place is sustained by two reading-rooms, one of which belongs to artisans. The public library, already noticed, is under excellent management, excepting that the entry-money and annual payment are both too high; it has about 140 subscribers. The School of Arts, or Mechanics Institution, generally supports a course of lectures in the winter season, attended by from 200 to 300 males and females. It possesses also a chemical and electrical apparatus, and various other philosophical instruments, and something like the foundation of a museum. To the care of this institution, a gentleman in Manchester, a native of Stirling, has committed a number of fine casts, principally from the antique, which form a small but interesting gallery of statuary. It is daily open for the inspection of the public. This society has also an excellent library, consisting of upwards of 1000 volumes, which are very much read. The price of admittance to all the benefits of the institution is only four shillings a year. All that is wanting to render it a most useful institution, is a house to contain its literary wealth. In almost every one of the churches and chapels there is also a congregational library, chiefly consisting of theological, although some admit historical works. Besides those of a general nature, there is also a consulting library for the legal profession, a medical, and likewise a horticultural library. There is likewise a singular kind of library, of which Stirling is the centre. It circulates among the landed gentlemen chiefly in the neighbourhood, and the subscription is at least two guineas a year. The funds are expended upon publications of the current year, at the end of which they are sold, and the proceeds are added to the stated contributions. This town has two weekly newspapers, the Stirling Journal and the Stirling Observer, the former Tory, and the latter Whig, both having an average provincial circulation.

The chief article of domestic trade in Stirling, situated as it is in a large and fertile district, now under the best culture, is grain of all kinds, amounting, it is said, to the value of upwards of L.500,000 annually, there being a great deal of barley consumed in the distilleries and breweries, which are numerous and upon extensive scales around Stirling. The manufactures are chiefly tartans, carpets, plaid-shawls, trouser-stuffs, and wool-spinning, which is beginning to be conducted with spirit in the town. Stirling shalloons, which figured so long in the statistics of the town, have now wholly disappeared, and their place is supplied by the articles enumerated above. Coach-building seems also to thrive here, as one establishment employs nearly seventy people, that of Mr Kinross, who within the last twelvemonth has been honoured with the distinction of coach-maker to the queen for Scotland. There are other two establishments, one of which has been lately commenced. To facilitate commercial and manufacturing industry, there are four stationary banks, and one which does business only on one day in each week, namely, on Friday, the market-day. They are all branches of banking establishments in Edinburgh or Glasgow. The commerce of the town is very limited, consisting chiefly of timber, grain for the distilleries, and a few other articles of little importance. There is a line of packets between Stirling and Leith, and another conveyance for goods by steam twice a week. But until the river be deepened, little improvement can be expected in this respect, as vessels above seventy tons burden cannot reach the town even at spring tide. The town council of Stirling is rather an important body, having the management of considerable funds; for, besides the sum already mentioned belonging to the charities, the town's finances, arising from salmon-fisheries, customs, shore-dues, &c., amount to between L.3000 and L.4000; all of which revenue is expended for the benefit of the public, in paving the streets, building and repairing the public markets, and other purposes, as has been already mentioned.

The castle, at the western extremity of the eminence upon which the town is built, is of greater antiquity than the town, and still exhibits marks of royal magnificence. Here James II. was born; and here also with his own hand he stabbed William earl of Douglas. The hall built by James III., who resided much here, for the meeting of parliament, is now used as barracks. The chapel royal, built by James VI. (who was educated here under the tuition of the celebrated George Buchanan) for the baptism of his son Prince Henry, and which was at that time the scene of one of the most pompous ceremonies ever exhibited in Scotland, is now fitted up as a store-room and armoury. The palace of James V. is a large quadrangular building, ornamented externally with many grotesque figures, and enclosing a small court called the lion's den. The lower story is now converted into barracks, with a canteen or sutlery; and the upper flat into apartments for the officers. In one of the apartments, called the king's room, the roof was covered with rich carvings in oak, which have been engraved and described in a work published in 1817, under the appellation of *Lucunar Strevelinense.* The quaint appellation of James V. *the gudeman of Ballingeich*, was derived from a hollow place immediately on the outside of the castle. Besides the places already noticed, the castle contains a large space, also surrounded by the exterior wall, in which magazines are built, called the Nether Baillery. The defences are the French, the Seven-Gun, and Queen Anne's Batteries, with several pieces of ordnance here and there, amounting in all to twenty-six. On the south side of the castle is a piece of flat ground called the Valley, which was appropriated for tournaments. It is now used as a horse-market. There is an adjoining rock called the Ladies Hill, whence they viewed the sports below. From the castle not fewer than twelve battle-fields are seen. In 1831 the population of Stirling was 8556.

STIRLINGSHIRE, a county in Scotland, partly maritime, being situated at the upper extremity of the Firth of Forth, and lying between 52° 30′ and 56° 17′ north latitude, and between 3° 35′ and 4° 40′ west longitude, upon the isthmus between the Forth and Clyde. It is bounded on the north by the counties of Perth and Clackmannan, on the east by the Firth of Forth and Linlithgowshire, on the south chiefly by Dunbartonshire; but at both the east and west extremities it is bounded for a few miles by Lanarkshire, and on the south-west and west by Dunbarton. Its length, upon the average of three measurements, is forty-two and a half miles; and its breadth, upon the average of six measurements, thirteen and a half, although in one parallel it extends to eighteen miles; and it contains 502 square miles, or 321,280 acres, divided into twenty-two entire parishes, with portions of other four which partly belong to the adjoining counties. The river and Firth of Forth is, for the most part, the boundary on the north, though parts of two parishes are on the north side of that river; on the west it includes part of Lochlomond, and a narrow neck extends to the north-west, the east side of which touches Loch Katrine. Like many other of the Scottish counties, it is of a very irregular form; yet most of its outline is well defined. Besides the Forth on the north and north-east, the Avon marks its separation from Linlithgowshire on the east and north-east, the Kelvin flows along a great part of the southern boundary, and the Endrick, before entering Lochlomond, divides it for some extent from Dunbartonshire on the west.

About two thirds of Stirlingshire consist of hills unfit for cultivation, but affording good pasturage for sheep, being chiefly covered with green herbage, though sometimes intermixed with heath. The principal chain of this description, called the Lennox Hills, but having other distinctive names, as Campsie Fells, Fintry Hills, runs across the county, from Dunbartonshire on the west, nearly to the town of Stirling on the north, but it seldom presents an elevation of more than 1500 feet. In other quarters, however, the elevation is greater; Benlomond, on the north-west, on the banks of Lochlomond, being 3191 feet high; and Bencleuch, in the parish of Alva, on the north side of the Forth, upwards of 2400 feet. On the north, and still more on the east of the Lennox Hills, the country is low; the summit-level of the Forth and Clyde Canal, which passes through the south-eastern side, being only about 162 feet above the sea; and much of the land along the Forth is a very rich plain, only a few feet higher than the water. Towards the western and southern extremities the surface is more varied, presenting tracts of heath, moss, and green pastures, intermixed with cultivated land; the latter confined, for the most part, to the banks of the streams.

Stirlingshire. Soil. Stirlingshire has every variety of soil common in Scotland; but that for which it is chiefly distinguished is the alluvial or *carse* land on the Forth, which is computed to extend to about 40,000 English acres within this county, and twice as much more in the adjoining counties of Perth, Clackmannan, and Linlithgow, or in all to about 187 square miles; certainly by far the richest tract in Scotland. It consists of the finest particles of earth, without stones; in point of friability approaching to the character of loam; in some places 30 feet deep, and seldom more than 25 feet above the level of the sea at high water; and contains beds of shells, moss, and clay marl. In one instance, at the depth of 19 feet, there have been found in a stratum of moss the roots of large trees, deers horns, and bones, while the superior strata were composed entirely of fine earth. In another instance, the skeleton of a whale, now in the museum of the university of Edinburgh, covered with four feet of soil, was found in a field, the surface of which is 18 feet above the present average level of the Forth, from which it was a mile distant.

Minerals. Coal, limestone, ironstone, and sandstone, abound in this county. Coal has not been found to the north and west of the Lennox Hills, but prevails very generally along their southern base, from Baldernock on the west, to Denny, St Ninian's, Falkirk, Larbert, and Airth, on the east; and generally throughout all the eastern quarter, on both sides of the Forth and Clyde Canal. By means of the Union Canal carried from the city of Edinburgh to the Forth and Clyde Canal near Falkirk, these extensive coal-fields have been rendered of easy access to the metropolis, which already receives large supplies of coal from that quarter, at little more than two thirds of the price which the inhabitants formerly paid for this necessary article. Limestone abounds in the same quarters with the coal, and in many instances there is one stratum of it above and another below the coal, the former always of the best quality. Sandstone also frequently accompanies both, though it is found in other parts. At Kilsyth there is a quarry of white sandstone, which takes a fine polish, and has been often used in ornamental work. Ironstone is in great abundance throughout the coal district, and is wrought in several places to a considerable extent, chiefly for the use of the Carron Works. It is also found in the parish of Kilsyth, in balls from a quarter of an inch to a foot in diameter, which are richer in metal than the common stone. Copper has not been discovered in veins so rich as to encourage their working, though mines were formerly opened at one or two places. Veins of silver were discovered, about sixty years ago, in the parishes of Logie and Alva, on the northern extremity of the county, and for a few weeks the working was very successful, but was soon abandoned. Cobalt was found in the same quarter. There are indications of other minerals in different parts of the county. In connection with the minerals it may be noticed, that in the parish of Logie, near to the beautiful village of Bridge of Allan, the mineral springs of Airthrey were discovered some years ago, and recommended to public notice. They are now attracting a great many visitors, and Bridge of Allan is rapidly assuming the appearance of a handsome town.

Rivers. Besides the Forth, the Avon, the Kelvin, and the Endrick, which, though having their sources in Stirlingshire, soon cease to belong to it exclusively, flowing for the most part on its boundaries, this district is well supplied with other streams, which traverse its interior. The Forth. The Forth, however, is by far the most important. It rises from a spring on the northern side and near the summit of Benlomond. After a course of eight or ten miles, under the name of the Water of *Duchray*, it passes into Perthshire, where it is called *Avendhu*, or Black River; and soon after, on returning to the borders of this county, it obtains the name of the Forth. A few miles above Stirling it receives the Teith, and afterwards the Allan, from the north, and the Bannockburn from the south. The tide, which flows a little above Stirling, renders it navigable to that town for vessels of 70 tons. Below Stirling the river winds in a remarkable manner across its valley, making so little progress, that, following its course to Alloa, the distance from Stirling Bridge is about 16 miles, while in a direct line it is scarcely seven. These windings are called the *Links* of the Forth. Two miles above Alloa it receives the Devon from the north-east. Below Alloa it expands into the large estuary called the Firth of Forth, which washes the north-eastern side of the county, till it meets with Linlithgowshire, a little to the south of Grangemouth. Next in importance, and the only other stream worthy of particular notice, is the Carron, which, rising in the interior, pursues an easterly course, and joins the Firth of Forth at Grangemouth. It is navigable for vessels of 200 tons as far as the village of Carron Shore, the shipping place of the Carron Company, nearly two miles from its confluence with the Forth. Besides Lochlomond, of which the greater part is in Dunbartonshire, several small pieces of water occur in different parts, none of them remarkable. Salmon are caught in the Forth, and also in Lochlomond, and in 1839 the fishery afforded a revenue of L.650 a year to the town of Stirling. Formerly the salmon-fishings were let as high as L.1400, part of which belonged to another proprietor.

Valuation and rental.

The valued rent of Stirlingshire is L.108,509. 3s. 3d. Scots, and the real rent of the lands and houses in 1815 was L.218,761 sterling. In 1811 the number of estates was 147, of which 109 were below L.500 Scots, and only nine above L.2000 of valuation, thus indicating that the landed property was much divided; and not a fourth of the whole was entailed, a smaller proportion than in most parts of Scotland. The estates of the duke of Montrose, Lord Dundas, Sir Charles Edmonstone, Mr Forbes of Callendar, Mr Murray of Polmaise, the principal proprietors, are rented at from L.6000 to L.14,000, and several others are worth from L.1000 to L.4000 a year; but the greater number are below L.1000. Some of the proprietors have increased the value of their estates by means of embankments on the Firth of Forth. Several hundred acres, many of them worth as high a rent as any in the county, have thus been reclaimed and brought into cultivation, and a great deal more may be gained in the same manner. All the small proprietors, and most of the great ones, reside upon their estates; and several of the latter occupy considerable farms of their own, which they have improved, and continue to cultivate in a very judicious manner. There is accordingly a great number of seats over all the lower parts of the county. Before the union between Scotland and England, considerable tracts were granted to the retainers and dependants, or the tenants, of the principal proprietors, and their heirs, for ever; subject only to the payment of the rent of those times, which is now very trifling. These are called *feuars* or *portioners*, and in some parishes, especially Denny, form a pretty numerous class.

Woodlands.

There is a good deal of both natural and planted wood in Stirlingshire, about 13,000 acres of the former, and 10,000 of the latter; and much of the former, in the state of coppice, has long yielded a regular income to the proprietors, little if at all inferior to the average rent of the arable land. The Buchanan woods, belonging to the duke of Montrose, seem to be under very regular management, being divided into twenty-four *hags* or portions, of which one is cut every year. About twenty-five years ago, this produced from L.16 to L.24 the Scots acre, after leaving a number of *reserves* to stand for timber. Every acre gives at a medium about one ton and a half of bark, which, during the late war, sold at L.18; and the small timber generally pays expenses. This does not now hold true, as bark does not bring above L.7. Much of the land on which this wood grows is of little value for any other purpose; not worth half a crown an acre. On the same estate, and also in other parts of the county, extensive plantations have been formed within the last seventy years.

The mountainous parts of Stirlingshire are occupied with sheep of the black-faced or heath breed, but of late years many Cheviot and other breeds have been introduced; and the lower hills by Highland cattle; and there the farms are necessarily of considerable extent. The arable land, however, is for the most part divided into small farms, especially the Carse lands on the Forth, where the general size does not exceed from 40 to 100 or perhaps 120 acres.

The agriculture of this county, which a few years ago was in a very inferior condition, is now (1840) in the highest state of improvement. Stirlingshire farmers and farm-servants are anxiously sought after in every part of the united kingdom. Landed proprietors even in East Lothian and Berwickshire, where farming had long been managed in a very spirited manner, and with decided success, have latterly confessed that an inoculation of Stirlingshire farming would prove highly beneficial to the agriculture of those counties. For the attainment of this confessed superiority, Stirlingshire is indebted to a variety of favourable circumstances, to which we shall now shortly advert in quite a practical manner, as the theory has already been submitted to our readers in the article upon AGRICULTURE. Among these circumstances may be chiefly noticed the Deanston or thorough-draining system, the subsoil or deep ploughing system, and the encouragement given to both by many of the landed proprietors. But before proceeding to state these circumstances, we may premise, that had not the farmers in this county been morally prepared to admit innovation, and to follow good example, these improvements, like many others equally beneficial in various departments of practical knowledge, must have fallen to the ground, to be again resuscitated and pressed upon public attention in more auspicious times. It is therefore to the zeal and indefatigable industry, stimulated by enlarged notions alike of public and private interest, and exercised by Stirlingshire farmers, that we and the whole empire have to congratulate ourselves upon those immense improvements in agriculture, which are enabling a small, and, generally speaking, a sterile country, to support a rapidly increasing population, while at the same time we regret to add, that those very farmers are, notwithstanding these improvements, scarcely able to maintain their position, in consequence of the depreciated and still depreciating value of the products of arable husbandry.

This admirable system, which was either invented by Mr Smith of the Deanston Works, or by him carried to the highest state of perfection, consists in running longitudinal cuts or drains to the depth of three feet, or at least two and a half, parallel to the ridges of the field, taking care that at the lower extremity they all terminate in a main drain running at right angles to the other drains, and which must at least be six or twelve inches deeper than the longitudinal or proper drains for the field. This cross drain is technically called the "main;" and, besides its greater depth, it should otherwise be more capacious, that it may with ease carry off the accumulated waters of the whole or greater part of the field. When the farm is drained wholly at the expense of the farmer, the main is frequently left open, although he incurs a considerable loss of ground, and some expense annually for clearing it out. The best mode of covering is to form an arch both below and above, or, in other words, make a cylinder of it. The building may be either with or without mortar; but with mortar it is much more durable, and leaves a smoother run for the water. The drain or main is sometimes covered with flag-stones, and soil to the depth of eighteen inches laid over all, bringing it to the level of the field; and so nothing is lost, but something gained. It must however be confessed that this process is too expensive for a tenant. With respect to the longitudinal drains, they ought, as already stated, to be at least three feet or two and a half deep, and from three to six inches wide at the bottom. If upon dry-field ground, where stones can easily and cheaply be procured, they are then filled to the height of from nine to twelve inches, with the stones broken so small as to pass through a ring of two and a half inches in diameter. They are then covered with sod having the grassy side under, or, when sod cannot be procured, with damaged hay or straw, old thatch, ferns, or even roots of quickens (triticum repens), saved for the purpose in cleaning the same and other fields of the farm. Over these looser materials, care must be taken to spread a layer of soil of a few inches in depth, which must be trodden down and well compacted together, that it may serve as a permanent close cover to the looser materials below, to prevent the crumbling and loose soil from dropping in among the small stones, and thus preventing the run of the water. Simple as this mode of covering is, it has hitherto been found to answer the purpose effectually; as some drains at Deanston constructed in this manner fifteen years ago are still as efficient as at first. These various preparations must not be raised higher than half the depth of the cut, as the superincumbent soil, to meliorate which all this labour has been undertaken, has now to be thrown in; and it must have an average depth of eighteen inches, in order that the subsoil-plough, in traversing the field, may not by any possibility injure the drain.

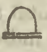
Ex se.

The expense of this mode of draining is very considerable, and has in most cases been deemed beyond the means of ordinary farmers, without some stipulated aid from their landlords. This we believe to be far the best way of managing so expensive an improvement; because the practical farmer, when the operations are entirely left to himself, will devise expedients for lessening expense, in direct outlay at least, of which expedients the landlord could not be supposed to avail himself. In some cases the drains must be distant from each other only ten feet. This is the most expensive system that has hitherto been thought necessary, even upon the wettest land or the most tenacious bottom. The other extreme is at the distance of forty feet, which is deemed sufficiently wide for any land that requires draining; and there is little in Scotland, except what is incumbent upon pure sand or fine gravel, which draining may not improve. It is thus evident that the expense of draining each acre must depend upon circumstances. We shall give Mr Smith's calculations, which we believe not to be overrated where every thing has to be paid for in money. It is unnecessary to give the whole table: it will be sufficient to state the expense at ten, twenty, thirty, and forty feet distance between the cuts. At ten feet between the cuttings, where the subsoil is an obdurate till, almost if not altogether impervious to water, the cost will amount to L.12; at twenty feet, which implies sandy clay partially pervious to water, L.6; at thirty feet, which implies a free open stony bottom, L.4; at forty feet, which implies the most open bottom or subsoil requiring draining, L.3. These sums, especially the first two, are large, but not larger than the work can actually be done for in money value; nor are they too great for the benefit to be derived from such judicious outlay; for if the work be properly executed, experience has not yet taught the real benefit which may be derived from such efficient drainage, nor how long it will endure in an effective state.

Out to a pr cal far

The actual outlay to a practical farmer, who calculates nothing but the cutting of the drains, breaking the stones, and putting them into the drains, his own people gathering the stones which are found in the field, carting them, and filling up the remaining part of the cuts, so as to bring the field to its proper level, for which he estimates no charge, the labour being performed by the force upon the farm, amounted to L.2. 14s. the acre. This was only eightpence more upon the acre than the sum stated in Mr Smith's table for the distance of thirty feet between the drains, which was the scheme executed by the farmer referred to upon a field of thirteen acres since last autumn, and which field afterwards produced an excellent green crop of potatoes and turnips. Here then is an admirable example of what may be accomplished by an active and enterprising farmer, wholly at his own expense, and without losing either the whole or any part of a crop. This was accomplished upon the farm of Bearside, near Stirling, the property of William Murray, Esq. of Touchadam and Polmaise, and possessed by Mr James Gray, whose active and enlightened industry is rapidly converting a piece of moorland, which some years ago bore only an unprofitable crop of tall furze, affording shelter to some scores of rabbits, into one of the most valuable farms upon the Polmaise estates. He has been busily engaged upon the same laborious task for the last six years, and two or three more will complete the object which he has in view. He may then with confidence rely upon his expense and toil being rewarded.[1] When stones have to be quarried and carted a greater distance, the expense will be somewhat greater.

Draining with tiles.

When stones cannot be procured in sufficient quantity, or at moderate expense, recourse is had to tiles made for the purpose. The accompanying figure represents a section of the tile . They are about five inches deep and four across, and generally fourteen inches long; and in most cases flat tiles are placed in the bottom of the drain, and the arched ones placed over them; but where the subsoil is very stiff, the extra expense of sole tiles is dispensed with. As draining with tile is the cheapest mode in clayey land, such as the Carses in Stirlingshire, and with stones as described above in dry-field, and as the filling-in process in both is the same, it is needless to repeat the description already given. With respect to the comparative merits of the two modes, the most competent judges prefer the small stone-drains, when at all practicable, to those formed with tile, both as concern durability and practical utility. Certain it is, they possess one decided advantage over tile, as they present a perfect barrier to the admission of vermin, as moles, rats, &c. and therefore the chances of being choked by the ravages of these noxious animals are greatly diminished, and the durability increased. It may be useful to add, that "the frequent drain system" is another appellation by which it is pretty generally known.

Subsoil system.

Not satisfied, however, with this expensive system of draining, Mr Smith of Deanston has had recourse to a system of ploughing invented by himself, and denominated, aptly enough, "subsoil-ploughing." The implement by which the work is accomplished, is just like any other old Scottish plough, without a mould, but larger, heavier, and stronger. It is never wrought with fewer than three, most commonly with four, and not unfrequently with six horses, according to the nature of the soil in which it has to operate. Where it is desirable to bring up any of the subsoil, this is performed by another large plough, called a "trench-plough," which has a mould attached to it like an ordinary plough, and is generally drawn by three horses. The mode of procedure consists in an ordinary plough with two horses going before it, with the usual depth of furrow, the subsoil-plough following with a depth of at least ten or even twelve inches more, and forcing to the surface, besides

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[1] To some it may appear invidious to select the names of individuals, when so many are at least equally active in improving. It will serve as our apology, that some names were absolutely necessary to verify our statements; and Mr Murray took the lead as a landlord in introducing these improvements, while among the tenantry Mr Gray has not been the least active.

Expense.

stirring the soil below, whatever stones of the weight of not more than four hundredweight it may encounter in its progress. When stones exceed the above weight, a lad following the plough marks their situation with a tally, that they may afterwards be removed with crowbars. These, with others found upon the surface, are the stones with which the drains are filled; and thus, while the drains serve as leaders for conveying the water away when collected, the thorough stirring of the subsoil permits a more rapid percolation, and also evaporation, by which the ground becomes very speedily dry, and consequently much better fitted for the reception and nourishment of seed of every kind. The expense of subsoil-ploughing, when paid in money, generally varies from 24s. to 30s. the acre; but it is now becoming a part of the routine labour of the farm. Supposing it, however, to be contracted for, and paid in cash, the extra expense does not exceed one fifth of the cost of trenching with the spade, and yet the work is as effectually done. The reader ought to remember, that the calculations are adjusted to the Scotish acre, and that four Scotish are equal to five statute acres; so that the amount of money required to execute four Scotish, will cover the expense of five imperial acres.

Beneficial results of these improvements.

In noticing this part of the subject, we shall first copy two short extracts from a writer in the Quarterly Journal of Agriculture for June 1839, pp. 69 and 70. Speaking principally of the draining, he says, "This so great benefit, not for Scotland only, but for the whole kingdom, is as yet in its infancy. Already the fame and the utility of it is spreading all over the island; and we have not a doubt, in a short time, there will not be found a spot that has not been made anew by means of this simple yet powerful and efficient system of draining.... It is perfectly wonderful to behold the mighty change this thorough-drain system is making in the different parts of the country where it is in operation. Wet land is made dry, poor weeping clays are converted into turnip-soil, and even what would formerly have been accounted dry is advanced in quality. Whole parishes in the vicinity of Stirling are completely transformed from unsightly marshes into beautiful and rich wheat-fields; and where the plough could scarcely be driven for slush and water, we see heavy crops per acre, and heavy weight per bushel, the quantity and the quality alike improved." But these statements, although true, and in no degree exaggerated, are yet of too general a nature to fix the attention of the reader. We shall therefore simply state two facts, which are well authenticated, as illustrative of the beneficial results of these decided improvements in agriculture. In the Carses, which have been cultivated from time immemorial, and have always been very productive, and which have sometimes been considered beyond the reach of improvement, the most distinct improvement is visible even in the best years; and in wet seasons the condition of the crop is still more distinctly marked for the better. In the driest seasons it is not beyond the truth to say, that the crop is larger from a sixth to a fourth, and the quality vastly improved in weight and fineness, while in wet and cold seasons, such as 1838 and 1839, it is impossible to estimate the value of these admirable improvements. Again, with respect to the other kinds of soil in Stirlingshire, namely, the dry-field, our remarks must be understood to apply less generally, as the soil is not so uniformly good; yet are the effects more decisively manifested here than in the Carses, as in wet seasons, without the draining and subsoil-ploughing, many fields would scarcely carry any crop at all, and so both seed and labour would be lost. The following statement may be received as applicable to many different instances of management. A small field of seven Scotish acres had during sixteen years of a nineteen years' lease produced upon an average the sum of from 10s. to 15s. the acre as its whole return. At this period, when the farmer felt himself secure in the prospect of another lease, he drained the ground at intervals of only fifteen feet, in consequence of the great wetness of both the active and subsoil. It was then subsoil-ploughed, and covered with a crop of potatoes and turnip. This was in 1836, a very wet season. The product was a good fair crop of both. In 1837 it was sown with barley, and produced the heaviest crop of that grain that had hitherto been produced on the farm. This yielded more pounds per acre than it had formerly given shillings. In 1838, although an exceedingly bad season, it yielded fully two tons of hay per acre; and in the ensuing year, although only seven acres in extent, it produced more food to the same number of milk-cows than thirteen acres of an undrained field did in the preceding year. As these were the first crops after being drained, there is reason to believe, that when again subjected to tillage after pasture it will be still more productive, as the drains will have had more time thoroughly to dry the field. Many such instances of beneficial influence could easily be pointed out in dry-field farming, but this would only be a useless repetition. It is pertinent enough to add, that not only are the crops improved, but both the seed-time and the harvest are rendered earlier than formerly; a circumstance of vital interest in the upland districts, where, under the ordinary modes of culture, it has not unfrequently been difficult, and sometimes impossible, to get the corn to ripen at all in wet seasons, which so frequently occur in our climate.

The encouragement of the landlords, most of whom are resident in this county, has been prompt and judicious, especially in patronising the introduction of the draining system, which is the basis of modern agriculture. Decidedly the most active of these were Mr Murray of Polmaise, the late Mr Graham of Airth, and Mr Moir of Leckie, who were among the first to direct their attention to this subject, and who effectually introduced the new system among their tenantry, and thus obtained for it a fair field. Since then its advantages have been so manifest as to induce the most prejudiced and stubborn of the farming population to adopt it to a greater or less extent. Nor has any popular clamour ever been raised against the improved culture; a proof that even the rural population are beginning to admit new ideas.

Drum- monds ricultu Museu

Another circumstance which has risen out of this improved agriculture, is the establishment of Drummonds Agricultural Museum; an institution which, while it may be called the offspring of the improved culture, has yet had a very beneficial effect in promoting the objects which gave rise to it. It was begun in the year 1831 by the Messrs Drummond, the spirited seedsmen in Stirling, and was founded, and for the first two or three years conducted, at their own expense. The gentlemen, and some of the more public-spirited of the farmers, of the district, have since contributed so much towards its expense, that the public are now admitted gratis. It is still, however, the Drummonds Museum, and they are at this moment building large premises for containing it and their own business establishment. The principal object contemplated by this museum is the collecting together under one view practical working specimens of every possible, or at least known implement, connected with agriculture, from the twisting of a straw-rope to the ponderous draining plough, the invention of Mr Macewan, farmer at Blackdub, near Stirling, and which is drawn by twelve horses. Few persons, even of those who are most conversant with the details of agriculture upon the most extensive and complicated scale, could have the slightest idea of the immense variety of implements here exhibited, both for show and sale. To specify particulars would answer no purpose. Besides the implements, there are also specimens of every kind of grain, root, or fruit, which will bear exhibition, along with soils, sections of drains, corn and hay stacks, amounting in all to between six and eight thousand specimens; and few weeks pass without additions being made to the number. It is only fair to add, that the landlords and farmers of the adjoining counties of Perth and Clackmannan, which, although politically separated, form only one district, the basin of the Forth, have as promptly availed themselves of these improvements as those of Stirlingshire.

The land on the banks of the Forth is exceedingly well adapted for orchards, of which there are a few, but of no great extent. The island of Inchmurrin, in Lochlomond, the property of the duke of Montrose, has been stocked with fallow deer for more than a century, the number being about 240, which are properly attended to, and kept always in a thriving condition.

The manufactures are carpets, tartans, plaid-shawls, trouser-stuffs, and other woollens, in the town of Stirling, but more in the neighbourhood. These within the last ten years have increased in nearly a tenfold degree, so that this district has now become one of the principal seats of the woollen manufacture in Scotland, and promises soon to take the lead. Paper, cottons, alum, copperas, soda, Prussian blue, &c. are produced on an extensive scale; spirits at several large distilleries, the amount of duty from home-made spirits being greater than in any other district in Scotland; and iron goods at Carron. The Carron Works, celebrated over all Europe, were established upon the banks of the river of that name about eighty years ago, by Dr Roebuck and Messrs Cadell and Garbet, who were joined in the undertaking by several other gentlemen. By the charter of the company, they are authorized to employ a capital of L.150,000, which is divided into 600 shares; and ten of these are required to give a vote in the management. During the late war they employed upwards of 2000 able-bodied men, and paid in wages above L.120,000 yearly; and this is nearly true at the present day. At these works all sorts of cast-iron goods are made, and also bar-iron, said to be equal to the Russian, but particularly cannon, and that kind called carronades, which having been invented here, take their name from the works. The boring of the cannon is a very interesting operation, which is performed in about forty-eight hours, by machinery moved by water. One of their engines raises upwards of thirty tons of water in a minute; and so extensive are the works, that they are said to consume every day about 200 tons of coals. They have water-carriage from the Firth of Forth by means of the Carron, and to the Firth of Clyde by the Forth and Clyde Canal, which passes through the district a little to the south of the Carron. The number of vessels in the London trade alone is seven, and about as many more are constantly trading to other places.

Some years ago another extensive foundery was projected, and it is at present in operation upon a respectable footing, manufacturing goods equal to those of Carron.

Notwithstanding the favourable situation of Stirlingshire, on a navigable river, and between the east and west seas, which for many years have been connected by a canal, it has but a small town-population, and till lately its commerce was inconsiderable. Even now, half its exports, not including its agricultural produce, is supposed to be furnished by the Carron Works. In consequence of the increase of the woollen manufacture, commerce must necessarily be increased also. The principal town is Stirling, containing, in 1831, 8556 inhabitants; a place of great antiquity, which, though situated on the navigable part of the Forth, has little trade by water, and is chiefly indebted for its importance to its situation on the confines of the Highlands. Falkirk, on the eastern side of the county, a little to the south of the Forth and Clyde Canal, had a population, including a large and populous parish, in 1831, of 12,743, and is distinguished for its great fairs or trysts, which are held on the second Tuesday in August, September, and October, where cattle, sheep, and horses are brought for sale to the annual value of L.650,000. Grangemouth, founded by Sir Laurence Dundas in 1777, on the angle formed by the junction of the Carron and the Forth and Clyde Canal, is now a considerable town, and the principal seaport of the county. Its trade is chiefly with the north of Europe and along the east coast. It has a custom-house, a dry dock, and other necessary works. The depth of water in the harbour is generally, in spring tides from sixteen to eighteen feet, and in neap tides from ten to twelve. The only other towns are Kilsyth, Bannockburn, Denny, Campsie, and Balfron. On the east side there is a number of small villages, occupied partly by agricultural labourers and mechanics, and partly by weavers employed by the Glasgow manufacturers.

Railway.

Besides the Forth and Clyde and Union Canals, the Edinburgh and Glasgow Railway, now constructing, passes through this county, in a direction nearly parallel to the canals, and must be productive of great benefit to its population.

Representation.

The county, which in 1831 had only 118 freeholders, has now a constituency of 2332, who send one member to parliament. Stirling, its only royal borough, is associated with Culross, Dunfermline, Inverkeithing, and Queensferry, in the elections for the Scotish burghs; and Falkirk, a parliamentary borough, with Airdrie, Hamilton, Lanark, and Linlithgow; Stirling and Falkirk being both the returning burghs. A poor-rate is only levied in a few parishes, the poor being chiefly supported, as in most parts of Scotland, by voluntary contributions.

Antiquities

Stirlingshire exhibits remains highly interesting to the antiquary, and has been the scene of some of the most remarkable events in Scotish history. The Roman wall, called the Wall of Antoninus, and vulgarly Græme's Dyke, which traversed this county, may still be traced in several places. The battles of Stirling, in which Wallace defeated the English under Warren earl of Surrey; of Falkirk, in which he in his turn was defeated; of Bannockburn, which secured the independence of Scotland; of Sauchie-burn, between James III. and his rebellious subjects, in which the former was defeated, and was afterwards treacherously slain at Milton; were fought in this county. Stirlingshire was in former days the battle-ground of Scotland. Here we may refer to Nimmo's History of Stirlingshire, Ray's Military Antiquities, and Chalmers's Caledonia.

Population.

The population of Stirlingshire, according to the census of 1801, was 50,825, in 1811 it amounted to 58,174, in 1821 to 65,376, and in 1831 to 72,600. The increase of population from 1811 to 1831 was 21,775.

STIRRUP, in the manège, a rest or support for the horseman's foot, for enabling him to mount, and for keeping him firm in his seat. Stirrups were unknown to the ancients. The want of them in getting upon horseback was supplied by agility or art. Some horses were taught to stoop to take up their riders; but the riders often leapt up by the help of their spears, or were assisted by their slaves, or made use of ladders for the purpose. Gracchus furnished the highways with stones, which were intended to answer the same end. The same was also required of the surveyors of the roads in Greece, as part of their duty. Menage observes that St Jerom is the first author who mentions stirrups. But the passage alluded to is not to be found in his epistles; and if it were there, it would prove nothing, because St Jerom lived at a time when stirrups are supposed to have been invented, and after the use of saddles. Montfaucon denies the genuineness of this passage; and, in order to account for the ignorance of the ancients with regard to an instrument so useful and so easy of invention, he observes, that while cloths and housings only were laid upon the horses' backs, on which the riders were to sit, stirrups could not have been used, because they could not have been fastened with the same security as upon a saddle. But it is more probable, that in this instance, as in many others, the progress of human genius and invention is uncertain and slow, depending frequently upon accidental causes.

STIVIERE, a market-town in the delegation of Mantua, in Austrian Lombardy, usually distinguished by the name Castiglione della Stiviere. It stands in a strong position, and has a castle, eight churches, and 5460 inhabitants; and is remarkable for the victory of the French over the Austrians in 1796. Long. 10. 47. E. Lat. 45. 42. N.

STOBÆUS, JOANNES, whose compilations have been found so highly valuable, is supposed to have been born at Stobi, a city of Macedonia. Heeren has endeavoured to render it probable that he must have lived between the years 450 and 500. He does not appear to have been a Christian. From about five hundred writers, in verse as well as prose, he extracted and digested an immense collection of passages; which has most commonly been considered as one work divided into four books, the first two being described as "Eclogæ Physicæ et Ethicæ," and the other two as Sermones. But, according to Heeren, they constitute two distinct compilations. As many of the books quoted by Stobæus have scarcely left any other vestiges behind them, his merit in preserving these numerous and variegated reliques of antiquity cannot well be too highly estimated. Of the third and fourth books, otherwise called the Florilegium, the Greek text was published by Victor Trincavellus, Venet. 1536, 4to. An edition, accompanied with a Latin version, was published by Conrad Gesner, Tiguri, 1543, fol. It was reprinted at Basel in 1549, and at Zürich in 1559. Other editions succeeded; but they have all been nearly superseded by that of Gaisford, Oxon. 1822, 4 tom. 8vo. The text, which has been adjusted with great industry and skill, is not accompanied with a Latin translation. Of the "Eclogarum libri duo," the Greek text was first published together with a Latin version by Canter, Antverp. 1575, fol. The editor made use of two manuscripts belonging to Sambucus and Sirlet; and hence a certain bibliographer has described this as Sirlet's edition. A valuable edition of the Eclogæ was long afterwards published by Heeren, Gottingæ, 1792–4, 2 tom. 8vo. The Florilegium and the Eclogæ had been published in the same volume, under the title of "Stobæi Sententiæ, ex thesauris Græcorum delectæ." Lugduni, 1608, fol. Some copies have a new title, with the date of 1609. Here we must not overlook the elegant labours of Grotius: "Dicta Poetarum quæ apud Stobæum exstant, emendata, et Latino carmine reddita." Paris. 1623, 4to.

STOCKBRIDGE, a town of the hundred of King's Somborne, in the division of Andover, in the county of Hampshire, 66 miles from London. It stands in a pleasant valley, with various streams running through it, which afford great sport to parties who repair to them to enjoy trout-fishing. It is an ancient borough, and returned two members to parliament till 1832, when it was disfranchised. It has a small market on Thursday. The inhabitants amounted in 1801 to 643, in 1811 to 663, in 1821 to 715, and in 1831 to 851.

STOCKHOLM, the capital of the kingdom of Sweden, stands in the centre of the province of that name. It is built on two peninsulas, and several islands of different dimensions, which are connected by numerous bridges and ferries, and, including the water, is of great extent, being two and a quarter miles in length, and near two miles in breadth. A great part of this enclosure is not covered with houses; and in many parts the rocks are interspersed among patches of land and gardens, so as to give it an appearance very different from that of any other of the European capitals. The whole is divided into ten districts, the most important of which, called the city (*Stadt*), is small but interesting, from being the residence of the higher classes of the inhabitants, and the site of the most prominent buildings. In this division the streets are narrow, dark, and badly paved. They run parallel to each other, and are united by cross streets; but in all of them the gutters in the middle are very repulsive to more than one sense. The houses however are large, firmly built, and not destitute of taste. The royal palace is of colossal dimensions, and erected in a noble style of architecture. Being rather elevated, it commands a view of the whole city on one side, and is surrounded with tasteful gardens on the other. Within it is contained the presence-chamber, the royal museum, a library of 30,000 volumes, the collection of the Swedish academies, a square with a monument and figure of Gustavus III., and the German church, with a tower of 120 feet in height. In the same part are also the exchange, the bank, the cabinet of coins and medals, the mint, the college of mining, and the town-hall. The royal stables are in another division. On one of the islands, forming a district, are the naval storehouses, and the hall of the admiralty. On another island, also a district, is a fort with twelve cannon and a lazaretto. On many of these districts, though each has some good buildings, the others are poor wooden houses, without taste or ornament, and destitute of cleanliness. The city is under the government of a stadtholder, with inferior officers; and under the police are organized bodies of watchmen and firemen. Here both the civil and the criminal courts are held. The ecclesiastical affairs are managed by the consistory, with a superintendent as president. Under it are fourteen pastorates of the Lutheran religion; and there are besides places of worship for German and French Calvinists, for Catholics, and for Finnish Lutherans. There are many schools both for elementary and classical learning, and also an academy of sciences, with an astronomical observatory, a society of antiquaries, and other bodies for promoting the different branches of knowledge. There are abundance of benevolent institutions, adapted to alleviate the various calamities to which mankind are subject, but especially hospitals for seamen and widows. Stockholm is the chief manufacturing place of the kingdom, and supplies silk, woollen, and cotton clothing, much linen, and also refined sugar, tobacco and snuff, pottery and china ware, glass, jewellery, brandy, and many smaller articles, but almost exclusively for domestic use. It is also the chief mart of foreign trade, to which the excellence and security of its harbour greatly contributes. About 500 or 600 vessels, of different burdens, are yearly despatched. Some of these arrive with cargoes of corn, but many in ballast. They are loaded with the excellent iron of Sweden, with copper, tar, pitch, anchors, nails, cannon, bar-steel, planks, masts, cordage, hides, leather, tiles, and in some years a large quantity of preserved herrings. The city has establishments for recreation in two theatres, several public walks, and a variety of clubs and other social assemblies. The population has been fluctuating. In 1795 it amounted to 74,378, in 1800 to 75,511, in 1805 to 72,652, in 1814 to 62,830, in 1818 to 65,474, in 1826 to 77,273, in 1832 to 79,526. Long. 17. 59. 30. E. Lat. 59. 19. 15. N.

STOCKING, that part of the clothing of the leg and foot which immediately covers and screens them from the rigour of the cold. Anciently, the only stockings in use were made of cloth, or of milled stuffs sewed together; but since the invention of knitting and weaving stockings of silk, wool, cotton, thread, &c. the use of cloth stockings is quite discontinued. Dr Howell, in his History of the World, vol. ii. p. 222, relates, that Queen Elizabeth, in 1501, was presented with a pair of black knit silk stockings by her silk woman, and thenceforth she never wore cloth ones any more. The same author adds, that King Henry VIII. ordinarily wore cloth hose, except there came from Spain, by great chance, a pair of silk stockings. His son, King Edward VI., was presented with a pair of long Spanish silk stockings by Sir Thomas Gresham, and the present was then much taken notice of. Hence it should seem that the invention of silk knit stockings originally came from Spain. Others relate, that one William Rider, an apprentice on London Bridge, seeing at the house of an Italian merchant a pair of knit worsted stockings from Mantua, took the hint, and made a pair exactly like them, which he presented to William earl of Pembroke, and that they were the first of that kind worn in England, anno 1564.

The modern stockings, whether woven or knit, are formed of an infinite number of little knots, called *stitches*, *loops*, or *meshes*, intermingled in one another. Knit stockings are wrought with needles made of polished iron or brass wire, which interweave the threads and form the meshes of which the stocking consists. At what time the art of knitting was invented, it is perhaps impossible to determine, though it has been usually attributed to the Scots, as it is said that the first works of this kind came from Scotland. It is added, that it was on this account that the company of stocking-knitters established at Paris in 1527 took for their patron St Fiacre, who is said to have been the son of a king of Scotland. But it is most probable that the method of knitting stockings by wires or needles was first brought from Spain.

Woven stockings are generally very fine. They are manufactured on a frame or machine made of polished iron, the structure of which it is needless to describe, as it may be seen in almost every considerable town in Great Britain. The invention of this machine is, by Mr Anderson, attributed to William Lee, M. A. of St John's College, Cambridge, at a period so early as 1589. Others have given the credit of the invention to a student of Oxford at a much later period, who, it is said by Aaron Hill,[1] was driven to it by dire necessity. This young man falling in love with an innkeeper's daughter, married her though she had not a penny, and he by his marriage lost a fellowship. They soon fell into extreme poverty; and their marriage producing the consequences naturally to be expected from it, the amorous pair became miserable, not so much on account of their sufferings, as from the melancholy dread of what would become of their yet unborn infant. Their only means of support was the knitting of stockings, at which the woman was very expert. "But sitting constantly together from morning to night, and the scholar often fixing his eyes, with stedfast observation, on the motion of his wife's fingers in the dexterous management of her needles, he took it into his imagination that it was not impossible to contrive a little loom which might do the work with much more expedition. This thought he communicated to his wife, and joining his head to her hands, the endeavour succeeded to their wish. Thus the ingenious stocking-loom, which is so common now, was first invented; by which he did not only make himself and his family happy, but has left his nation indebted to him for a benefit which enables us to export silk stockings in great quantities, and to a vast advantage, to those very countries from whence before we used to bring them at considerable loss in the balance of our traffic."

STOCKPORT, a town in the hundred of Macclesfield and county of Chester, 173 miles from London. It stands on the banks of the river Mersey, over which is a neat stone bridge of a single arch, resting on rocks on both sides. By means of a canal this town has water communication with the rivers Dee, Ribble, Trent, and Severn, and thus with the greater part of the kingdom. The trade which it carries on is very extensive. It was formerly confined in a great measure to making cotton goods; but of late years the silk-manufacture has been introduced, and has been prodigiously extended. There are two parish churches. The oldest, called the Red Church, is built on a solid rock, and has a neat square tower, with a good set of bells. There are also many places of worship for the various dissenting sects. By the act of 1832 it has been created a borough, and returns two members to the House of Commons. There is a large market on Fridays. The inhabitants amounted in 1801 to 14,830, in 1811 to 17,545, in 1821 to 21,726, and in 1831 to 25,469.

STOCKS, or PUBLIC FUNDS *in England*. See FUNDING SYSTEM.

STOCKTON, a town in the ward of that name, in the county of Durham, 248 miles from London. It stands on the river Tees, which is navigable to it; and consists principally of one well-built, long, and wide street, in which is the church, the town-hall, and grammar-school. It is an ancient borough, governed by a mayor, a recorder, and aldermen, but elects no members to the House of Commons. It formerly contained a castle, which has been demolished, and the stones applied to the erection of more modern buildings. The bridge over the Tees is an elegant object. The inhabitants carry on a considerable trade in making coarse linens, huccabacks, table-cloths, and sail-cloths; and several ships are built on the river. Stockton is well supplied with coals, vegetables, fruit, fish, and other necessaries; and it has a market on Wednesday and another on Saturday. The number of inhabitants amounted in 1801 to 4009, in 1811 to 4229, in 1821 to 5006, and in 1831 to 7763.

STOKESLEY, a town in the north riding of the county of York, and in the wapentake of Langborough. It is 242 miles from London, and forty-three from York. It stands on the river Leven, and consists of one well-built, long street, with no remarkable building except the manor-house, adjoining to the churchyard, which at an early period was granted to Guy de Baliol, whose family came to England with William the Conqueror. The town depends on the fertility of the land around it, from which a market on Saturday is well supplied. The parish comprises four small townships. The population amounted in 1801 to 1755, in 1811 to 1759, in 1821 to 2290, and in 1831 to 2376.

STOICS, the name given to a sect of Grecian philosophers, from Στοα, the porch in Athens, which the founder of the sect chose for his school.

STOLE, a sacerdotal ornament worn by the Romish parish priests above their surplice, as a mark of superiority in their respective churches; and by other priests over the alb, at celebrating of mass, in which case it goes across the stomach; and by deacons over the left shoulder, in the form of a scarf. The stole is a broad swath, or slip of stuff, hanging from the neck to the feet, and is marked with three crosses.

Groom of the STOLE, the eldest gentleman of the king's bedchamber, whose office it was to present and put on his majesty's first garment, or shirt, every morning, and to order the things in the chamber.

STOLPE, a town of Prussian Pomerania, in the government of Koslin, the capital of a circle of the same name. It stands on the river Stolpe, which is navigable to it. It contains 650 houses, with 5840 inhabitants, who are chiefly employed in linen and woollen manufactures, in fisheries on the river for salmon, and in distilleries and breweries. Long. 16. 50. E. Lat. 54. 27. 29. N.

STONE, a town in the hundred of Pirehill and county of Stafford, 141 miles from London. It is pleasantly situated on the banks of the river Trent, is neat and well built; and by means of a canal has an easy communication with most parts of the kingdom. The church is a fine structure, with a square tower and a good set of bells. The inhabitants amounted in 1801 to 2305, in 1811 to 2314, in 1821 to 2855, and 1831 to 3460.

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[1] See an Account of the Rise and Progress of the Beech Oil Invention, &c. 8vo, 1715.

Stone, *Edmund*, a distinguished self-taught mathematician, was born in Scotland, but neither the place nor the time of his birth is well known; nor have we any memoirs of his early life, except in a letter from the Chevalier Ramsay to Father Castel, a Jesuit of Paris, and published in the *Mémoires de Trevoux.* Born the son of a gardener of the Duke of Argyle, he arrived at eight years of age before he learned to read. By chance a servant having taught him the letters of the alphabet, there needed nothing more to discover and expand his genius. He applied himself to study, and arrived at the knowledge of the most sublime geometry and analysis, without a master, without a conductor, without any other guide but pure genius. He was author and translator of several useful works, viz. 1. A New Mathematical Dictionary, in 8vo, first printed in 1726. 2. Fluxions, in 8vo, 1730. The Direct Method is a translation from the French of De l'Hospital's "Analyse des infiniment Petits;" and the Inverse Method was supplied by Stone himself. 3. The Elements of Euclid, in 2 vols. 8vo, 1731. Stone was a fellow of the Royal Society, and had inserted in the Philosophical Transactions (vol. xli. p. 218) an "Account of two species of lines of the 3d order, not mentioned by Sir Isaac Newton or Mr Stirling." In 1758 he published "The Construction and principal Uses of Mathematical Instruments; translated from the French of M. Bion. In 1742 or 1743 his name was withdrawn from the list of the Royal Society; and in his old age he appears to have been left to poverty and neglect. He survived till March or April 1768.

Stone, *Jerome*, the son of a seaman, was born in the parish of Scoonie, Fifeshire. His father died abroad when he was but three years of age, and his mother, with her young family, was left in very narrow circumstances. Jerome having obtained the ordinary school education, reading English, writing, and arithmetic, betook himself to the business of a pedlar. He began his philological pursuits with the study of the Hebrew and Greek tongues, and made himself so far master of these, without any assistance, as to be able to interpret the Hebrew Bible and Greek Testament into English *ad aperturam libri.* At this time he did not know one word of Latin. Some time afterwards, he was encouraged to prosecute his studies at the university of St Andrews; and an unexampled proficiency in every branch of literature recommended him to the esteem of the professors. Having finished his studies, he settled as schoolmaster at Dunkeld, where he died in 1757, in the 30th year of his age.

STONEHAVEN, or Stonehive, a seaport town in Kincardineshire, Scotland, occupies part of the parishes of Dunnotar and Fetteresso. It is situated in a south-westerly direction from Aberdeen, from which it is distant fifteen miles. The more ancient part of the town, which was built in the reign of Charles II., stands on the south side of the Carron, and presents an appearance somewhat paltry. But on the north side of the stream some elegant streets, with a square in the centre, have risen up under the auspices of Captain Barclay of Ury, upon whose ground they are built. Between the old and new towns there is a communication by means of a bridge. There is safe anchorage for shipping in the harbour, which is a natural basin, sheltered on the south-east by a high rock, and on the north-east by a quay, where goods can be landed with convenience and despatch. The harbour has been recently improved by the erection of a jetty. The vessels that sail out of this port are chiefly employed in the coal and lime trade, but the amount of tonnage is inconsiderable. Here many persons reside who occupy themselves in the herring-fishery; and there was formerly employment for a number of weavers, but their trade has in a great measure deserted them. The prosperity of the place depends in some degree upon the persons connected with the sheriff court of the county, which is held here. Although the capital of Kincardineshire, Stonehaven is only a borough of barony, of which the magistrates, who are authorized by the charter to preside in the justice of peace court, are appointed by the superior and feuars. A weekly market is held here, and also five annual fairs. In the vicinity of Stonehaven stand the parish churches of Dunnotar and Fetteresso. The town itself contains other two places of worship, one of which is an Episcopal chapel, and the other a meeting-house of the United Associated Synod. The population amounted in 1821 to 2150, and in 1831 to 2965.

STONES, in *Natural History*, have been defined bodies which are insipid, not ductile, nor inflammable, nor soluble in water. For a view of the classification of stones, and of their distribution, see Mineralogy and Geology.

Some philosophers say that stones are vegetables; that they grow and increase in size like a plant. This theory, we believe, was first offered to the world by M. Tournefort, in the year 1702, after returning from his travels in the East. It was founded on a curious fact. In surveying the labyrinth of Crete, he observed that the names which visitors had engraved upon the rock were not formed of hollow, but of prominent letters, like basso-relievos. He supposes that these letters were at first hollowed out by knives; that the hollows have since been filled up by the growth of the stone; and hence he concludes that stones vegetate. We wish we were fully assured of the fact, that the letters were at first hollowed, before we attempt to account for their prominency. But even allowing the supposition to be true that they were at first hollow, we reply it is only a single fact, and that from a single fact it is altogether unphilosophical to deduce a general system. In the second place, this protuberancy of the characters is very improperly called vegetation, for it is not produced by a process in any respect like the vegetation of a plant. Vegetation supposes vessels containing fluids, and growth by expansion; but who ever heard of vessels in a stone, of fluids moving in them, or of the different parts expanding and swelling like the branch or trunk of a tree? Even the fact which Tournefort mentions proves nothing. He does not pretend to say that the rock itself is increasing, but only that a few small hollows are filled with new stony matter, which rises a little above the surrounding surface of the rock. This matter evidently has been once liquid, and at length has congealed in the channel into which it had run. But is not this easily explained by a common process, the formation of stalactites? When water charged with calcareous matter is exposed to the action of air, the water evaporates, and leaves the calcareous earth behind, which hardens and becomes like a stone.

Rocking Stone, or *Logan*, a stone of a prodigious size, so exactly poised that it would rock or shake with the smallest force. Of these stones the ancients give us some account. Pliny says, that at Harpasa, a town of Asia, there was a rock of such a wonderful nature, that if touched with the finger it would shake, but could not be moved from its place with the whole force of the body. Ptolemy mentions a gygonian stone near the ocean, which was agitated when struck by the stalk of an asphodel, but could not be removed by a great exertion of force. The word *gygonius* seems to be Celtic; for *gwingog* signifies *motitans*, the rocking stone.

Many rocking stones are to be found in different parts of this island; some natural, others artificial, or placed in their position by human art. In the parish of St Leven, Cornwall, there is a promontory called *Castle Treryn.* On the western side of the middle group, near the top, lies a very large stone, so evenly poised that any hand may move it from one side to another; yet it is so fixed on its base that no lever nor any mechanical force can remove it from its present situation. It is called the *Logan-stone*, and is at such a height from the ground that no person can believe that it was raised to its present position by art. But there are other rocking stones, which are so shaped and so situated, that there can be no doubt but they were erected by human strength. Of this kind Borlase thinks the great *Quoit* or *Karn-lehau*, in the parish of Tywidnek, to be. It is thirty-nine feet in circumference, and four feet thick at a medium, and stands on a single pedestal. There is also a remarkable stone of the same kind in the island of St Agnes in Scilly. The under rock is ten feet six inches high, forty-seven feet round the middle, and touches the ground with no more than half its base. The upper rock rests on one point only, and is so nicely balanced that two or three men with a pole can move it. It is eight feet six inches high, and forty-seven in circumference. On the top there is a basin hollowed out, three feet eleven inches in diameter at a medium, but wider at the brim, and three feet deep. From the globular shape of this upper stone, it is highly probable that it was rounded by human art, and perhaps even placed on its pedestal by human strength. In Sithney parish, near Helston, in Cornwall, stood the famous logan or rocking stone, commonly called *Men Amber*, q. d. *Men an Bar*, or the *top-stone*. It was eleven feet by six, and four high, and so nicely poised on another stone that a little child could move it, and all travellers who came this way desired to see it. But Shrubsall, Cromwell's governor of Pendennis, with much ado caused it to be undermined, to the great grief of the country. There are some marks of the tool on it, and, from its quadrangular shape, it was probably dedicated to Mercury.

That the rocking stones are monuments erected by the Druids, has by some writers been taken for granted; but tradition has not informed us for what purpose they were intended. Mr Toland thinks that the Druids made the people believe that they alone could move them, and that by a miracle; and that by this pretended miracle they condemned or acquitted the accused, and brought criminals to confess what could not otherwise be extorted from them. How far this conjecture is right, we shall leave to those who are deeply versed in the knowledge of antiquities to determine.

Sonorous STONE, a kind of stone remarkable for emitting an agreeable sound when struck, and much used in China for making musical instruments which they call *king*. The various kinds of sonorous stones known in China differ considerably from one another in beauty, and in the strength and duration of their tone; and what is very surprising is, that this difference cannot be discovered either by the different degrees of their hardness, weight, or fineness of grain, or by any other qualities which might be supposed to determine it. Some stones are found remarkably hard, which are very sonorous; and others exceedingly soft, which have an excellent tone; some extremely heavy emit a very sweet sound; and there are others as light as pumice-stone which have also an agreeable sound.

STONEHENGE, a celebrated monument of antiquity, stands in the middle of a flat area near the summit of a hill six miles distant from Salisbury. It is enclosed by a circular double bank and ditch near thirty feet broad, after crossing which we ascend thirty yards before we reach the work. The whole fabric consisted of two circles and two ovals. The outer circle is about 108 feet in diameter, consisting, when entire, of sixty stones, thirty uprights and thirty imposts, of which remain only twenty-four uprights, seventeen standing and seven down, three and a half feet asunder, and eight imposts. Eleven uprights have their five imposts on them by the grand entrance. These stones are from thirteen to twenty feet high. The smaller circle is somewhat more than eight feet from the inside of the outer one, and consisted of forty smaller stones (the highest six feet), of which only nineteen remain, and only eleven standing: the walk between these two circles is 300 feet in circumference. The adytum or cell is an oval formed of ten stones (from sixteen to twenty-two feet high), in pairs, with imposts, which Dr Stukeley calls *trilithons*, and above thirty feet high, rising in height as they go round, and each pair separate, and not connected as the outer pair; the highest eight feet. Within these are nineteen smaller single stones, of which only six are standing. At the upper end of the adytum is the altar, a large slab of blue coarse marble, twenty inches thick, sixteen feet long, and four broad; pressed down by the weight of the vast stones that have fallen upon it. The whole number of stones, uprights, imposts, and altar, is exactly 140. The stones are far from being artificial, but were most probably brought from those called the *Gray Weathers*, on Marlborough Downs, fifteen or sixteen miles off; and if tried with a tool, they appear of the same hardness, grain, and colour, generally reddish. The heads of oxen, deer, and other beasts, have been found on digging in and about Stonehenge; and human bones in the circumjacent barrows. There are three entrances from the plain to this structure, the most considerable of which is from the north-east, and at each of them were raised on the outside of the trench two huge stones, with two smaller within, parallel to them.

Stonehenge.

It has been long a dispute among the learned, by what nation and for what purpose these enormous stones were collected and arranged. The first account of this structure we meet with is in Geoffrey of Monmouth, who, in the reign of King Stephen, wrote the history of the Britons in Latin. He tells us that it was erected by the counsel of Merlin the British enchanter, at the command of Aurelius Ambrosius, the last British king, in memory of 460 Britons who were murdered by Hengist the Saxon. The next account is that of Polydore Virgil, who says that the Britons erected this as a sepulchral monument of Aurelius Ambrosius. Others suppose it to have been a sepulchral monument of Boadicea, the famous British queen. Inigo Jones is of opinion that it was a Roman temple; from a stone sixteen feet long and four broad, placed in an exact position to the eastward, altar-fashion. Dr Charlton attributed it to the Danes, who were two years masters of Wiltshire. A tin tablet, on which were some unknown characters, supposed to be Punic, was digged up near it in the reign of Henry VIII., but is lost; probably that might have given some information respecting its founders. Its common name, *Stonehenge*, is Saxon, and signifies a "stone gallows," to which these stones, having transverse imposts, bear some resemblance. It is also called in Welch *choir gour*, or "the giants' dance."

Mr Grose thinks that Dr Stukeley has completely proved this structure to have been a British temple, in which the Druids officiated. He supposes it to have been the metropolitan temple of Great Britain, and translates the words *choir gour* "the great choir or temple." The learned Mr Bryant is of opinion that it was erected by a colony of Cuthites, probably before the time of the Druids; because it was usual with them to place one vast stone upon another for a religious memorial; and these they often placed so equably, that even a breath of wind would sometimes make them vibrate. Of such stones one remains at this day in the pile of Stonehenge. The ancients distinguished stones erected with a religious view by the name of *amber*; by which was signified any thing solar and divine. The Grecians called them πετραι αμβροσιαι, *petræ ambrosiæ*. Stonehenge, according to Mr Bryant, is composed of these amber stones: hence the next town is denominated *Ambresbury*; not from a Roman Ambrosius, for no such person ever existed, but from the *Ambrosiæ petræ*, in whose vicinity it stood. Some of them were rocking stones; and there was a wonderful monument of this kind near Penzance in Cornwall, which still retains the name of *main-amber*, or the sacred stones. Such a one is mentioned by Apollonius Rhodius, supposed to have been raised in the time of the Argonautæ, in the island Tenos, as the monument of the two winged sons of Boreas, slain by Hercules; and there are others in China and other countries.

STOPPERS, in a ship, certain short pieces of rope, which are usually knotted at one or both ends, according to the purpose for which they are designed.

STORNOWAY, a parish, seaport, and chief town in the island of Lewis, Scotland. The town is situated on a point of land at the head of Loch Stornoway, and was originally placed there by James VI. and erected by him into a borough of barony, in order to act as a means of civilization for the Western Islands. The harbour is capacious and of good depth, and the shipping belonging to the port is much more extensive than could be supposed for a place so remote and uninviting. The town consists of several streets of well-built slated houses, having numerous shops. Its public buildings are a neat and commodious custom-house, a town-house, a parish church, an assembly-room, and two school-houses. The town is a fishing station, and a large proportion of the inhabitants are therefore employed in the white and herring fisheries. The resident feuars and burgesses elect the town council and magistrates, consisting of two bailies and six councillors. The revenue of the borough is very small. The gross custom-house receipts collected here in 1838 amounted to L.519. 2s. 4d. The population of the parish in 1821 amounted to 4119, and in 1831 to 5422. The increase of the population is ascribed to the gradual improvement of the parish, but more particularly to the erection of new stations or villages for the purpose of improving the soil and prosecuting the fisheries.

STOURBRIDGE, a town in the hundred of Halfshire and county of Worcester, 123 miles from London. It stands on the river Stour, over which is a good stone bridge. By a canal it has communication with most parts of the kingdom, and thus distributes its productions, which consist of glass-ware, ironmongery, and pottery. From some excellent clay to be found in the vicinity, the inhabitants make a great number of crucibles. It is an ancient borough, governed by bailiffs and other officers, but sends no members to parliament. It has a market on Fridays. The inhabitants amounted in 1801 to 3431, in 1811 to 4072, in 1821 to 5090, and in 1831 to 6148.

STOURPORT, a market-town of the county of Worcester, which owes its origin to the recent formation of basins at the junction of the river Stour with the Severn. In these basins the barges that pass on the canals in the north of England meet the vessels which ascend the Severn from Bristol and Gloucester; and thus goods are transmitted from one part of the kingdom to the other with regularity and economy. The vicinity abounds in coal, much of which supplies the salt-makers at Droitwich, as well as the glass-makers in and around the place, and the iron-workers also, who abound in the neighbourhood. The town is well built, most of the houses being of recent erection. There is a handsome chapel of ease, and a magnificent iron bridge over the Severn, with a single arch of 150 feet span. On Wednesdays and Saturdays it has markets, which are well supplied. It is 124 miles from London, and eleven from Worcester. As it is a part of the parish of Old Swenford, which lies in two counties, the population-tables do not sufficiently show what has been the population of this new town at the four decennial parliamentary enumerations. It is now estimated at 6800.

STOVE, for heating apartments, green-houses, hot-houses, fruit-walls, &c.

When treating of the mechanical properties of air, we explained the manner in which the expansion occasioned by heat produces the draught up the chimney; and in the article SMOKE we considered the circumstances which tend to check, to promote, and to direct this current, so as to free us from the smoke and vitiated air which accompany the consumption of the fuel. Under HEAT, the communication and radiation have been fully explained. By the former, the caloric is given from one object to another, and communicated from particle to particle of the same object *by contact;* by the latter, it emanates in straight lines, through the air, from substance to substance, the emanations being absorbed by some bodies, and reflected by others.

The power which objects possess of receiving and communicating heat by the former of these modes, is termed their *conducting power;* by the latter, their *radiating,* their *absorbing,* and *reflecting* power. Those which receive it quickly by the former, also give it off quickly in the same way; and those which radiate powerfully also absorb powerfully; of course they reflect little: accordingly the radiating and reflecting powers are opposed to each other. Metals are good conductors; stones, bricks, and porous bodies of a similar nature, are bad conductors. The radiating, reflecting, and absorbing powers depend not so much on the nature of the substance, as on the surface. Highly polished surfaces radiate and absorb little, while dark and rough ones radiate and absorb powerfully; of course, resplendent surfaces are good reflectors.

When fuel is consumed with the view of heating apartments, the communication of heat depends entirely on the manner in which it is consumed. In an open fire-place or common grate, the heat thrown into the apartment is chiefly that emitted by radiation and reflection; the former coming directly from the fuel, and from the parts of the fire-place warmed by it; the latter being the radiated heat reflected by the polished parts of the grate. The rays thus thrown off, being absorbed by the objects in the room, then communicate warmth to the atmosphere which it contains. But part of the warmth must also be received by communication; for the walls adjoining the fire-place being heated by *contact,* will likewise communicate caloric to the air brought in contact with them; and as it is expanded it will ascend, and allow other particles to flow in, also to receive their supply. This however is small in comparison to that given to the apartment by radiation and reflection.

Much of the heat thus thrown into the room is carried off, indeed may be said to be lost; for, owing to the manner in which the fuel is consumed, a large supply of air is necessary for the combustion, which, rushing in upon the fuel, is itself, after acting on it, carried up the vent. Hence, to warm apartments in this way, a great deal of fuel is required. The quantity must depend very much on the form of the fire-place, and on the materials of which it is constructed.

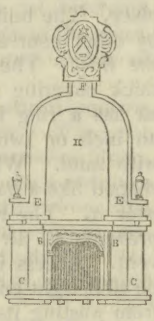
The principle on which stoves operate is different. A stove, however modified in form, is merely a fire-place enclosed on all sides; the air necessary for the combustion entering from below, and carried off, as in a common grate, by a vent. Now, in this way of consuming fuel, the radiation is trifling in comparison to the communication by contact. Of course much must depend on the kind of stove employed; but it is allowed, that by far the greater part of the heat which the atmosphere of the room receives is that given directly by communication; for the air in contact with the sides of the stove is heated, is expanded, and carried upwards; and thus, by the constant flow of cool air on the stove, the whole of that in the room is warmed. No doubt, the stove being itself warm, must give off heat, not only by contact, but also by radiation; and the proportion thus emitted must depend on the temperature and surface, as already explained. But though heat is thus distributed, yet it must be borne in mind, that it is chiefly by contact that the atmosphere of the room is warmed; and as the air is thus easily heated, much less fuel is required than when it is burned in an open fire-place. The necessary supply of air is therefore not so great; and it is this which principally causes the difference in our feelings when in a room warmed by a stove, and by a grate; for in the latter instance, not only have we the exhilarating influence excited by the blaze of the fuel, but there is a more rapid renewal of air through the apartment, and accordingly the atmosphere has not the close unpleasant feeling which it has when warmed by a stove.

The warming by stoves must therefore be conducted on principles different from those adopted in the employment of open fire-places. The general principle is, 1st, to employ the fuel in the most effectual manner for heating the external part of the stove, which is immediately efficient in warming the contiguous air, chiefly by contact; and, 2d, to keep within the room the air thus warmed, at least as much as is consistent with wholesomeness and cleanliness. It would occupy a volume to describe the immense variety of stoves which ingenuity has constructed. We shall content ourselves with giving a specimen of the two chief classes into which they may be distinguished.

The air of a room may be equally warmed by applying it either to the surface of a small stove made very hot, or to the surface of a much larger stove more moderately heated. The first kind is chiefly used in Holland, Flanders, and the milder climates of Germany and Poland. The last are used in the frozen climates of Russia and Sweden. The first are generally made of cast-iron, the last partly of iron and partly of brick-work.

Fig. 1 represents a small German stove, fully sufficient for warming a room of 24 feet by 18. The base is about three feet broad and fourteen inches deep, that is, from back to front, and six or seven feet high. The decoration is in the fashion of that country; but the operative structure of it will admit of any style of ornament. A is the fire-place, and the wood or charred coal is laid on the bottom, which has no bars. Bars would admit the air too freely among the fuel, and would both consume it too fast and raise too great a heat. That no heat may be uselessly expended, the sole of the fire-place and the whole bottom of the stove is raised an inch or two above the floor of the room, and the air is therefore warmed by it in succession, and rises upwards. For the same reason, the back of the stove is not in contact with the wall of the room, or of the niche in which it is placed. The fire-place is shut up by a door which fits closely to its case, and has a small wicket at the bottom, whose aperture is regulated by a sliding plate, so as to admit no more air than what suffices for slowly consuming the fuel. The flame and heated air rise to the top of the fire-place, three or four inches above the arch or mantle-piece, and get out laterally by two narrow passages B, B, immediately below the top-plate of the base. The current bends downward on each side, passes at C, C, under the partition-plates which divide the two side-chambers, and then rises upwards through the outer division of each, and passes through narrow slits D, D, in the top-plate, and from thence along the two hollow piers, E, E. The two lateral currents unite at the top of the arch, and go through the single passage F into the larger hollow behind the escutcheon G. From this place it either goes straight upwards into the vent in the wall by a pipe on the top of the stove, or it goes into the wall behind by a pipe inserted in the back of the stove. The propriety of this construction is very obvious. The current of hot air is applied to the exterior of the stove everywhere except in the two side-chambers of the base, where the partition-plates form one side of the canal. Even this might be avoided by making each of these side-chambers a detached hollow pillar. But this would greatly increase the trouble of construction and joining together, and is by no means necessary. The arch H has a graceful appearance, and affords a very warm situation for any thing that requires it, such as a drink in a sick person's bed-chamber, &c. Persons of a certain class use this place for keeping a dish warm; nay, the lower part of the arch is frequently occupied by an enclosed chamber, where the heat rises high enough even for dressing victuals, as will be easily imagined when we reflect that the sole of it is the roof of the fire-place.

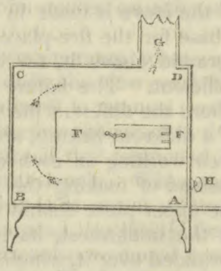
Fig. 1.



The stove now described is supplied with fuel and with air by the front door opening into the room. That there may be space for fuel, this middle part projects a few inches before the two side-chambers. These last, with the whole upper part of the stove, are not more than ten inches deep. The passages therefore from the fire-place are towards the back of it; so that if we have a mind to see the fire, which is always cheerful, the door may be thrown open, and there is no danger of the smoke coming out after the current has once warmed the upper part of the stove. When the stove is of such dimensions that the base is about two feet and a half or three feet high, the fire-place may be furnished with a small grate in the British style. If the door is so hung that it can not only be thrown back, but lifted off its hinges, we have a stove-grate of the completest kind, fully adequate, in our mild climate, to warm a handsome apartment, even with an open fire; and when we hang on the door, and shut up the fire-place, a stove of the dimensions already given is almost too much for a large drawing-room.

A very simple form of stove is that represented in the annexed cut. It consists of a square box of iron, A B C D, resting on feet, and having a projecting hearth-plate at E. FF is an inner box projecting into the outer one. G is the chimney. The fuel is burned at A; and the flame passes to the chimney around the inner box, which may be used as an oven for cooking. At H there is a large door for the introduction of the fuel, in which there is also a smaller door. Both of these are generally kept shut when the furnace is in use; but when a greater heat is required, the smaller door is opened.

Fig. 2.



The effect of stoves as now described may be greatly increased, as is frequently done, by having the mouth communicating with or joined to an opening of the same dimensions, formed in the wall; and the door is in this case on the other side of the wall, in an antechamber or lobby. In some places the apartments are disposed round a spacious lobby, in which the doors of all the stoves are situated, and through which the fuel and air necessary for the combustion are supplied. But this method, though it warms the apartment, is very unfavourable to health and cheerfulness; for the same air confined and repeatedly breathed, and adulterated with the volatile emanations of the room, loses the refreshing quality which is so desirable, and even so necessary for health.

Something of this kind, it has been already mentioned, is unavoidable in all rooms warmed by stoves; and the hotter the surface of the stove, the more and more unpleasant does the air in it become; because, in addition to the slight renewal of air consequent on their use, when the surface becomes very hot, the impurities constantly floating in the atmosphere are decomposed, and emit offensive effluvia. The stove already described is almost always made of metal, and this objection applies particularly to it; hence the necessity of being attentive when cleaning it outside, to avoid the contact of greasy or oleaginous matter, which is so easily decomposed by heat, and gives off offensive and deleterious vapours.

The objections stated to the stoves as now described, have given rise to the use of those constructed of brick-work, or other materials of a similar nature. These are much used in Flanders, Holland, and Germany, where they are made of the most elegant forms, and finely decorated; but it is evident that they cannot be so effectual, nor equally warm a room with the same expense of fuel; earthen ware being inferior to metal in its conducting power. In addition to this, they are liable to a very great objection, the difficulty of preventing their cracking when heated; for different parts of the stove being of different heats, they expand unequally; and no cement can be expected to withstand this, especially when we recollect, that the heat which causes the baked earthen ware to expand, causes a contraction of the clay or cement with which the parts of the stove are joined together. Accordingly stoves of this kind do not stand long without cracking, even when strengthened by iron hoops and cramps judiciously disposed within them; nor does hooping them externally prevent it. When a crack is thus occasioned, it is not only unsightly, but may be dangerous, from its allowing the vitiated air to escape into the apartment.

For these and other reasons, we can scarcely hope to make stoves of brick-work or pottery which shall bear the necessary heat without cracking; and their use must therefore be confined to cases where very moderate heat is sufficient. We need not describe their construction. It is evident that it should be more simple than that of iron stoves; and we imagine, that in the very few cases in which they are likely to be employed in this country, a single fire-place, and an arch over it, divided by a partition or two of thin tile to lengthen the flue, will be quite enough. If the stove is made in whole or in part of potter's ware, a base for the fire-place, with an urn, column, obelisk, or pyramid above it, for increasing the surface, will also be sufficient. The failure commonly happens at the joinings, where the different pieces of a different heat, and perhaps of a different baking, are apt to expand unequally, and by their working on each other, one of them must give way. Instead of making the joints close and using any cement, the upper piece should therefore stand in a groove formed in the undermost, having a little powdered chalk or clay sprinkled over it, which will effectually prevent the passage of any air; and room being thus given for the unequal expansion, the joint remains entire. This may be considered as a general direction for all furnace-work, where it is in vain to attempt to hinder the mutual working of the parts. When fitted up with these precautions, the brick or pottery stoves are incomparably more sweet and pleasant than the iron ones.

But in the intense colds of Russia and Sweden, or even for very large rooms in this kingdom, stoves of these small dimensions are not sufficiently powerful; and we must follow the practice of those countries where they are made of great size, and very moderately heated. It is needless to describe their external form, which may be varied at pleasure. We shall only enlarge a little on the peculiarities connected with the general principle of their construction.

The stove is intended as a sort of magazine, in which a great quantity of heat may be quickly accumulated, to be afterwards slowly communicated to the apartment. The stove is therefore built extremely massive, and is found to be more powerful when coated with clay as wet as can be made to hang together. We imagine the reason of this to be, that very wet clay, and more particularly stucco, must become exceedingly porous when dry, and therefore a very slow conductor of heat. Instead of sticking on the glazed tiles with no more clay or stucco than is sufficient to attach them, each tile has at its back a sort of box, baked in one piece, about two or three inches deep. It is represented in fig. 3. This is filled with mortar, and then stuck on the brick-work of the stove, which has a great number of iron pins or hooks driven into the joints, which may sink into this clay and keep it firmly attached when dry. This coating, with the massive brick-work, forms a great mass of matter to be heated by the fuel. The lowest chamber, which is the fire-place, is somewhat wider, and considerably thicker than the stories above, which are merely flues. When the fire-place is finished, and about to be arched over, a flat iron bar of small thickness is laid along the top of the side-wall on both sides, a set of finishing bricks being moulded on purpose, with a notch to receive the iron bar. Cross bars are laid over these, one at each end and one or two between, having a bit turned down at the ends, which takes hold of the longitudinal bars, and keeps them from being thrust outwards either by the pressure of the arch or by the swelling in consequence of the heat. In fig. 4, A is the cross section of one of the long bars, and BC is part of one of the cross bars, and CD is the clench which confines the bar A. This precaution is chiefly necessary, because the contraction of the stove upwards obliges the walls of the other stories to bear a little on the arch of the fire-place. The building above is kept together in like manner by other courses of iron bars at every second return of the flue. The top of the stove is finished by a pretty thick covering of brick-work. The last passage for the air has a ring lining its upper extremity, and projecting an inch or two above it. The flat round it is covered with sand. When we would stop this passage, a cover shaped like a basin or cover for dishes at table is whelmed over it. The rim of this, resting on the sand, effectually prevents all air from coming through and getting up the vent. Access is had to this damper by a door which can be shut tight enough to prevent the heated air of the room from wasting itself up the vent. When the room is too warm, it may be very rapidly cooled by opening this door. The warm air rushes up with great rapidity, and is replaced by cool air from without.

Fig. 3.

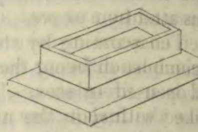
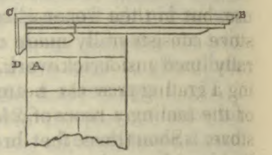


Fig. 4.



In a stove of this kind the fire is kindled early in the morning, after which the stove-door is shut, and the air-aperture below left open for some time to blow it up; but in the course of a short time, to prevent the too rapid consumption of the fuel, the fire-door is opened, by which the draught is checked. In this way the combustion is allowed to go on, and the materials of the stove become warmed, after which the air-passages are shut, so as to prevent any abstraction of heat by the current that would otherwise be occasioned. The stove thus becomes a great mass of heated matter, which is gradually pouring warmth into the apartment during the whole of the day; and as the temperature of the surface never becomes very high, the impurities in the atmosphere are not decomposed, and consequently it is free from those offensive effluvia unavoidable when metal stoves are used. One precaution, however, is necessary in the management of these stoves, which does not apply to the metal ones; we must take care that when the air-apertures are closed, there is no back-draught to carry the products of combustion into the apartment, which might be attended with fatal consequences. These being almost free from smoke, give little or no warning of their presence, and when inhaled for some time, produce giddiness and lassitude, and in some cases a dangerous state of insensibility. Hence the necessity of allowing the fire to be burned down, or nearly so, before closing the air-apertures. Should the escape of the noxious gases into the room be suspected, the furnace-door and air-apertures must be opened, and a draught established through the stove, by kindling some wood shavings in it, the door and windows of the room being at the same time thrown open. This attention to back-draught is of course more necessary when charcoal or coke is used instead of coal, the products of combustion being then entirely free from smoke. When coal is used in stoves, the vent-tubes are apt to become choked with soot; but this may in a great measure be prevented by giving for a short time every day a brisk draught, by which the soot will be burned.

To prevent the injurious or disagreeable effects of the first kind of stoves, and at the same time to secure their advantages, numerous modifications have been proposed, not only with the view of preventing the too great heat of the external surface, but also of avoiding unnecessary expenditure of fuel. Perhaps the most important of these is *Arnott's stove;* the principle of which consists in allowing the fuel to burn very slowly, the admission of air for the combustion being regulated by an adjustment connected with the stove, and influenced by the degree of heat produced. Numerous forms and modifications of this stove are now in use, but in their general structure they are the same. The stove consists of a square or cylindrical box of iron, generally lined inside with a thick layer of fire-clay, and having a grating near the bottom, on which the fuel is burned; or the fuel may be contained in a small fire-box within the stove. Sometimes the fuel is burned within a hollow cylinder of fire-clay, in which case the stove is not lined with it. There is an ash-pit below for the reception of the ashes, and the products of the combustion are, as usual, carried off by a vent.

The principal feature of this stove is the contrivance by which the air is admitted for the combustion. When the stove-door or ash-pit door is open, the combustion is lively, and the fuel is soon consumed; but when these are shut, and they ought to be so made as to shut quite close, then air must be admitted otherwise, and this is done by the air-tube, furnished, as already stated, with a regulator.

Fig. 5.

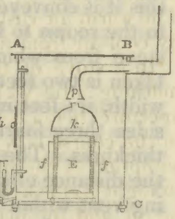
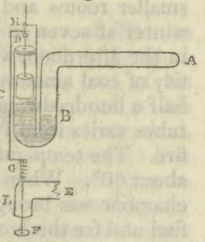


Fig. 6.



The annexed figure represents the stove of its simplest form. ABCD is the outer casing of iron, in which there is the fire-box E, with its grating. Over the fire-box there is a dome, *k*, with a funnel to carry the products of combustion into the chimney; *h* is the stove-door, and *g* is the *thermometer regulator*, or adjustment by which the air is admitted for combustion. A great variety of these regulators has been described. Perhaps the best of these is represented by the annexed cut. ABC is a glass tube, shut at A, containing air from A to B, and filled with mercury from B to C. On the mercury at C is placed a float, from which there proceeds an upright rod D, kept steady by passing through a support at H. From this upright wire there descends another, FGH, terminated by the plate-valve F. LE is the air-tube of the stove. When the heat within is great, the air in the shut limb of the regulator at A is expanded, and forces up the mercury at C, raising the rods and plate-valve F, and thus bringing it near to, or in contact with, the mouth of the tube, by which more or less air is admitted to the stove, according to the heat within. If the combustion is proceeding too slowly, then the air in the tube A is not much expanded, consequently air is allowed to enter the stove more freely; but when, owing to this, the combustion becomes lively, and the temperature too high, then, by the elevation of the plate-valve, air enters in smaller quantity, and the temperature is moderated. Instead of the flat plate a conical valve is sometimes used, which, passing more or less into the mouth of the tube, allows the passage of less or more air; and sometimes this contrivance is resorted to. *ed* is the wire raised by the movement of the mercury; *ab* is a plate hung on an axis within the air-tube, and acting like a throttle-valve. When the edge of the plate is turned to the current, air is admitted freely; but when the heat becomes high, then the mercury rises and makes the plate revolve, by which more and more of the area of the tube is shut, and consequently less and less air is admitted. Perhaps the simplest of these regulators is that here represented. *abc* is a bent tube shut at *a*, where it contains air, and open at *c*, where it is cup-shaped. The bent part at *b* is occupied by mercury. From *c* there proceeds a bent tube to supply air to the stove. When the heat within is great, the air in *a* is expanded, and forces the mercury up in *c*, and thus, bringing it in contact with the mouth, prevents the free admission of air to the stove. Numerous other contrivances of a similar nature have been recommended, all acting in the same way. Instead of these, the admission of air is sometimes regulated by a semicircular slide over the mouth of the air-tube, which may be placed so as to admit to the stove a greater or smaller quantity, as occasion requires.

Fig. 7.

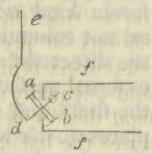
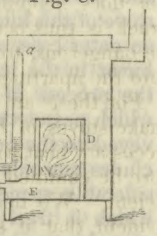


Fig. 8.



The principle on which this stove operates, whatever modification of it may be used, is merely the slow combustion of the fuel, by which the stove itself is warmed; and there is thus a reservoir of heat to be communicated to the air in the apartment. As the quantity of fuel consumed is small, there is no necessity for frequent supply. When one of the ordinary dimensions for a room is in use, it will require to be supplied morning and evening, supposing that it is kept constantly burning, and the ashes removed once a day. These, instead of falling into the ash-pit, may be received in a box placed there for the purpose, which is taken out and emptied, so as to avoid dust in the apartment.

The quantity of fuel consumed must of course depend on circumstances. During the severe winter of 1836–37, Dr Arnott kept his library at a temperature varying from 60° to 63° of Fahrenheit, by about six pounds of coal a day; which, supposing the coal to be twenty shillings per ton, is at the daily expense of less than a penny.

Though the Arnott stove answers well the purpose for which it is intended, that is, economy of fuel, for most undoubtedly a room may be kept warm at a very moderate expense, yet it is liable to the objection already stated with regard to the unpleasant feeling consequent on the use of all stoves of the kind, and indeed with it more than others; for, owing to the very slight expenditure of fuel, there is little or no change in the atmosphere. It is generally allowed that a pound of coal on an average requires about 150 cubic feet of air for combustion; but as part of the air passes off without being acted on, 200 may be allowed, and this is a large allowance where the combustion is going on so slowly as in the stove. Now suppose the apartment in which the stove is placed to be fifteen feet long by twelve wide and eleven in height, its cubic contents are 1980 feet; and suppose six pounds of coal per day to be the consumption, each pound requiring about 200, that is in all 1200 feet of air for combustion. This quantity must pass through the stove and be carried off by the vent, so that in the course of twenty-four hours the atmosphere of the apartment is not once completely changed, and consequently renewed, by the direct influence of the fire. Hence it is that the apartment is so easily warmed; but it is this which necessarily renders it so unpleasant.

The stoves now described answer for small apartments. When the place to be heated is large, or when several apartments in the same building are to be warmed, a different kind is used. The heat in these cases is in general not communicated to the apartment or apartments by the direct influence of the stove, but by air heated by its external surface (of course not brought into contact with the fuel), and then conveyed by tubes or otherwise to the places to be warmed, on the principle already illustrated, that when heated it expands and ascends, and consequently rushes along the tubes, the supply being kept up by the constant flow of cold air upon the hot sides of the stove. Stoves for this purpose are made of iron or of brick-work, and sometimes of both. Fig. 9 represents a cast-metal stove of this kind. It may be considered as a double stove; an outer case, and a furnace or inner stove. The fuel is burnt in the inner stove, and the smoke produced during the process of combustion is carried off by a chimney, which passes through the top of the outer stove, and is conveyed to the outside of the building. The outer case includes not only the furnace or inner stove, but also a considerable space, occupied by the air of the atmosphere, which is freely admitted through a number of openings placed around it; and when any current of air is produced, it passes off from the space between the outer case and inner stove, and is conveyed by tubes through the body of the apartment. But we shall first describe the different parts of which the stove is composed, after which we shall be better able to understand its mode of operation.

Fig. 9.

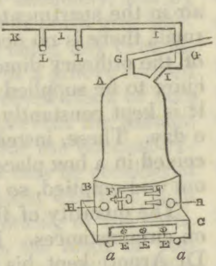


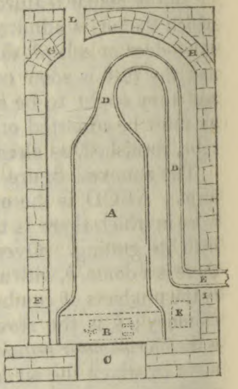
Fig. 9 exhibits a perspective view of this stove. AB is the body, which is about three feet high, and of a circular form. C is a square pedestal, on which the stove is placed, and which contains the ash-pit. The height of the pedestal is about a foot, and it is nearly insulated by resting on the spherical supports *a a*, also of cast iron. EEE are openings in front of the ash-pit, through which the air enters to support the combustion. These openings can be enlarged or diminished, or opened and shut, at pleasure. FF is the door of the furnace, through which the fuel is introduced. This door is attached to the inner furnace, and is double. It is one foot broad, and eleven inches high. GG is the chimney, which passes from the furnace within, through the outer case, and conveys the smoke out of the building. HH are openings in the outer case, and are eight in number, through which the air enters, and being heated, is greatly rarefied, and passes off through the funnel or pipe III. This pipe communicates only with the outer stove, and being shut at the end K, the air rushes out from the small tubes LL, inserted into the side of the pipe III, and thus mixes with the cold air of the apartment. The diameter of the outer case at the bottom is about two feet, and the diameter of the furnace within is about sixteen inches.

The length of the body of a church in which two stoves of the form and dimensions now described are erected, is about sixty feet, and the breadth is about forty-five feet. The tubes III are conveyed along the lower edge of the gallery, about half the length of the church. The fires are lighted about four or five o'clock on the Sunday morning during the earlier part of the cold season, but as the season advances it is usual to light them earlier. From this time till the congregation assembles for the afternoon service, the furnaces are constantly supplied with fuel. By this management the air in the church is kept comfortably warm during the coldest season of the year.

When only one apartment is to be heated by a stove of this kind, the stove ought to be placed in the apartment, because then it is supplied with air from it, which has been previously heated; whereas, when it is placed in another situation, the supply of heated air thrown into the apartment being derived from without, that within must be forced out to make way for it, and consequently at a great expenditure of fuel. When several apartments are to be warmed, suppose those of a dwelling-house, the stove ought to be situated in some part of the lobby, from which the tubes proceed to the rooms. Of course the size of the stove, and the distribution and size of the tubes, must depend on the supply of heat required.

There is one very great objection to the stove as now described. It has been already stated, that when air is projected against a red-hot surface, the impurities constantly floating in it are burned, and emit offensive effluvia; and this is generally the case with metallic hot-air stoves. Hence the necessity of having them so placed that they shall be supplied with air as free as possible from impurities. Instead of having the whole of the stove made of metal, the inner part is sometimes metal and the outer covering brick-work; in which case the chamber between them is generally larger than in the others, consequently the temperature does not become so high, and the objection urged against the metal stoves is in a great measure removed.

Fig. 10.



The annexed figure represents a vertical section of a stove of this kind. A is the stove of metal, with the door at B and ash-pit at C. DD is the vent, making a turn downwards, and carried into the chimney at E. FGHI is the outer casing of brick-work, completely enclosing the stove, and also the descending part of the vent; K is the opening for the admission of air to the hot chamber. L is the tube for carrying off the warm air, and from this it is conveyed by other tubes to the rooms to be heated. The stove from which this figure is taken is two feet and a quarter in width, six feet in height, and the sides three fourths of an inch in thickness. The brick casing is at the distance of six inches from the metal, and the descending vent within is six inches in diameter. It is used for warming a lecture-room thirty-five feet long, twenty-seven broad, and twenty high, also a large apartment thirty feet long, twenty-seven broad, and eighteen high, besides two smaller rooms and a staircase. The fire is kindled during winter at seven in the morning, and kept burning till four in the afternoon, when it is allowed to go out. The quantity of coal amounts daily, on an average, to rather less than half a hundredweight. The temperature of the air from the tubes varies from 120° to 180°, according to the state of the fire. The temperature of the different apartments is kept at about 60°. When first erected, the supply of air for the hot chamber was brought from without; but now the air for the fuel and for the hot chamber are both taken from the apartment in which the stove is placed, which is generally at the temperature of 70°.

When the place to be heated is spacious, or when there are several apartments, it is customary to have the part of the stove immediately exposed to the fire lined with fire-brick, in order to prevent the direct action of the fuel on the metal; for in these instances the stove is much larger than that described, and consequently the fire more powerful. Its size must depend on the size and number of the apartments. In its general construction it resembles the other, consisting of the inner part for the fuel, with its grating, ash-pit, and vent, and of the outer casing, with the aperture for the supply of air to the chamber, and the tube or tubes for its transmission to the apartments.

The great advantage attending the use of stoves of this kind is, that they do not become so warm as to decompose the impurities in the air flowing into the hot chamber, and consequently there are no offensive effluvia generated. As the temperature is not so high as that of metal stoves, more of the warm air is requisite, by which there is a frequent renewal of that in the apartment, and the temperature throughout is more uniform than when a smaller quantity of hotter air is admitted. It has already been mentioned that the temperature of the air from the hot chamber of the stove described is from 120° to 180°. Perhaps this is higher than it ought to be. Many prefer having the stove so constructed that the temperature of the air which it throws into the apartment shall not exceed 70°. Of course, in this case, a much larger quantity of it is necessary. By throwing in a sufficient supply, that of the apartments may be maintained at about 60°. The mouths of the hot air-tubes are made to terminate as near the floor as possible, that the air may rise, and gradually mix with the atmosphere of the apartment.

In erecting stoves for the supply of hot air in this way, there are many circumstances to be considered, to which it would here be useless to allude. Much must depend on local situation, the size and number of the apartments, and the draught through them. These considerations must be left to the skill and ingenuity of the workman, who must be guided by keeping in view the general principles which determine the supply of air to the furnace, the ascensional force of the column of warm air to be conveyed through the tubes, the manner in which the apartments to be warmed are disposed, &c.

In heating buildings by these stoves when they are not in constant use, as is the case in churches, the time for keeping them going must also depend on circumstances. If the object is merely to throw in a supply of warm air, then the stove must be kindled a few hours before the apartment is to be occupied, especially if it is not expected that there shall be much change in its atmosphere; but if the object is to keep the place warm, then the stove ought to be kept in constant use, so as to be constantly throwing in warm air. During night the fire can be damped, and it is again made brisk when required. This is much better than allowing the fire to go out, because in again heating the stove to the requisite temperature, there must be a considerable waste of fuel. After the fire is in good condition, and the stove well heated, the combustion should be allowed to proceed slowly, which is accomplished by the proper regulation of the draught.

STOW, JOHN, an industrious historian, son of Thomas Stow, merchant-tailor, of St Michael's, Cornhill, in London, was born about the year 1525. Of the early part of his life we know very little, except that he was bred to his father's business, which in the year 1560 he relinquished, devoting himself entirely to the study of our ancient historians, chronicles, annals, charters, registers, and records. Of these he made a considerable collection, travelling for that purpose to different parts of the kingdom, and transcribing such manuscripts as he could not purchase. But this profession of an antiquary being attended with no present emolument, he was obliged for subsistence to return to his trade. It happened, however, that his talents and necessities were made known to Dr Parker, archbishop of Canterbury; who being himself an antiquary, encouraged and enabled Stow to prosecute his darling study. In those times of persecution, though Elizabeth was then upon the throne, honest John Stow did not escape danger. His collection of popish records was deemed a cause of suspicion. His younger brother Thomas preferred no less than 140 articles against him before the ecclesiastical commission; but the proof being insufficient, he was acquitted. In 1565 he first published his Summary of the Chronicles of England. About the year 1584 he began his Survey of London. In 1585 he was one of the two collectors for a great muster of Limestreet ward. During the same year he petitioned the corporation of London to bestow on him the benefit of two freemen, to enable him to publish his Survey; and in 1589 he again petitioned for a pension. Whether he succeeded is not known. He was principally concerned in the second edition of Holinshed's Chronicle, published in 1587. He also corrected and twice augmented Chaucer's Works, published in 1561 and in 1597. His Survey of London was first published in 1598. To these laborious works he would have added his large Chronicle, or History of England; but he lived only to publish an abstract of it, under the title of "*Flores Historiarum*, or Annals of this Kingdom, from the time of the Ancient Britons to his own." This work was printed in 1600. The folio volume which was printed after his death, with the title of Stow's Chronicle, was taken from his papers by Edmund Howes. Having thus spent his life and fortune in these laborious pursuits, he was at last obliged to solicit the charitable and well-disposed for relief. For this purpose, King James I. granted him in 1603 a brief, which was renewed in 1604, authorizing him to collect in churches the benefactions of his fellow-citizens. He died in April 1605, aged eighty; and was buried in his parish church of St Andrew's Undershaft, where his widow erected a decent monument to his memory. John Stow was a most indefatigable antiquary, a faithful historian, and an honest man.

STOW ON THE WOLD, a town of the hundred of Haughton, in the county of Gloucester, eighty-two miles from London. It stands on a hill in a wild district near the river Windrash. It is irregularly and not well built. The parish is very extensive, though not densely peopled. The town has a market on Thursday, and several fairs at which sales are made of hops, sheep, and cheese. The inhabitants amounted in 1801 to 1471, in 1811 to 1544, in 1821 to 1731, and in 1831 to 1810.

STOWEY-NETHER, a town of the county of Somerset, in the hundred of Willerton and Freemanners, six miles from Bridgewater, and 149 miles from London. It is in a fertile district at the foot of the Quanloch Hills. It formerly contained a castle, of which no vestige now appears, though the ditch that surrounded it may be traced. The parish church is a handsome building; and near to it is a spring, which has the property of incrusting, with the appearance of stone, pieces of wood, or other substances that may be thrown into it. There is a small market held on Thursday. The population amounted in 1801 to 586, in 1811 to 620, in 1821 to 773, and in 1831 to 778.

STOWMARKET, a town in the hundred of Stow and county of Suffolk, seventy-six miles from London. It stands on the river Orwell, and has also a canal. It is a place of small trade, with a market on Thursday. The inhabitants amounted in 1801 to 1761, in 1811 to 2006, in 1821 to 2252, and in 1831 to 2672.

STOWAGE, the general disposition of the several materials contained in a ship's hold, with regard to their figure, magnitude, or solidity.

STRABO, an illustrious geographer, was born at Amasia, a city of Cappadocia. The time of his birth cannot be ascertained, but he is known to have flourished during the age of Augustus and Tiberius. He studied under

Xenarchus, a Peripatetic philosopher; but afterwards, influenced by the authority of Athenodorus, who had been his preceptor, and who became eminent in the reign of Augustus, he adopted the tenets of the Stoics. He obtained the friendship of Cornelius Gallus, governor of Egypt. In order to collect materials for his great work, he travelled in many different regions; and after much toil and research completed his Geography, which is justly regarded as a very precious relique of antiquity. It consists of seventeen books, all of which are not however entire. The first two books are employed in showing that the study of geography is not only worthy of, but even necessary to, a philosopher; the third describes Spain; the fourth, Gaul and the Britannic isles; the fifth and sixth, Italy and the adjacent isles; the seventh, which is imperfect at the end, Germany, the countries of the Getæ and Illyrii, Taurica Chersonesus, and Epirus; the eighth, ninth, and tenth, Greece with the neighbouring isles; the four following, Asia within Mount Taurus; the fifteenth and sixteenth, Asia without Taurus, India, Persia, Syria, Arabia; and the seventeenth, Egypt, Ethiopia, Carthage, and other countries of Africa.

Strabo's Geography first appeared in a Latin version, executed by Phavorinus and Tifernas, and printed at Rome by Sweynheym and Pannartz. It is an ample folio volume, without date, but is supposed to have been printed in or about the year 1469. The earliest edition with a date is that of Venice, 1472, fol. The *editio princeps* of the Greek text proceeded from the press of Aldus, Venet. 1516, folio. This edition, which is not distinguished by its accuracy, was succeeded by that of Marcus Hopper, Basil. 1549, fol. He has printed a Latin translation by Glareanus and Hartungus. An edition, containing an elegant version, with notes and castigations, was next produced by Xylander, Basil. 1571, fol. But all these were eclipsed by the edition of Casaubon, Genev. 1597, fol. By the aid of four MSS. and of his own critical sagacity, he greatly improved the Greek text. He retained the version of Xylander. He afterwards augmented and improved his annotations, and the work was reprinted at Paris in 1620, after the death of the very learned editor. This second edition of Casaubon, together with the notes of various other critics, was republished by T. Janson van Almeloveen, Amst. 1707, fol. He has subjoined the *Chrestomathiæ*, or epitome of Strabo; which, according to Dodwell, was compiled by some unknown writer between the years 976 and 996. It had been found of some use, not only in contributing to the correction of the text, but likewise in supplying to a certain extent the defect of the seventh book. An elaborate and valuable edition of Strabo was commenced by Siebenkees, and completed by Tzschucke, Lipsiæ, 1796–1819, 7 tom. 8vo. Much was expected from the edition of Falconer, Oxon. 1807, 2 tom. fol. It was one defect of the editor, that he was not sufficiently acquainted with the labours of the continental critics. Nor must we overlook an edition of the text, illustrated with Greek notes by Coray, Paris. 1815, 4 tom. 8vo. Strabo was translated into German by Penzel. A French translation was undertaken by command of the emperor, and was executed by De la Porte du Theil, Coray, and Letronne. The introduction, and the notes distinguished by the letter G, were contributed by Gossellin. "Géographie de Strabon, traduite du Grec en Français." Paris, 1805–19, 5 tom. 4to.

STRADA, **Famianus**, an ingenious and learned Jesuit, was born at Rome in the year 1572, and there taught rhetoric for fifteen years. He wrote several pieces upon the art of oratory, and published some orations with a view of illustrating by example what he had inculcated by precept. But his "Prolusiones Academicæ" and his "Historia de Bello Belgico" are the works which raised his reputation, and have preserved his memory. His history of the war of Flanders was published at Rome, the first decad in 1640, the second in 1647; the whole extending from the death of Charles V. which happened in 1558, to the year 1590. It is written in good Latin, as all allow; but its merit in other respects has been variously estimated. His "Prolusiones Academicæ" show great ingenuity, and a masterly skill in classical literature; that prolusion especially in which he introduces Lucan, Lucretius, Claudian, Ovid, Statius, and Virgil, each of them versifying according to his own strain. This work has often been printed. Strada died at Rome in the Jesuits College in the year 1649.

STRAHAN, **William**, an eminent printer, was born at Edinburgh in the year 1715. His father, who had a small appointment in the customs, gave his son the education which every one of decent rank then received in a country where the avenues to learning were easy, and open to men of the most moderate circumstances. After having passed through the tuition of a grammar-school, he served an apprenticeship to a printer, and when a very young man removed to a wider sphere in that line of business, and went to follow his trade in London. Sober, diligent, and attentive, while his emoluments were for some time very scanty, he contrived to live rather within than beyond his income; and though he married early, and without such a provision as prudence might have looked for in the establishment of a family, he continued to thrive, and to better his circumstances. This he would often mention as an encouragement to early matrimony; and used to say, he never had a child born that Providence did not send some increase of income to provide for the increase of his household. With sufficient vigour of mind, he had that happy flow of animal spirits that is not easily discouraged by unpromising appearances.

His abilities in his profession, accompanied with perfect integrity and unabating diligence, enabled him, after the first difficulties were overcome, to advance with rapid success. And he was one of the most flourishing men of the trade, when, in the year 1740, he purchased a share of the patent for king's printer, of Mr Eyre, with whom he maintained the most cordial intimacy during the rest of his life. Beside the emoluments arising from this appointment, as well as from a very extensive private business, he now drew largely from a field which it required some degree of speculative sagacity to cultivate, on account of the great literary property which he acquired by purchasing the copyrights of the most celebrated authors of the time. Here his liberality kept pace with his prudence, and in some cases went perhaps rather beyond it. Never had such rewards been given to the labours of literary men, as were received from him and his associates in their purchases of copyrights.

Having now attained the first great object of business, wealth, Mr Strahan looked with a very allowable ambition on the stations of political rank and eminence. Politics had long occupied his active mind, and he had for many years pursued them as his favourite amusement, by corresponding on that subject with some of the first characters of the age. Mr Strahan's queries to Dr Franklin in the year 1769, respecting the discontents of the Americans, published in the London Chronicle of 28th July 1778, show the just conception which he entertained of the important consequences of that dispute, and his anxiety as a good subject to investigate, at that early period, the proper means by which their grievances might be removed, and a permanent harmony restored between the two countries. In the year 1775 he was elected a member of parliament for the borough of Malmesbury in Wiltshire, with a very illustrious colleague, Mr Fox; and in the succeeding parliament, for Wooton Basset, in the same county. In this station, applying himself with that industry which was natural to him, he was a useful member, and attended the house with a scrupulous punctuality. His talents for business acquired the consideration to which they were entitled, and were not unnoticed by the minister.

In his political connection, he was constant to the friends to whom he had first been attached. He was a steady supporter of that party who were turned out of administration in spring 1784, and lost his seat in the House of Commons by the dissolution of parliament with which that change was followed; nor did he show any disposition to resume his place on the return of the new parliament. He had begun to feel some decline in his health, which had rather suffered from the long sittings with which the political warfare had been attended. Without any fixed disease. his strength visibly decayed; and though his spirits survived his strength, yet the vigour and activity of his mind were considerably impaired. Both continued gradually to decline till his death, which happened on the 9th of July 1785, in the seventy-first year of his age.

STRAIKS, in the military art, are strong plates of iron, six in number, fixed with large nails called *straik-nails*, on the circumference of a cannon-wheel, over the joints of the fellows, both to strengthen the wheel, and to save the fellows from wearing on hard ways or streets.

STRAIN or Stress, in *Mechanics*, are terms indiscriminately used to express the force which is excited in any part of a machine or structure of any kind, tending to break it in that part. Thus every part of a rope is equally strained by the weight which it suspends. Every part of a pillar is equally strained by the load which it supports. A mill axle is equally twisted and strained in every part which lies between the part of the wheel actuated by the moving power and the part which is resisted by the work to be performed. Every part of a lever or joist is differently strained by a force acting on a distant part.

It is evident that we cannot make the structure fit for its purpose, unless the strength at every part be at least equal to the stress laid on, or the strain excited in that part. It is no less plain, that if we are ignorant of the principles which determine this strain, both in intensity and direction, in relation to the magnitude and the situation of its remote cause, the only security we have for success is to give to every part of the assemblage such solidity that we can leave no doubt of its sufficiency. But daily experience shows us that this vague security is in many cases uncertain, if we are thus ignorant. In all cases it is slovenly, unlike an artist, attended with useless expense, and in machines is attended with a loss of power which is wasted in changing the motions of a needless load of matter.

It must therefore greatly tend to the improvement of all professions occupied in the erection or employment of such structures, to have a distinct notion of the strains to which these parts are exposed. Frequently, nay generally, these strains are not immediate, but arise from the action of forces on distant parts, by which the assemblage is strained, and there is a tendency to rupture in every part. This strain is *induced* on every part, and is there modified by fixed mechanical laws. These it is our business to learn; but our chief object in this investigation is to determine the strength of materials which it is necessary to oppose in every part to this strain, and how to oppose this strength in such a manner that it shall be exerted to the best advantage. The notions of strain and strength therefore hardly admit of separation; for it is even by means of the strength of the intermediate parts that the strain is propagated to, or excited in, the part under consideration. It is proper therefore to consider the whole together under the article Strength of Materials.

STRAIT, a narrow channel or arm of the sea, enclosed between lands on either side, and affording a passage out of one great sea into another.

There are three kinds of straits. 1. Such as join one ocean to another. Of this kind are the Straits of Magellan and Le Maire. 2. Those which join the ocean to a gulf: the Straits of Gibraltar and Babelmandel are of this kind, the Mediterranean and Red Sea being only large gulfs. 3. Those which join one gulf to another; as the Straits of Caffa, which join the Palus Mæotis to the Euxine or Black Sea.

STRAKES, or Streaks, in a ship, the uniform ranges of planks on the bottom and sides of a ship, or the continuation of planks joined to the ends of each other, and reaching from the stem to the stern-post and fashion-pieces; the lowest of these, which is called the *garboard streak*, is let into the keel below, and into the stem and stern-post. They say also a ship *heels a strake*, that is, hangs or inclines to one side, the quantity of a whole plank's breadth.

Strakes, or *Strcks*, in mining, are frames of boards fixed on or in the ground, where they wash and dress the small ore in a little stream of water, hence called *straked ore*.

STRALSUND, one of the governments into which the Prussian province of Pomerania is divided. It comprehends the whole of what was Swedish Pomerania, with the island of Rugen, and some others in the Baltic Sea. It extends over 1584 square miles, and contains fourteen cities and towns, and 347 villages. The population, by the census of 1817, amounted to 129,239, and by that of 1834 to 153,945. With the exception of about 450 Catholics and 152 Jews, all the inhabitants are of the Lutheran church. The soil is generally fertile and well cultivated, yielding of corn, flax, and hemp, more than is consumed. The capital, a city of the same name, stands in the island of Rugen, opposite the Strait of Gellen, by which it is separated from the continent. The harbour is good and secure, and the city is strongly fortified both on the land and the sea sides. It is ancient, and in a style of building corresponding to its age. It has five churches and a college, with a few other public buildings. In the year 1834 it contained 14,713 inhabitants, who have extensive foreign trade, chiefly in domestic productions. Long. 13. 29. E. Lat. 54. 6. N.

STRANGE, Sir Robert, an eminent engraver, who carried the art to great perfection in this country, and was distinguished not only as an artist, but highly respected and beloved on account of his private virtues and domestic habits. Modest as he was ingenious, he used to say that the works of an artist should serve for his life and monument. His works no doubt will perpetuate his name while any taste for the fine arts remains. He was born in the island of Pomona, in Orkney, on the 14th of July 1721, being lineally descended from David Strange or Strang, a younger son of the family of the Stranges or Strangs of Balcasky, in the county of Fife, who settled in Orkney at the time of the Reformation. But as there were no males remaining of the elder branch of the Stranges of Balcasky, Sir Robert became the male representative of it, and was found by a legal investigation to have a right to the armorial bearings and every other mark of honour belonging to that ancient family. He received his classical education in Kirkwall in Orkney, under the care of a learned, worthy, and much respected gentleman, Mr Murdoch Mackenzie, who has rendered very important service to his country by the accurate surveys and charts which he has given of the islands of Orkney, and of the British and Irish coasts.

Originally intended for the law, Mr Strange soon became tired of that profession, and perceived that his genius decisively led him to the arts of drawing and engraving. For this purpose he was introduced to Mr Richard Cooper of Edinburgh, the only person there who had any taste in that department of the fine arts. He was bound with him as an apprentice for six years; during which time he made such progress in his new profession, that his friends entertained the highest expectation of his success; nor were they disappointed.

Strange, Sir Robert.

In the year 1747 he married Isabella, only daughter of William Lumsden, son of Bishop Lumsden; and soon after his marriage he went to France, where with the most ardent application he prosecuted his studies, chiefly at Paris, under the direction of the celebrated Le Bas, who engraved many excellent prints from the Dutch painters. It was from Le Bas that he had the first hint of the use of the instrument commonly called the *dry needle;* but which he afterwards greatly improved by his own genius, and which has added such superior beauties to his engravings.

In the year 1751 Mr Strange removed with his family from Edinburgh, and settled in London, where he engraved several fine historical prints, which justly acquired to him great reputation. At this period historical engraving had made little progress in Britain, and he may be properly considered as its father. The admiration which he always had for the works of the great Italian painters made him long desire to visit Italy, the seat of the fine arts; and the farther he advanced in life, he became the more persuaded that a journey to that country was essential to an artist who had the laudable ambition to excel in his profession. He therefore undertook this journey in the year 1760. In Italy he made many admirable drawings, several of which he afterwards engraved. In Italy singular marks of attention were everywhere bestowed on Mr Strange, not only by great personages, but by the principal academies of the fine arts in that country. He was chosen a member of the academies of Rome, Florence, and Bologna, and professor in the royal academy at Parma. To show the estimation in which his talents were held at Rome, we cannot but record the following anecdote. The ceiling of the room of the Vatican library, in which the collection of engravings is kept, is elegantly painted by Signor Roffanelli. It represents the progress of engraving; and the portraits of the most eminent artists in that line are there introduced, among which is that of Strange. Under his arm he holds a portfolio, on which his name is inscribed. In France, where he resided many years at different periods, his talents likewise received every mark of attention that could be bestowed on a foreigner. He was chosen a member of the royal academy of painting at Paris. Nor was he undistinguished in his own country. He received the honour of knighthood on the 5th of January 1787.

Such was Sir Robert Strange as an artist; nor was he less distinguished by his truly amiable moral qualities, which endeared him to all who had the happiness to know him. With regard to his works, he left fifty capital plates, which have been carefully preserved in his family. They are engraved from pictures by the most celebrated painters of the Roman, Florentine, Lombard, Venetian, and other schools. They are historical both sacred and profane, poetical, allegorical.

From his earliest establishment in life, Sir Robert carefully preserved about eighty copies of the finest and most choice impressions of each plate he engraved; which, from length of time, have acquired a beauty, mellowness, and brilliancy, easier seen than described. He did this with a view of presenting them to the public at a period when age should disable him from adding to their number. These he collected into as many volumes, and arranged them in the order in which they were engraved. To each volume he prefixed two portraits of himself, on the same plate, the one an etching, the other a finished proof, from a drawing by John Baptiste Greuse. This is the last plate which he engraved, and is a proof that neither his eyes nor hand were impaired by age. It likewise shows the use he made both of aquafortis and the graver. Each volume, besides a dedication to the king, contains an introduction on the progress of engraving, and critical remarks on the pictures from which his engravings are taken. These volumes were ready to be given to the public, when Sir Robert's death delayed this magnificent publication. He died at London, 5th July 1792.

The following is an authentic catalogue of his works. Plate 1. Two Heads of the Author, one an etching, the other a finished proof, from a drawing by John Baptiste Greuse; 2. The Return from Market, by Wouvermans; 3. Cupid, by Vanloo; 4. Mary Magdalen, by Guido; 5. Cleopatra, by the same; 6. The Madonna, by the same; 7. The Angel Gabriel, by the same; 8. The Virgin, holding in her hand a book, and attended by angels, by Carlo Maratt; 9. The Virgin with the Child asleep, by the same; 10. Liberality and Modesty, by Guido; 11. Apollo rewarding Merit and punishing Arrogance, by Andrea Sacchi; 12. The Finding of Romulus and Remus, by Pietro da Cortona; 13. Cæsar repudiating Pompeia, by the same; 14. Three Children of King Charles I. by Vandyke; 15. Belisarius, by Salvator Rosa; 16. St Agnes, by Dominichino; 17. The Judgment of Hercules, by Nicolas Poussin; 18. Venus attired by the Graces, by Guido; 19. and 20. Justice and Meekness, by Raffaello; 21. The Offspring of Love, by Guido; 22. Cupid Sleeping, by the same; 23. Abraham giving up the handmaid Hagar, by Guercino; 24. Esther a Suppliant before Ahasuerus, by the same; 25. Joseph and Potiphar's Wife, by Guido; 26. Venus blinding Cupid, by Titian; 27. Venus, by the same; 28. Danae, by the same; 29. Portrait of King Charles I. by Vandyke; 30. The Madonna, by Correggio; 31. St Cæcilia, by Raffaello; 32. Mary Magdalen, by Guido; 33. Our Saviour appearing to his Mother after his Resurrection, by Guercino; 34. A Mother and Child, by Parmegiano; 35. Cupid Meditating, by Schidoni; 36. Laomedon, king of Troy, detected by Neptune and Apollo, by Salvator Rosa; 37. The Death of Dido, by Guercino; 38. Venus and Adonis, by Titian; 39. Fortune, by Guido; 40. Cleopatra, by the same; 41. Two Children at School, by Schidoni; 42. Mary Magdalen, by Correggio; 43. Portrait of King Charles I. attended by the Marquis of Hamilton, by Vandyke; 44. Queen Henrietta, attended by the Prince of Wales, and holding in her arms the Duke of York, by the same; 45. Apotheosis of the Royal Children, by West; 46. The Annunciation, by Guido; 47. Portrait of Raffaello Sancio d'Urbino, by himself; 48. Sappho, by Carlo Dolci; 49. Our Saviour asleep, by Vandyke; 50. St John in the Desert, by Murillo.

STRANRAER, a seaport and royal borough, is situated on the southern shore of Lochryan, Wigtonshire, nine miles north-east of Portpatrick, and fifty south of Ayr. The town constitutes a distinct parish, and is the seat of a presbytery. It formerly belonged, in nearly equal parts, to the neighbouring parishes of Inch and Leswalt, from which it was disunited and formed into a separate parish in 1617, at which period also it was erected into a royal borough. But the town now exceeds the limits of the royal borough, and stretches into the two parishes just mentioned. Stranraer is a thriving place, and forms the emporium for the Rhyns, or western division of Wigtonshire. In 1835 there were 37 vessels belonging to it, the aggregate tonnage of which, per register, was 1789. A steam-boat has for 15 years plied weekly between Stranraer and Glasgow, and sometimes there are two or three on the passage. A high-water stone pier was built 25 years ago. The public buildings are, an elegant parish church, recently erected, four dissenting chapels, a town-hall, and a jail, which latter was formerly one of the residences of the noble family of Stair. Sir John Ross, the celebrated navigator, has a residence within the parliamentary bounds of the borough, appropriately called North-West Castle. The population in 1831 amounted to 3329, but including the suburbs, about 3800. There are no fewer than eight schools in the borough, of which six are unendowed. Stranraer has a weekly market, and several annual fairs. It unites with Whithorn, Wigton, and New Galloway, in sending a member to parliament, and in 1839 had 219 registered voters.

STRAPADO, or STRAPPADO, a kind of military punishment. The criminal's hands being tied behind him, he is hoisted up with a rope to the top of a long piece of wood, and again let fall almost to the ground; so that, by the weight of his body in the shock, his arms are dislocated. Sometimes he has to undergo three strapadoes or more.

STRASBOURG, an arrondissement of the department of the Lower Rhine, in France. It is a rich district, extending over 523 square miles, is divided into 12 cantons, and these into 162 communes, with a population of 218,839 persons. The chief city, of the same name, is also the capital of the department. It is the see of a bishop, the seat of the Lutheran consistory, and of the courts of law. The city stands in a highly cultivated plain, at the distance of about one mile from the river Rhine, on the river Ill, a small but navigable river. Its waters are distributed in various small canals through the city, and connect it with the Rhine. The streets are narrow, and the buildings for the most part old and massive, many of them very lofty. Strasburg is strongly fortified, and defended by three powerful fortresses and a strong citadel. Even in the time of peace it usually contains a garrison of 10,000. The cathedral, one of the finest Gothic buildings in France, was begun in 1275 and finished in 1439. Its tower is a most imposing object, 445 feet in height, being the loftiest erection known except the largest of the Egyptian pyramids. Besides six Catholic, there are seven Lutheran, and one Calvinist church. The other public buildings are the royal palace, the prefecture, the town-hall, the mint, and two theatres. Strasburg is the seat of a university. The population, which in 1836 amounted to 7885, is chiefly of German origin, and most of the people speak that language. The industry of the inhabitants is much exercised in making sail-cloth and other linen goods, woollens of various kinds, and in spinning and weaving cottons. There are tanneries, distilleries, founderies, paper-mills, and glass-houses; and considerable trade is carried on with Switzerland on one side, and with Germany and Holland on the other. Long. 6. 39. 31. E. Lat. 48. 34. 56. N.

STRATA, the several beds or layers of different matters whereof the earth is composed. See MINERALOGY and GEOLOGY.

STRATAGEM, in the art of war, any device for deceiving and surprising an enemy. The ancients dealt very much in stratagems, the moderns wage war more openly. Polyænus and Frontinus, the former a Greek, the latter a Latin writer, have each left a treatise on stratagems of war.

STRATEGUS, ϛρατηγος, in *Antiquity*, an officer among the Athenians, whereof there were two chosen yearly, to command the troops of the state. Plutarch avers there was one chosen from each tribe; but Pollux seems to say they were chosen indifferently from the people. The people themselves made the choice, on the last day of the year, in a place called *Pnyx*. The two *strategi* did not command together, but took their turns day by day, as we find from Herodotus and Cornelius Nepos. Constantine the Great, besides many other privileges granted to the city of Athens, honoured its chief magistrate with the title of Μεγας Στρατηγος, or the Great General.

STRATFORD, sometimes distinguished by the name *Long Stratford*, or *Stratford le Bow*. It is the first town in the county of Essex, on the road from London, and, being connected with Middlesex by a bridge, said to be the oldest in England, over the river Lea, may be considered as a suburb of the metropolis. It is in the hundred of Beacontree, and within the parish of West Ham. The soil is rich, but marshy, and intersected with canals and streams. Like the other suburbs of London, it has much increased in population, as well as industrious pursuits. The East India Docks are within the parish. One of the pursuits in this place is that of practical chemistry, on a large scale, for making magnesia, the volatile salts, Prussian blue, and other preparations. There are, besides, bleachers, calico-printers, brewers, distillers, and millers. The parish of West Ham is divided into four parts, but the division of Stratford is by very far the largest, though not distinguished in the decennial population returns. The number of souls in the parish of West Ham amounted in 1801 to 6485, in 1811 to 8136, in 1821 to 9753, and in 1831 to 11,580.

STRATFORD, *Fenny*, a market-town in the county of Buckingham, seven miles from Stony Stratford, and forty-six from London. It is in the hundred of Newport, and is a chapelry of the parish of Blechley. Being on the great road from London to the north of England, and to Scotland, as well as to Ireland, this place chiefly depends on the money spent by travellers. It consists of one long street, on a rising ground, with the river Lofield in the bottom. There is a chapel of ease, dedicated to St Martin. The mother-church at Blechley, a mile and a half distant, is an elegant structure. There was formerly some employment in making lace, which has of late declined; but there is some trade by the Grand Junction Canal, and more is expected when the railway from London to Birmingham is completed. The population amounted in 1801 to 469, in 1811 to 481, in 1821 to 521, and in 1831 to 635, but in the whole parish to 1254.

STRATFORD, *Stony*, a market-town in the hundred of Newport and county of Buckingham, fifty-two miles from London. It stands on the Ouse, which divides it from Northamptonshire, and is on the Roman or Watling Street road. It is partly in the parish of Calderton, and partly in that of Wolverton, and had a church, or rather a chapel of ease, to each of these parishes, both of which were burnt in 1742; but a new one has been erected, and is a handsome structure, dedicated to St Giles. The town consists of one street, nearly a mile in length, with well-built houses on each side, mostly constructed of freestone. It has a good market on Friday, and but little trade on other days, as may be inferred from the state of its population, which amounted in 1801 to 1653, in 1811 to 1488, in 1821 to 1499, and in 1831 to 1619.

STRATFORD-ON-AVON, a town in the hundred of Barlichway and county of Warwick, ninety-four miles from London. It stands on the navigable river Avon, over which is a bridge of fourteen arches. It is moderately well built, and has some trade in corn and malt, but no manufactures. It is chiefly remarkable as the birth-place of Shakspeare, whose memory has here been celebrated by splendid pageants. In the guild-hall is a large room, called Shakspeare's, with a portrait of him and of the celebrated actor Garrick. The inhabitants amounted in 1801 to 2418, in 1811 to 2842, in 1821 to 3069, and in 1831 to 3488.

STRATH, in the Scotish language, signifies a long narrow valley, along the centre of a river.

STRATHAVEN, a town in Lanarkshire, Scotland, sixteen miles from Glasgow. It is pleasantly situated at the end of a ridge of small eminences, on the banks of the Pomilion, which runs through it, and divides it into two parts. The original part of the town is old, as is shown by its being erected into a borough of barony in the year 1450, and is most irregularly built, the streets being crowded together, and intersected by long narrow lanes. The modern part is well laid out, and in it are many excellent houses. A number of neat small villas has also been erected in the neighbourhood, by the wealthier burgesses. The old castle of Strathaven overhangs the town, and, though now in ruins, adds considerably to its beauty. The inhabitants are an industrious, enterprising class of individuals; and from their business habits they are yearly raising their town to greater importance. Considerable business is done in the cotton trade. In addition to the established church, there are chapels belonging to the Relief and United Secession bodies of dissenters. The markets for agricultural and commercial produce are well supplied. The streets and shops are lighted with gas; and in consequence of the Pomilion running through it, the supply of water has contributed greatly to its cleanliness and comfort. The population in 1821 amounted to 2866, and in 1831 it had increased to 3597, an increase caused principally by the flourishing state of its trade and manufactures.

STRATHMIGLO, a parish in Fifeshire, Scotland. In it is situated the borough of barony of the same name, erected into such in the year 1600, consisting principally of an irregular street, with lanes diverging from it at right angles, and having in the middle a town-house, with a neat tower and spire seventy feet in height. Besides a parish church, there is a place of worship belonging to the Secession body. The inhabitants are principally employed in weaving. In 1821 the population of the parish amounted to 1842, and in 1831 to 1940.

STRATHMORE, or the GREAT STRATH, is that district of Scotland which stretches across from the town of Stonehaven in Kincardineshire, on the east coast, to the district of Cowal in Argyleshire, on the west coast. The chain of the Grampian Mountains bounds it on the north, and the Sidlaw, Ochill, and Menteith or Lennox range of hills on the south. There is also a vale of the same name in the parish of Durness, Sutherlandshire.

STRATHSPEY is the vale of the river Spey, which runs through part of the counties of Inverness and Elgin.

STRATO, a philosopher of Lampsacus, disciple and successor in the school of Theophrastus, about 248 years before the Christian era. He applied himself with uncommon industry to the study of nature; and after the most mature investigations, he supported that nature was inanimate, and that there was no god but nature. He was appointed preceptor to Ptolemy Philadelphus, who revered his abilities and learning, and rewarded his labours with unbounded liberality. He wrote different treatises, none of which has been preserved.

STRATON, a town of Cornwall, in the hundred of its own name, 224 miles from London. It has a market on Tuesday and another on Saturday, though both are little frequented. The inhabitants amounted in 1801 to 960, in 1811 to 1094, in 1821 to 1580, and in 1831 to 1613.

STRAUBING, a town of the kingdom of Bavaria, in the circle of the Lower Danube, the capital of the bailiwick of the same name. It is finely situated on the banks of the Danube, over which is a fine bridge. It contains seven churches, four hospitals, a gymnasium and several other schools, 700 houses, and 6800 inhabitants, who trade extensively by the river in corn and live cattle. Long. 11. 29. 28. E. Lat. 48. 52. 39. N.

STREATHAM, a town in the hundred of Brixton and county of Surrey, five miles from London, on the road to Croydon. The hamlet of Tooting is considered as a portion of it. Streatham is pleasantly situated, and contains many magnificent houses. Among others is one belonging to the duke of Bedford. The church is very neat, and was almost rebuilt in the year 1833. Near to it is a mineral spring, of aperient quality. The inhabitants amounted in 1801 to 2357, in 1811 to 2729, in 1821 to 3616, and in 1831 to 5068.

STRENGTH OF MATERIALS,

Importance of the subject.

IN *Mechanics*, is a subject of so much importance, that in a nation so eminent as this for invention and ingenuity in every species of manufacture, and in particular so distinguished for its improvements in machinery of every kind, it is somewhat singular that no writer has treated it in the detail which its importance and difficulty demand. The man of science who visits our great manufactories is delighted with the ingenuity which he observes in every part, the innumerable inventions which come even from individual artisans, and the determined purpose of improvement and refinement which he sees in every workshop. Every cotton-mill appears an academy of mechanical science; and mechanical invention is spreading from these fountains over the whole kingdom. But the philosopher is mortified to see this ardent spirit cramped by ignorance of principle, and many of those original and brilliant thoughts obscured and clogged with needless and even hurtful additions, and a complication of machinery which checks improvement even by its appearance of ingenuity. There is nothing in which this want of scientific education, this ignorance of principle, is so frequently observed, as in the injudicious proportion of the parts of machines and other mechanical structures; proportions and forms of parts in which the strength and position are nowise regulated by the strains to which they are exposed, and where repeated failures have been the only lessons.

Strength of materials arises from cohesion.

The strength of materials arises immediately or ultimately from the cohesion of the parts of bodies. Our examination of this property of tangible matter has as yet been very partial and imperfect, and by no means enables us to apply mathematical calculations with precision and success. The various modifications of cohesion, in its different appearances of perfect softness, plasticity, ductility, elasticity, hardness, have a mighty influence on the strength of bodies, but are hardly susceptible of measurement. Their texture, whether uniform like glass and ductile metals, crystallized or granulated like other metals and freestone, or fibrous like timber, is a circumstance no less important; yet even here, although we derive some advantage from remarking to which of these forms of aggregation a substance belongs, the aid is but small. All we can do in this want of general principles is, to make experiments on every class of bodies. Accordingly philosophers have endeavoured to instruct the public in this particular. The Royal Society of London, at its very first institution, made many experiments at their meetings, as may be seen in the first registers of the society; and since then a vast multitude of experiments have been made by public bodies and private individuals. The best of these, perhaps, up to the date of the present edition, are those of Mr Barlow.

But to make use of any experiments, there must be employed some general principle by which we can generalize their results. They will otherwise be only narrations of detached facts. We must have some notion of that intermedium, by the intervention of which an external force applied to one part of a lever, joist, or pillar, occasions a strain on a distant part. This can be nothing but the cohesion between the parts. It is this connecting force which is brought into action, or, as we more shortly express it, excited. This action is modified in every part by the laws of mechanics. It is this action which we call the *strength* of that part, and its effect is the strain on the adjoining parts; and thus it is the same force, differently viewed, that constitutes both the strain and the strength. When we consider it in the light of a resistance to fracture, we call it *strength*.

We call every thing a *force* which we observe ever to be accompanied by a change of motion; or, more strictly speaking, we infer the presence and agency of a force wherever we observe the state of things in respect of motion different from what we know to be the result of the action of all the forces which we know to act on the body. Thus when we observe a rope prevent a body from falling, we infer a moving force inherent in the rope, with as much confidence as when we observe it drag the body along the ground. The *immediate action* of this force is undoubtedly exerted between the immediately adjoining parts of the rope. The immediate effect is the keeping the particles of the rope together. They ought to separate by any external force drawing the ends of the rope contrariwise; and we ascribe their not doing so to a mechanical force really opposing this external force. When desired to give it a name, we name it from what we conceive to be its effect, and therefore its characteristic, and we call it *cohesion.* This is merely a name for the fact; but it is the same thing in all our denominations. We know nothing of the causes but in the effects; and our name for the cause is in fact the name of the effect, which is *cohesion.* We mean nothing else by gravitation or magnetism. What do we mean when we say that Newton understood thoroughly the nature of gravitation, of the force of gravitation; or that Franklin understood the nature of the electric force? Nothing but this: Newton considered with patient sagacity the general facts of gravitation, and has described and classed them with the utmost precision. In like manner, we shall understand the nature of cohesion when we have discovered with equal generality the laws of cohesion, or general facts which are observed in the appearances, and when we have described and classed them with equal accuracy.

Let us therefore attend to the more simple and obvious phenomena of cohesion, and mark with care every circumstance of resemblance by which they may be classed. Let us receive these as the laws of cohesion, characteristic of its supposed cause, the force of cohesion. We cannot pretend to enter on this vast research. The modifications are innumerable; and it would require the penetration of more than Newton to detect the circumstance of similarity amidst millions of discriminating circumstances. Yet this is the only way of discovering which are the primary facts characteristic of the force, and which are the modifications. The study is immense, but it is by no means desperate; and we entertain great hopes that it will ere long be successfully prosecuted; but, in our particular predicament, we must content ourselves with selecting such general laws as seem to give us the most immediate information of the circumstances that must be attended to by the mechanician in his constructions, that he may unite strength with simplicity, economy, and energy.

1. Then, it is a matter of fact that all bodies are in a certain degree perfectly elastic; that is, when their form or bulk is changed by certain moderate compressions or distractions, it requires the continuance of the changing force to continue the body in this new state; and when the force is removed, the body recovers its original form. We limit the assertion to *certain moderate* changes. For instance, take a lead wire of one fifteenth of an inch in diameter and ten feet long; fix one end firmly to the ceiling, and let the wire hang perpendicular; affix to the lower end an index like the hand of a watch; on some stand immediately below let there be a circle divided into degrees, with its centre corresponding to the lower point of the wire; now turn this index twice round, and thus twist the wire. When the index is let go, it will turn backwards again, by the wire untwisting itself, and make almost four revolutions before it stops; after which it twists and untwists many times, the index going backwards and forwards round the circle, diminishing, however, its arch of twist each time, till at last it settles precisely in its original position. This may be repeated for ever. Now, in this motion, every part of the wire partakes equally of the twist. The particles are stretched, require force to keep them in their state of extension, and recover completely their relative positions. These are all the characters of what the mechanician calls *perfect* elasticity. This is a quality quite familiar in many cases, as in glass, tempered steel, &c., but was thought incompetent to lead, which is generally considered as having little or no elasticity. But we make the assertion in the most general terms, with the limitation to moderate derangement of form. We have made the same experiment on a thread of pipe-clay, made by forcing soft clay through the small hole of a syringe by means of a screw, and we found it more elastic than the lead wire; for a thread of one twentieth of an inch diameter and seven feet long allowed the index to make two turns, and yet completely recovered its first position.

What is meant by a set.

2. But if we turn the index of the lead wire four times round, and let it go again, it untwists again in the same manner, but it makes little more than four turns back again; and after many oscillations it finally stops in a position almost two revolutions removed from its original position. It has now acquired a new arrangement of parts, and this new arrangement is permanent like the former; and, what is of particular moment, it is perfectly elastic. This change is familiarly known by the denomination of a *set.* The wire is said to have *taken a set.* When we attend minutely to the procedure of nature in this phenomenon, we find that the particles have, as it were, slid on each other, still cohering, and have taken a new position, in which their connecting forces are in equilibrio; and in this change of relative situation, it appears that the connecting forces which maintained the particles in their first situation were not in equilibrio in some position intermediate between that of the first and that of the last form. The force required for changing this first form augmented with the change, but only to a certain degree; and during this process the connecting forces always tended to the recovery of this first form. But after the change of mutual position has passed a certain magnitude, the union has been partly destroyed, and the particles have been brought into new situations; such, that the forces which now connect each with its neighbour tend, not to the recovery of the first arrangement, but to push them farther from it, into a new situation, to which they now verge, and require force to prevent them from acquiring. The wire is now in fact again perfectly elastic; that is, the forces which now connect the particles with their neighbours, augment to a certain degree as the derangement from this new position augments. This is not reasoning from any theory. It is narrating facts, on which a theory is to be founded. What we have been just now saying, is evidently a description of that sensible form of tangible matter which we call *ductility.* It has every gradation of variety, from the softness of butter to the firmness of gold. All these bodies have some elasticity; but we say they are not perfectly elastic, because they do not completely recover their original form when it has been greatly damaged. The whole gradation may be most distinctly observed in a piece of glass or hard sealing-wax. In the ordinary form glass is perhaps the most completely elastic body that we know, and may be bent till just ready to snap, and yet completely recovers its first form, and takes no set whatever; but when heated to such a degree as just to be visible in the dark, it loses its brittleness, and becomes so tough that it cannot be broken by any blow; but it is no longer elastic, it takes any set, and keeps it. When more heated, it becomes as plastic as clay; but in this state is remarkably distinguished from clay by a quality which we may call *viscidity,* which is something like elasticity, of which clay and other bodies purely plastic exhibit no appearance. This

Ductility.

Viscidity.

is the joint operation of strong adhesion and softness. When a rod of perfectly soft glass is suddenly stretched a little, it does not at once take the shape which it acquires after some little time. It is owing to this that, in taking the impression of a seal, if we take off the seal while the wax is yet very hot, the sharpness of the impression is immediately destroyed. Each part drawing its neighbour, and each part yielding, the prominent parts are pulled down and blunted, and the sharp hollows are pulled upwards and also blunted. The seal must be kept on till the wax has become not only stiff, but hard.

Observed in all homogeneous plastic bodies.

This viscidity is to be observed in all plastic bodies which are homogeneous. It is not observed in clay, because clay is not homogeneous, but consists of hard particles of argillaceous earth sticking together by their attraction for water. Something like it might be made of finely powdered glass and a clammy fluid such as turpentine. Viscidity has all degrees of softness, till it degenerates to ropy fluidity like that of olive oil. Perhaps something of it may be found even in the most perfect fluid with which we are acquainted, as we observed in the experiments for ascertaining specific gravity.

When ductility and elasticity are combined in different proportions, an immense variety of sensible modes of aggregation may be produced. Some degree of both are probably to be observed in all bodies of complex constitution; that is, which consist of particles made up of many different kinds of atoms. Such a constitution of a body must afford many situations permanent, but easily deranged.

Particles acted on by attractions and repulsions.

In all these changes of disposition which take place among the particles of a ductile body, the particles are at such distance that they still cohere. The body may be stretched a little; and on removing the extending force, the body shrinks into its first form. It also resists moderate compressions; and when the compressing force is removed, the body again swells out. Now the corpuscular *fact* here is, that the particles are acted on by attractions and repulsions, which balance each other when no external force is acting on the body, and which augment as the particles are made, by any external cause, to recede from this situation of mutual inactivity; for since force is requisite to produce either the dilatation or the compression, and to maintain it, we are obliged, by the constitution of our minds, to infer that it is opposed by a force accompanying or inherent in every particle of dilatable or compressible matter; and as this necessity of employing force to produce a change indicates the agency of these corpuscular forces, and marks their kind, according as the tendencies of the particles appear to be toward each other in dilatation, or from each other in compression; so it also measures the degrees of their intensity. Should it require three times the force to produce a double compression, we must reckon the mutual repulsions triple when the compression is doubled; and so in other instances. We see from all this that the phenomena of cohesion indicate some relation between the centres of the particles. To discover this relation is the great problem in corpuscular mechanism, as it was in the Newtonian investigation of the force of gravitation. Could we discover this law of action between the corpuscles with the same certainty and distinctness, we might with equal confidence say what will be the result of any position which we give to the particles of bodies; but this is beyond our hopes. The law of gravitation is so simple, that the discovery or detection of it amid the variety of celestial phenomena required but one step; and in its own nature its possible combinations still do not greatly exceed the powers of human research. One is almost disposed to say that the Supreme Being has exhibited it to our reasoning powers as sufficient to employ with success our utmost efforts, but not so abstruse as to discourage us from the noble attempt. It seems to be otherwise with respect to cohesion. Mathematics informs us, that if it deviates sensibly from the law of gravitation, the simplest combinations will make the joint action of several particles an almost impenetrable mystery. We must therefore content ourselves, for a long time to come, with a careful observation of the simplest cases that we can propose, and with the discovery of secondary laws of action, in which many particles combine their influence. In pursuance of this plan, we observe,

The great problem in corpuscular mechanism.

Parti kept their by a lanc force

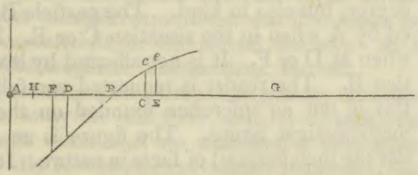
3. That whatever is the situation of the particles of a body with respect to each other, when in a quiescent state, they are kept in these situations by the balance of opposite forces. This cannot be refused, nor can we form to ourselves any other notion of the state of the particles of a body. Whether we suppose the ultimate particles to be of certain magnitudes and shapes, touching each other in single points of cohesion; or whether, with Boscovich, we consider them as at a distance from each other, and acting on each other by attractions and repulsions, we must acknowledge, in the first place, that the centres of the particles (by whose mutual distances we must estimate the distance of the particles) may and do vary their distances from each other. What else can we say when we observe a body increase in length, in breadth, and thickness, by heating it, or when we see it diminish in all these dimensions by an external compression? A particle, therefore, situated in the midst of many others, and remaining in that situation, must be conceived as maintained in it by the mutual balancing of all the forces which connect it with its neighbours. It is like a ball kept in its place by the opposite action of two springs. This illustration merits a more particular application. Suppose a number of balls ranged on the table in the angles of equilateral triangles, and that each ball is connected with the six which lie around it by means of an elastic wire curled like a cork-screw; suppose such another stratum of balls above this, and parallel to it, and so placed that each ball of the upper stratum is perpendicularly over the centre of the equilateral triangle below, and let these be connected with the balls of the under stratum by similar spiral wires. Let there be a third and a fourth, and any number of such strata, all connected in the same manner. It is plain that this may extend to any size, and fill any space. Now let this assemblage of balls be firmly contemplated by the imagination, and be supposed to shrink continually in all its dimensions, till the balls, and their distances from each other, and the connecting wires, all vanish from the sight as discrete individual objects. All this is very conceivable. It will now appear like a solid body, having length, breadth, and thickness; it may be compressed, and will again resume its dimensions; it may be stretched, and will again shrink; it will move away when struck; in short, it will not differ in its sensible appearance from a solid elastic body. Now when this body is in a state of compression, for instance, it is evident that any one of the balls is at rest, in consequence of the mutual balancing of the actions of all the spiral wires which connect it with those around it. It will greatly conduce to the full understanding of all that follows to recur to this illustration. The analogy or resemblance between the effects of this constitution of things and the effects of the corpuscular forces is very great; and wherever it obtains, we may safely draw conclusions from what we know would be the condition of a body of common tangible matter. We shall just give one instructive example, and then have done with this hypothetical body. We can suppose it of a long shape, resting on one point; we can suppose two weights A, B, suspended at the extremities, and the whole in equilibrio. We commonly express this state of things by saying that A and B are in equilibrio. This is very inaccurate. A is in fact in equilibrio with the united action of all the springs which connect the ball to which it is applied with the adjoining balls. These springs are brought into action, and each is in equilibrio with the joint action of

Illus- tion propo- tion.

By ex- ple.

of all the rest. Thus through the whole extent of the hypothetical body the springs are brought into action in a way and in a degree which mathematics can easily investigate. We need not do this: it is enough for our purpose that our imagination readily discovers that some springs are stretched, others are compressed, and that a pressure is excited on the middle point of support, and the support exerts a reaction which precisely balances it; and the other weight is, in like manner, in immediate equilibrio with the equivalent of the actions of all the springs which connect the last ball with its neighbours. Now take the analogical or resembling case, an oblong piece of solid matter, resting on a fulcrum, and loaded with two weights in equilibrio; for the actions of the connecting springs substitute the corpuscular forces; and the result will resemble that of the hypothesis.

Fig. 1.



Now, as there is something that is at least analogous to a change of distance of the particles, and a concomitant change of the intensity of the connecting forces, we may express this in the same way that we are accustomed to do in similar cases. Let A and B (fig. 1) represent the centres of two particles of a coherent elastic body in their quiescent inactive state, and let us consider only the mechanical condition of B. The body may be stretched. In this case the distance AB of the particles may become AC. In this state there is something which makes it necessary to employ a force to keep the particles at this distance. C has a tendency towards A, or we may say that A attracts C. We may represent the magnitude of this tendency of C *towards* A, or this attraction of A, by a line C*c* perpendicular to AC. Again, the body may be compressed, and the distance AB may become AD. Something obliges us to employ force to continue this compression, and D tends *from* A, or A appears to *repel* D. The intensity of this tendency or repulsion may be represented by another perpendicular D*d*; and, to represent the different directions of these tendencies, or the different nature of these actions, we may set D*d* on the opposite side of AB. It is in this manner that Boscovich has represented the actions of corpuscular forces in his celebrated Theory of Natural Philosophy. Newton had said, that as the great movements of the solar system were regulated by forces operating at a distance, and varying with the distance, so he strongly suspected (*valde suspicor*) that all the phenomena of cohesion, with all its modifications in the different sensible forms of aggregation, and in the phenomena of chemistry and physiology, resulted from the similar agency of forces varying with the distance of the particles. The learned Jesuit pursued this thought; and has shown, that if we suppose an ultimate atom of matter endowed with powers of attraction and repulsion, varying, both in kind and degree, with the distance, and if this force be the same in every atom, it may be regulated by such a relation to the distance from the neighbouring atom, that a collection of such may have all the sensible appearance of bodies in their different forms of solids, liquids, and vapours, elastic or unelastic, and endowed with all the properties which we perceive, by whose immediate operation the phenomena of motion by impulse, and all the phenomena of chemistry, and of animal and vegetable economy, may be produced. He shows, that notwithstanding a perfect sameness, and even a great simplicity, in this atomical constitution, there will result from this union all that unspeakable variety of form and property which diversifies and embellishes the face of nature. We shall take another opportunity of giving such an account of this celebrated work as it deserves. We mention it only by the by, as far as a general notion of it will be of some service on the present occasion. For this purpose, we just observe that Boscovich conceives a particle of any individual species of matter to consist of an unknown number of particles of simpler constitution; each of which particles, in their turn, is compounded of particles still more simply constituted, and so on through an unknown number of orders, till we arrive at the simplest possible constitution of a particle of tangible matter, susceptible of length, breadth, and thickness, and necessarily consisting of four atoms of matter. And he shows that the more complex we suppose the constitution of a particle, the more must the sensible qualities of the aggregate resemble the observed qualities of tangible bodies. In particular, he shows how a particle may be so constituted, that although it act on one other particle of the same kind through a considerable interval, the interposition of a third particle of the same kind may render it totally, or almost totally, inactive; and therefore an assemblage of such particles would form such a fluid as air. All these curious inferences are made with uncontrovertible evidence; and the greatest encouragement is thus given to the mathematical philosopher to hope, that by cautious and patient proceeding in this way, we may gradually approach to a knowledge of the laws of cohesion, that will not shun a comparison even with the Principia of Newton. No step can be made in this investigation, but by observing with care, and generalizing with judgment, the phenomena, which are abundantly numerous, and much more at our command than those of the great and sensible motions of bodies. Following this plan, we observe,

Every body compressible and dilatable.

Law of nature discovered by Dr Hooke;

4. It is a matter of fact, that every body has some degree of compressibility and dilatability; and when the changes of dimension are so moderate that the body completely recovers its original dimensions on the cessation of the changing force, the extensions or compressions are sensibly proportional to the extending of compressing forces; and therefore *the connecting forces are proportional to the distances of the particles from their quiescent, neutral, or inactive positions.* This seems to have been first viewed as a law of nature by the penetrating eye of Dr Robert Hooke, one of the most eminent philosophers of the last century. He published a cipher, which he said contained the theory of springiness and of the motions of bodies by the action of springs. It was this, *ceiiinosssttuu.* When explained in his dissertation, published some years after, it was *ut tensio sic vis.* This is precisely the proposition now asserted as a general fact, a law of nature. This dissertation is full of curious observations of facts in support of his assertion. In his application to the motion of bodies, he gives his noble discovery of the balance-spring of a watch, which is founded on this law. The spring, as it is more and more coiled up, or unwound, by the motion of the balance, acts on it with a force proportional to the distance of the balance from its quiescent position. The balance, therefore, is acted on by an accelerating force, which varies in the same manner as the force of gravity acting on a pendulum swinging in a cycloid. Its vibrations therefore must be performed in equal time, whether they are wide or narrow. In the same dissertation Hooke mentions all the facts which John Bernoulli afterwards adduced in support of Leibnitz's whimsical doctrine of the force of bodies in motion, as the doctrine of the *vires vivæ;* a doctrine which Hooke might justly have claimed as his own, had he not seen its futility.

and confirmed by the experiments of others.

Experiments made since the time of Hooke show that this law is strictly true in the extent to which we have limited it, viz. in all the changes of form which will be completely undone by the elasticity of the body. It is nearly true to a much greater extent. James Bernoulli, in his dissertation on the elastic curve, relates some experiments of his own, which seem to deviate considerably from it; but on close examination they do not. The finest experiments are those of Coulomb, published in some late volumes of the Memoirs of the Academy of Paris. He suspended balls by wires, and observed their motions of oscillation, which he found accurately corresponding with this law.

This we shall find to be a very important fact in the doctrine of the strength of bodies, and we desire the reader to make it familiar to his mind. If we apply to this our manner of expressing these forces by perpendicular ordinates Cc, Dd (fig. 1), we must take other situations E, F, of the particle B, and draw Ec, Ff; and we must have $Dd : Ff = BD : BF$, or $Cc : Ee = BC : BE$. In such a supposition $FdBce$ must be a straight line. But we shall have abundant evidence by and by that this cannot be strictly true, and that the line Bce, which limits the ordinates expressing the attractive forces, becomes concave towards the line ABE, and that the part Bdf is convex towards it. All that can be safely concluded from the experiments hitherto made is, that *to a certain extent* the forces, both attractive and repulsive, are *sensibly* proportional to the dilatations and compressions. For,

When a body is much dilated, a small addition of force will increase its dilatation.

5. It is universally observed, that when the dilatations have proceeded a certain length, a less addition of force is sufficient to increase the dilatation in the same degree. This is always observed when the body has been so far stretched that it takes a set, and does not completely recover its form. The like may be generally observed in compressions. Most persons will recollect, that in violently stretching an elastic cord, it becomes suddenly weaker, or more easily stretched. But these phenomena do not positively prove a diminution of the corpuscular force acting on one particle: it more probably arises from the disunion of some particles whose action contributed to the whole or sensible effect. And in compressions we may suppose something of the same kind; for when we compress a body in one direction, it commonly bulges out in another; and in cases of very violent action some particles may be disunited, whose transverse action had formerly balanced *part* of the compressing force. For the reader will see on reflection, that since the compression in one direction causes the body to bulge out in the transverse direction, and since this bulging out is in opposition to the transverse forces of attraction, it must employ some part of the compressing force. And the common appearances are in perfect uniformity with this conception of things. When we press a bit of dryish clay, it swells out and cracks transversely. When a pillar of wood is overloaded, it swells out, and small crevices appear in the direction of the fibres. After this it will not bear half of the load. This the carpenters call *crippling;* and a knowledge of the circumstances which modify it is of great importance, and enables us to understand some very paradoxical appearances, as will be shown by and by.

This partial disuniting of particles formerly cohering, is, we imagine, the chief reason why the totality of the forces which really oppose an external strain does not increase in the proportion of the extensions and compressions. But sufficient evidence will also be given that the forces which would connect one particle with one other particle do not augment in the accurate proportion of the change of distance; that in extensions they increase more slowly, and in compressions more rapidly.

Ductility another cause of deviation.

But there is another cause of this deviation perhaps equally effectual with the former. Most bodies manifest some degree of ductility. Now what is this? The fact is, that the parts have taken a new arrangement, in which they again cohere. Therefore, in the passage to this new arrangement, the sensible forces, which are the joint result of many corpuscular forces, begin to respect this new arrangement instead of the former. This must change the simple law of corpuscular force, characteristic of the particular species of matter under examination. It does not require much reflection to convince us that the possible arrangements which the particles of a body may acquire, without appearing to change their nature, must be more numerous according as the particles are of a more complex constitution; and it is reasonable to suppose that the constitution even of the most simple kind of matter that we are acquainted with is exceedingly complex. Our microscopes show us animals so minute, that a heap of them must appear to the naked eye an uniform mass with a grain finer than that of the finest marble or razor hone; and yet each of these has not only limbs, but bones, muscular fibres, blood-vessels, fibres, and a blood consisting in all probability of globules organized and complex like our own. The imagination is here lost in wonder; and nothing is left us but to adore inconceivable art and wisdom, and to exult in the thought that we are the only spectators of this beautiful scene who can derive pleasure from the view. But let us proceed to observe,

The es which nect partic of tangi bodies change a cha of distan

6. That the forces which connect the particles of tangible bodies change by a change of distance, not only in degree, but also in kind. The particle B (fig. 1) is attracted by A when in the situation C or E. It is repelled by it when at D or F. It is not affected by it when in the situation B. The reader is requested carefully to remark, that this is not an inference founded on the authority of our mathematical figure. The figure is an expression (to assist the imagination) of facts in nature. It requires no force to keep the particles of a body in their quiescent situations: but if they be separated by stretching the body, they endeavour (pardon the figurative expression) to come together again. If they be brought nearer by compression, they endeavour to recede. This endeavour is manifested by the necessity of employing force to maintain the extension or condensation; and we represent this by the different position of our lines. But this is not all: the particle B, which is repelled by A when in the situation F or D, is neutral when at B, and is attracted when at C or E, may be placed at such a distance AG from A greater than AB that it shall be again repelled, or at such a distance AH that it shall be again attracted; and these alterations may be repeated again and again. This is curious and important, and requires something more than a bare assertion for its proof.

Light a nately tracted repelle

In the article Optics we mentioned the most curious and valuable observations of Sir Isaac Newton, by which it appears that light is thus alternately attracted and repelled by bodies. The rings of colour which appear between the object-glasses of long telescopes showed, that in the small interval of $\frac{1}{1000}$th of an inch, there are at least an hundred such changes observable, and that it is highly probable that these alternations extend to a much greater distance. At one of these distances the light actually converges towards the solid matter of the glass, which we express shortly by saying that it is attracted by it, and that at the next distance it declines from the glass, or is repelled by it. The same thing is more simply inferred from the phenomena of light passing by the edges of knives and other opaque bodies. We refer the reader to the experiments themselves, the detail being too long for this place; and we request him to consider them minutely and attentively, and to form distinct notions of the inferences drawn from them. And we desire it to be remarked, that although Newton, in his discussion, always considers light as a set of corpuscles moving in free space, and obeying the actions of external forces like any other matter, the particular conclusion in which we are just now interested does not at all depend on this notion of the nature of light. Should we, with Descartes or Huygens, suppose light to be the undulation of an elastic medium, the conclusion will be the same. The undulations at certain distances are disturbed by forces directed towards the body, and at a greater distance the disturbing forces tend *from* the body.

But the same alternations of attraction and repulsion may be observed between the particles of common matter. If we take a piece of very flat and well-polished glass, such as is made for the horizon-glasses of a good Hadley's quadrant, and if we wrap round it a fibre of silk as it comes from the cocoon, taking care that the fibre shall nowhere cross another, and then press this pretty hard on such another piece of glass, it will lift it up and keep it suspended. The particles therefore of the one do most certainly attract those of the other, and this at a distance equal to the thickness of the silk fibre. This is nearly the limit; and it sometimes requires a considerable pressure to produce the effect. The pressure is effectual only by compressing the silk fibre, and thus diminishing the distance between the glass plates. This adhesion cannot be attributed to the pressure of the atmosphere, because there is nothing to hinder the air from insinuating itself between the plates, since they are separated by the silk. Besides, the experiment succeeds equally well under the receiver of an air-pump. This most valuable experiment was first made by Huygens, who reported it to the Royal Society. It is narrated in the Philosophical Transactions, No. 86.

Here, then, is an attraction acting, like gravity, at a distance. But take away the silk fibre, and try to make the glasses touch each other, and we shall find a very great force necessary. By Newton's experiments it appears, that unless the prismatic colours begin to appear between the glasses, they are at least $\frac{1}{890}$th of an inch asunder or more. Now we know that a very considerable force is necessary for producing these colours, and that the more we press the glasses together the more rings of colours appear. It also appears from Newton's measures, that the difference of distance between the glasses where each of these colours appears is about the 89,000th part of an inch. We know further, that when we have produced the last appearance of a greasy or pearly colour, and then augment the pressure, making it about 1000 pounds on the square inch, all colours vanish, and the two pieces of glass seem to make one transparent undistinguishable mass. They appear now to have no air between them, or to be in mathematical contact. But another fact shows this conclusion to be premature. The same circles of colours appear in the top of a soap-bubble; and as it grows thinner at top, there appears an unreflecting spot in the middle. We have the greatest probability therefore that the perfect transparency in the middle of the two glasses does not arise from their being in contact, but because the thickness of air between them is too small in that place for the reflection of light. Nay, Newton expressly found no reflection where the thickness was $\frac{2}{5}$ths or more of the $\frac{1}{89000}$th part of an inch.

All this while the glasses are strongly repelling each other, for great pressure is necessary for continuing the appearance of those colours, and they vanish in succession as the pressure is diminished. This vanishing of the colours is a proof that the glasses are moving off from each other, or repelling each other. But we can put an end to this repulsion by very strong pressure, and at the same time sliding the glasses on each other. We do not pretend to account for this effect of the sliding motion; but the fact is, that by so doing, the glasses will cohere with very great force, so that we shall break them by any attempt to pull them asunder. It commonly happens (at least it did so with us), that in this sliding compression of two smooth flat plates of glass, they scratch and mutually destroy each other's surface. It is also worth remarking, that different kinds of glass exhibit different properties in this respect. Flint glass will attract even though a silk fibre lies double between them, and they much more readily cohere by this sliding pressure.

Here, then, are two distances at which the plates of glass attract each other; namely, when the silk fibre is interposed, and when they are forced together with this sliding motion. And in any intermediate situation they repel each other. We see the same thing in other solid bodies.

Lead and iron.

Two pieces of lead, made perfectly clean, may be made to cohere by grinding them together in the same manner. It is in this way that pretty ornaments of silver are united to iron. The piece is scraped clean, and a small bit of silver like a fish scale is laid on. The die which is to strike it into a flower or other ornament is then set on it, and we give it a smart blow, which forces the metals into contact as firm as if they were soldered together. It sometimes happens that the die adheres to the coin so that they cannot be separated: and it is found that this frequently happens when the engraving is such that the raised figure is not completely surrounded with a smooth flat ground. The probable cause of this is curious. When the coin has a flat surface all around, this is produced by the most prominent part of the die. This applies to the metal, and completely confines the air which filled the hollow of the die.

Probable cause why the die adheres to the coin.

As the pressure goes on, the metal is squeezed up into the hollow of the die; but there is still air compressed between them, which cannot escape by any passage. It is therefore prodigiously condensed, and exerts an elasticity proportioned to the condensation. This serves to separate the die from the metal when the stroke is over. The hollow part of the die has not touched the metal all the while, and we may say that the impression was made by air. If this air escape by any engraving reaching through the border, they cohere inseparably.

We have admitted that the glass plates are in contact when they adhere thus firmly. But we are not certain of this: for if we take these cohering glasses, and touch them with water, it quickly insinuates itself between them. Yet they still cohere, but can now be pretty easily separated.

Repulsion the cause of some bodies swimming in a fluid specifically lighter than themselves.

It is owing to this repulsion, exerted through its proper sphere, that certain powders swim on the surface of water, and are wetted with great difficulty. Certain insects can run about on the surface of water. They have brushy feet, which occupy a considerable surface, and if their steps be viewed with a magnifying glass, the surface of the water is seen depressed all around, resembling the footsteps of a man walking on feather beds. This is owing to a repulsion between the brush and the water. A common fly cannot walk in this manner on water. Its feet are wetted, because they attract the water instead of repelling it. A steel needle, slightly greased, will lie on the surface of water, make an impression as a great bar would make on a feather bed; and its weight is less than that of the displaced water. A dew-drop lies on the leaves of plants without touching them mathematically, as is plain from the extreme brilliancy of the reflection at the posterior surface; nay, it may be sometimes observed that the drops of rain lie on the surface of water, and roll about on it like balls on a table. Yet all these substances can be wetted; that is, water can be applied to them at such distances that they attract it.

What we lately remarked of water insinuating itself between the glass plates without altogether destroying their cohesion, shows that this cohesion is not the same that obtains between the particles of one of the plates; that is, the two plates are not in the state of one continued mass. It is highly probable, therefore, that between these two states there is an intermediate state of repulsion, nay, perhaps, many such, alternated with attractive states.

A piece of ice is elastic, for it rebounds and rings. Its particles, therefore, when compressed, resile; and when stretched, contract again. The particles are therefore in the state represented by B in figure 1, acted on by repulsive forces if brought nearer, and by attractive forces if drawn further asunder. Ice expands, like all other bodies, by heat. It absorbs a vast quantity of fire, which, by combining its attractions and repulsions with those of the particles of ice, changes completely the law of action, and the ice becomes water. In this new state the particles are again in limits between attractive and repulsive forces; for water has been shown, by the experiments of Canton and Zimmerman, to be elastic or compressible. It again expands by heat. It again absorbs a prodigious quantity of heat, and becomes elastic vapour; its particles repelling each other at all distances yet observed. The distance between the particles of one plate of glass and those of another which lies on it, and is carried by it, is a distance of repulsion; for the force which supports the upper piece is acting in opposition to its weight. This distance is less than that at which it would *suspend* it below it with a silk fibre interposed; for no prismatic colours appear between them when the silk fibre is interposed. But the distance at which glass attracts water is much less than this, for no colours appear when glass is wetted with water. This distance is less, and not greater, than the other; for when the glasses have water interposed between them instead of air, it is found, that when any particular colour appears, the thickness of the plate of water is to that of the plate of air which would produce the same colour, nearly as three to four. Now, if a piece of glass be wetted, and exhibit no colour, and another piece of glass be simply laid on it, no colour will appear; but if they are strongly pressed, the colours appear in the same manner as if the glasses had air between. Also, when glass is simply wetted, and the film of water is allowed to evaporate, when it is thus reduced to a proper thinness the colours show themselves in great beauty.

Particles of matter connected by forces acting at a distance.

These are a few of many thousand facts, by which it is unquestionably proved that the particles of tangible matter are connected by forces acting at a distance, varying with the distance, and alternately attractive and repulsive. If we represent these forces, as we have already done in fig. 1, by the ordinates C*c*, D*d*, E*e*, F*f*, &c. of a curve, it is evident that this curve must cross the axis at all those distances where the forces change from attractive to repulsive, and the curve must have branches alternately above and below the axis.

All these alternations of attraction and repulsion take place at small and insensible distances. At all sensible distances the particles are influenced by the attraction of gravitation; and therefore this part of the curve must be a hyperbola whose equation is $y=\frac{a^3}{x^2}$. What is the form of the curve corresponding to the smallest distance of the particles? that is, what is the mutual action between the particles just before their coming into absolute contact? Analogy should lead us to suppose it to be repulsion; for solidity is the last and simplest form of bodies with which we are acquainted. Fluids are more compounded, containing fire as an essential ingredient. We should conclude that this ultimate repulsion is insuperable, for the hardest bodies are the most elastic. We are fully entitled to say that this repelling force exceeds all that we have ever yet applied to overcome it; nay, there are good reasons for saying that this ultimate repulsion, by which the particles are kept from mathematical contact, is really insuperable in its own nature, and that it is impossible to produce mathematical contact.

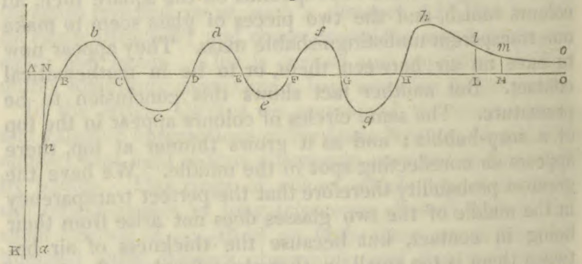
Mathematical contact impossible.

We shall just mention one of these, which we consider as unanswerable. Suppose two atoms, or ultimate particles of matter, A and B. Let A be at rest, and B move up to it with the velocity 2; and let us suppose that it comes into mathematical contact, and impels it (according to the common acceptation of the word). Both move with the velocity 1. This is granted by all to be the final result of the collision. Now the instant of time in which this communication happens is no part either of the duration of the solitary motion of A, nor of the joint motion of A and B: it is the separation or boundary between them. It is at once the end of the first and the beginning of the second, belonging equally to both. A was moving with the volocity 2. The distinguishing circumstance, therefore, of its mechanical state is, that it has a determination (however incomprehensible) by which it would move for ever with the velocity 2, if nothing changed it. This it has during the whole of its solitary motion, and therefore in the last instant of this motion. In like manner, during the whole of the joint motion, and therefore in the first instant of this motion, the atom A has a determination by which it would move for ever with the velocity 1. In one and the same instant, therefore, the atom A has two incompatible determinations. Whatever notion we can form of this state, which we call velocity, as a distinction of condition, the same impossibility of conception, or the same absurdity, occurs. Nor can it be avoided in any other way than by saying, that this change of A's motion is brought about by insensible gradations; that is, that A and B influence each other precisely as they would do if a slender spring were interposed. The reader is desired to look at what we have said in the article PHYSICS.

The two magnets there spoken of are good representatives of two atoms endowed with mutual powers of repulsion; and the communication of motion is accomplished in both cases in precisely the same manner.

If, therefore, we shall ever be so fortunate as to discover the law of variation of that force which connects one *atom* of matter with another atom, and which is therefore characteristic of matter, and the ultimate source of all its sensible qualities, the curve whose ordinates represent the kind and the intensity of this atomical force will be something like that sketched in fig. 2. The first branch *a n* B will have AK (perpendicular to the axis AH) for its assymptote, and the last branch *lmo* will be to all sense a hyperbola, having AO for its assymptote; and the ordinates *l*L, *m*M, &c. will be proportional to $\frac{1}{AL^2}$, $\frac{1}{AM^2}$, &c. expressing the universal gravitation of matter. It will have many branches B*b*C, D*d*E, F*f*G, &c. expressing attractions, and alternate repulsive branches C*c*D, E*e*F, G*g*H, &c. All these will be contained within a distance AH, which does not exceed a very minute fraction of an inch.

Fig. 2.



The si plest e tended ticle co sists of atoms.

The simplest particle which can be a constituent of a body having length, breadth, and thickness, must consist of four such atoms, all of which combine their influence on each atom of another such particle. It is evident that the curve which expresses the force that connects two such particles must be totally different from this original curve, this hylarchic principle. Supposing the last known, our mathematical knowledge is quite able to discover the first; but when we proceed to compose a body of particles, each of which consists of four such particles, we may venture to say that the compound force which connects them is almost beyond our search, and that the discovery of the primary force from an *accurate* knowledge of the corpuscular forces of *this* particular matter is absolutely out of our power.

All that we can learn is, the possibility, nay, the certainty, of an innumerable variety of external sensible forms and qualities, by which different kinds of matter will be distinguished, arising from the number, the order of composition, and the arrangement of the subordinate particles of which a particle of this or that kind of matter is composed. All these varieties will take place at those small and insensible distances which are between A and H, and may produce all that variety which we observe in the tangible or mechanical forms of bodies, such as elasticity, ductility, hardness, softness, fluidity, vapour, and all those unseen motions or actions which we observe in fusion and congelation, evaporation and condensation, solution and precipitation, crystallization, vegetable and animal assimilation and secretion, &c.; while all bodies must be, in a certain degree, elastic, all must gravitate, and all must be incompenetrable.

This general and satisfactory resemblance between the appearance of tangible matter and the legitimate consequence of this general hypothetical property of an atom of matter, affords a considerable probability that such is the origin of all the phenomena. We earnestly recommend to our readers a careful perusal of Boscovich's celebrated treatise. A careful perusal is necessary for seeing its value; and nothing will be got by a hasty inspection. The reader will be particularly pleased with the facility and evidence with which the ingenious author has deduced all the ordinary principles of mechanics, and with the explanation which he has given of fluidity, and his deduction from thence of the laws of hydrostatics. No part of the treatise is more valuable than the doctrine of the propagation of pressure through solid bodies. This, however, is but just touched on in the course of the investigation of the principles of mechanics. We shall borrow as much as will suffice for our present inquiry into the strength of materials; and we trust that our readers are not displeased with this general sketch of the doctrine (if it may be so called) of the cohesion of bodies. It is curious and important in itself, and is the foundation of all the knowledge which we can acquire of the present article. We are sorry to say that it is as yet a new subject of study; but it is a very promising one, and we by no means despair of seeing the whole of chemistry brought by its means within the pale of mechanical science. The great and distinguishing agent in chemistry is heat, or fire the cause of heat; and one of its most singular effects is the conversion of bodies into elastic vapour. We have the clearest evidence that this is brought about by mechanical forces; for it can be opposed or prevented by external pressure, a very familiar mechanical force. We may perhaps find another mechanical force which will prevent fusion.

Having now made our readers familiar with the mode of action in which cohesion operates in giving strength to solid bodies, we proceed to consider the strains to which this strength is opposed.

A piece of solid matter is exposed to four kinds of strains, different in the manner of their operation.

1. It may be torn asunder, as in the case of ropes, stretchers, king-posts, tie-beams, &c.

2. It may be crushed, as in the case of pillars, posts, and truss-beams.

3. It may be broken across, as happens to a joist or lever of any kind.

4. It may be wrenched or twisted, as in the case of the axle of a wheel, the nail of a press, &c.

I.—IT MAY BE PULLED ASUNDER.

Matter may be pulled asunder;

This is the simplest of all strains, and the others are indeed modifications of it. To this the force of cohesion is *directly* opposed, with very little modification of its action by any particular circumstances.

When a long cylindrical or prismatic body, such as a rod of wood or metal, or a rope, is drawn by one end, it must be resisted at the other, in order to bring its cohesion into action. When it is fastened at one end, we cannot conceive it any other way than as equally stretched in all its parts; for all our observations and experiments on natural bodies concur in showing us that the forces which connect their particles in any way whatever are equal and opposite. This is called the *third law of motion;* and we admit its universality, while we affirm that it is purely experimental. Yet we have met with dissertations by persons of eminent knowledge, where propositions are maintained inconsistent with this. During the dispute about the communication of motion, some of the ablest writers have said, that a spring compressed or stretched at the two ends was gradually less and less compressed or stretched from the extremities towards the middle: but the same writers acknowledged the universal equality of action and re-action, which is quite incompatible with this state of the spring. No such inequality of compression or dilatation has ever been observed; and a little reflection will show it to be impossible, in consistency with the equality of action and re-action.

Since all parts are thus equally stretched, it follows that the strain in any transverse section is the same, as also in every point of that section. If therefore the body be supposed of a homogeneous texture, the cohesion of the parts is equable; and since every part is equally stretched, the particles are drawn to equal distances from their quiescent positions, and the forces which are thus excited, and now exerted in opposition to the straining force, are equal. This external force may be increased by degrees, which will gradually separate the parts of the body more and more from each other, and the connecting forces increase with this increase of distance, till at last the cohesion of some particles is overcome. This must be immediately followed by a rupture, because the remaining forces are now weaker than before.

It is the united force of cohesion, immediately before the disunion of the first particles, that we call the *strength* of the section. It may also be properly called its *absolute strength*, being exerted in the simplest form, and not modified by any relation to other circumstances.

a circumstance to be attended to in every construction requiring strength.

If the external force have not produced any permanent change on the body, and it therefore recovers its former dimensions when the force is withdrawn, it is plain that this strain may be repeated as often as we please, and the body which withstands it once will always withstand it. It is evident that this should be attended to in all constructions, and that in all our investigations on this subject this should be kept strictly in view. When we treat a piece of soft clay in this manner, and with this precaution, the force employed must be very small. If we exceed this, we produce a permanent change. The rod of clay is not indeed torn asunder, but it has become somewhat more slender; the number of particles in a cross section is now smaller; and therefore, although it will again, in this new form, suffer or allow an endless repetition of a *certain* strain without any farther permanent change, this strain is smaller than the former.

Something of the same kind happens in all bodies which receive a *set* by the strain to which they are exposed. All ductile bodies are of this kind. But there are many bodies which are not ductile. Such bodies break completely whenever they are stretched beyond the limit of their perfect elasticity. Bodies of a fibrous structure exhibit very great

Great varieties in cohesion, but

varieties in their cohesion. In some the fibres have no lateral cohesion, as in the case of a rope. The only way in which all the fibres can be made to unite their strength, is to twist them together. This causes them to bind each other so fast, that any one of them will break before it can be drawn out of the bundle. In other fibrous bodies, such as timber, the fibres are held together by some cement or gluten. This is seldom as strong as the fibre. Accordingly timber is much easier pulled asunder in a direction transverse to the fibres. There is, however, every possible variety in this particular.

In stretching and breaking fibrous bodies, the visible extension is frequently very considerable. This is not solely the increasing of the distance of the particles of the cohering fibre; the greatest part chiefly arises from drawing the crooked fibre straight. In this, too, there is great diversity; and it is accompanied with important differences in their power of withstanding a strain. In some woods, such as fir, the fibres on which the strength most depends are very straight. Such woods are commonly very elastic, do not take a set, and break abruptly when overstrained: others, such as oak and birch, have their resisting fibres very undulating and crooked, and stretch very sensibly by a strain. They are very liable to take a set, and they do not break so suddenly, but give warning by *complaining*, as the carpenters call it; that is, by giving visible signs of a derangement of texture. Hard bodies of an uniform glassy structure, or granulated like stones, are elastic through the whole extent of their cohesion, and take no set, but break at once when overloaded.

Notwithstanding the immense variety which nature exhibits in the structure and cohesion of bodies, there are certain general facts of which we may now avail ourselves with advantage. In particular,

the absolute cohesion or strength proportional to the area of the section perpendicular to the extending force.

The absolute cohesion is proportional to the area of the section. This must be the case where the texture is perfectly uniform, as we have reason to think it is in glass and the ductile metals. The cohesion of each particle being alike, the whole cohesion must be proportional to their number, that is, to the area of the section. The same must be admitted with respect to bodies of a granulated texture, where the granulation is regular and uniform. The same must be admitted of fibrous bodies, if we suppose their fibres equally strong, equally dense, and similarly disposed through the whole section; and this we must either suppose, or must state the diversity, and measure the cohesion accordingly.

We may therefore assert, as a general proposition on this subject, that the absolute strength in any part of a body, by which it resists being pulled asunder, or the force which must be employed to tear it asunder *in that part*, is proportional to the area of the section perpendicular to the extending force.

Therefore all cylindrical or prismatical rods are equally strong in every part, and will break alike in any part; and bodies which have unequal sections will always break in the slenderest part. The length of the cylinder or prism has no effect on the strength. Also the absolute strengths of bodies which have similar sections are proportional to the squares of their diameters or homologous sides of the section.

Relative strength.

The weight of the body itself may be employed to strain it and to break it. It is evident, that a rope may be so long as to break by its own weight. When the rope is hanging perpendicularly, although it is equally strong in every part, it will break towards the upper end, because the strain on any part is the weight of all that is below it. Its *relative strength* in any part, or power of withstanding the strain which is actually laid on it, is inversely as the quantity below that part.

When the rope is stretched horizontally, as in towing a ship, the strain arising from its weight often bears a very sensible proportion to its whole strength.

These are the chief general rules which can be safely deduced from our clearest notions of the cohesion of bodies. In order to make any practical use of them, it is proper to have some measures of the cohesion of such bodies as are commonly employed in our mechanics, and other structures where they are exposed to this kind of strain. These must be deduced solely from experiment; therefore they must be considered as no more than general values, or as the averages of many particular trials. The irregularities are very great, because none of the substances are constant in their texture and firmness. Metals differ by a thousand circumstances unknown to us, according to their purity, to the heat with which they were melted, to the moulds in which they were cast, and the treatment they have afterwards received, by forging, wire-drawing, tempering, &c.

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It is a very curious and inexplicable fact, that by forging a metal, or by frequently drawing it through a smooth hole in a steel plate, its cohesion is greatly increased. This operation undoubtedly deranges the natural situation of the particles. They are squeezed closer together in one direction, but it is not in the direction in which they resist the fracture. In this direction they are rather separated to a greater distance. The general density, however, is augmented in all of them except lead, which grows rather rarer by wire-drawing; but its cohesion may be more than tripled by this operation. Gold, silver, and brass, have their cohesion nearly tripled; copper and iron have it more than doubled. In this operation they also grow much harder. It is proper to heat them to redness after drawing a little. This is called *nealing* or *annealing*. It softens the metal again, and renders it susceptible of another drawing without the risk of cracking in the operation.

We do not pretend to give any explanation of this remarkable and very important fact, which has something resembling it in woods and other fibrous bodies, as will be mentioned afterwards.

The varieties in the cohesion of stones and other minerals, and of vegetable and animal substances, are hardly susceptible of any description or classification.

Cohesio
and
strength
different
metals.

We shall take for the measure of cohesion the number of pounds avoirdupois which are just sufficient to tear asunder a rod or bundle of one inch square. From this it will be easy to compute the strength corresponding to any other dimension.

1*st, Metals.*

		lbs.
Gold, cast		20,000 24,000
Silver, cast		40,000 43,000
Copper, cast,	Japan	19,000
	Barbary	22,000
	Hungary	31,000
	Anglesea	34,000
	Sweden	37,000
Iron, cast		42,000 59,000
Iron, bar	Ordinary	68,000
	Stirian	75,000
	Best Swedish and Russian	84,000
	Horse-nails	71,000[1]

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[1] This was an experiment by Muschenbroeck, to examine the vulgar notion that iron forged from old horse-nails was stronger than all others, and shows its falsity.

Steel, bar	Soft	120,000
	Razor temper	150,000
Tin, cast	Malacca	3,100
	Banca	3,600
	Block	3,800
	English block	5,200
	——— grain	6,500
Lead, cast		860
Regulus of antimony		1,000
Zinc		2,600
Bismuth		2,900

It is very remarkable, that almost all the mixtures of metals are more tenacious than the metals themselves. The change of tenacity depends much on the proportion of the ingredients, and the proportion which produces the most tenacious mixture is different in the different metals. We have selected the following from the experiments of Muschenbroeck. The proportion of ingredients here selected is that which produces the greatest strength.

Two parts of gold with one of silver	28,000
Five parts of gold with one of copper	50,000
Five parts of silver with one of copper	48,500
Four parts of silver with one of tin	41,000
Six parts of copper with one of tin	41,000
Five parts of Japan copper with one of Banca tin	57,000
Six parts of Chili copper with one of Malacca tin	60,000
Six parts of Swedish copper with one of Malacca tin	64,000
Brass consists of copper and zinc in an unknown proportion; its strength is	51,000
Three parts of block-tin with one part of lead	10,200
Eight parts of block-tin with one part of zinc	10,000
Four parts of Malacca tin with one part of regulus of antimony	12,000
Eight parts of lead with one of zinc	4,500
Four parts of tin with one of lead and one of zinc	13,000

These numbers are of considerable use in the arts. The mixtures of copper and tin are particularly interesting in the fabric of great guns. We see that, by mixing copper, whose greatest strength does not exceed 37,000, with tin, which does not exceed 6000, we produce a metal whose tenacity is almost double, at the same time that it is harder and more easily wrought. It is, however, more fusible, which is a great inconvenience. We also see that a very small addition of zinc almost doubles the tenacity of tin, and increases the tenacity of lead five times; and a small addition of lead doubles the tenacity of tin. These are economical mixtures. This is very valuable information to the plumbers, for augmenting the strength of water-pipes.

By having recourse to these tables, the engineer can proportion the thickness of his pipes, of whatever metal, to the pressures to which they are exposed.

2d, *Woods.*

We may premise to this part of the table the following general observations.

1. The wood immediately surrounding the pith or heart of the tree is the weakest, and its inferiority is so much more remarkable as the tree is older. In this assertion, however, we speak with some hesitation. Muschenbroeck's *detail* of experiments is decidedly in the affirmative. M. Buffon, on the other hand, says that his experience has taught him that the heart of a sound tree is the strongest; but he gives no instances. From many observations of our own on very *large* oaks and firs, we are certain that the heart is much weaker than the exterior parts.

2. The wood next the bark, commonly called the *white* or *blea*, is also weaker than the rest; and the wood gradually increases in strength as we recede from the centre to the blea.

3. The wood is stronger in the middle of the trunk than at the springing of the branches or at the root; and the wood of the branches is weaker than that of the trunk.

4. The wood of the north side of all trees which grow in our European climates is the weakest, and that of the south-east side is the strongest; and the difference is most remarkable in hedge-row trees, and such as grow singly. The heart of a tree is never in its centre, but always nearer to the north side, and the annual coats of wood are thinner on that side. In conformity with this, it is a general opinion of carpenters that timber is stronger whose annual plates are thicker. The trachea or air-vessels are weaker than the simple ligneous fibres. The air-vessels are the same in diameter and number of rows in trees of the same species, and they make the visible separation between the annual plates. Therefore, when these are thicker, they contain a greater proportion of the simple ligneous fibres.

5. All woods are more tenacious while green, and lose very considerably by drying after the trees are felled.

The only author who has put it in our power to judge of the propriety of his experiments is Muschenbroeck. He has described his method of trial minutely, and it seems unexceptionable. The woods were all formed into slips fit for his apparatus, and part of the slip was cut away to a parallelopiped of $\frac{1}{5}$th of an inch square, and therefore $\frac{1}{25}$th of a square inch in section. The absolute strengths of a square inch were as follow:

Absolute strength of different kinds of wood,

	lib.		lib.
Locust tree	20,100	Pomegranate	9750
Juleb	18,500	Lemon	9250
Beech, oak	17,300	Tamarind	8750
Orange	15,500	Fir	8330
Alder	13,900	Walnut	8130
Elm	13,200	Pitch-pine	7650
Mulberry	12,500	Quince	6750
Willow	12,500	Cypress	6000
Ash	12,000	Poplar	5500
Plum	11,800	Cedar	4880
Elder	10,000		

Muschenbroeck has given a very minute detail of the experiments on the ash and the walnut, stating the weights which were required to tear asunder slips taken from the four sides of the tree, and on each side, in a regular progression from the centre to the circumference. The number of this table corresponding to these two timbers may therefore be considered as the average of more than fifty trials made of each; and he says that all the others were made with the same care. We cannot therefore see any reason for not confiding in the results; yet they are considerably higher than those given by some other writers. Mr Pitot, on the authority of his own experiments, and of those of Mr Parent, avers that sixty pounds will just tear asunder a square line of sound oak, and that it will bear fifty with safety. This gives 8640 for the utmost strength of a square inch, which is much inferior to Muschenbroeck's valuation.

We may add to these,

and of other substances.

Ivory	16,270
Bone	5,250
Horn	8,750
Whalebone	7,500
Tooth of sea-calf	4,075

No substance to be strained in architecture above one half its strength.

The reader will surely observe, that these numbers express something more than the utmost cohesion; for the weights are such as will very quickly, that is, in a minute or two, tear the rods asunder. It may be said in general, that two thirds of these weights will sensibly impair the strength after a considerable while, and that one half is the utmost that can remain suspended at them without risk for ever; and it is upon this last allotment that the engineer should reckon in his constructions. There is, however, considerable difference in this respect. Woods of a very straight fibre, such as fir, will be less impaired by any load which is not sufficient to break them immediately.

According to Mr Emerson, the load which may be safely suspended to an inch square is as follows:

Iron	76,400
Brass	35,600
Hempen rope	19,600
Ivory	15,700
Oak, box, yew, plum-tree	7,850
Elm, ash, beech,	6,070
Walnut, plum	5,360
Red fir, holly, elder, plane, crab	5,000
Cherry, hazel	4,760
Alder, asp, birch, willow	4,290
Lead	430
Freestone	914

He gives us a practical rule, that a cylinder whose diameter is *d* inches, loaded to one fourth of its absolute strength, will carry as follows:

Iron	135	cwt.
Good rope	22	
Oak	14	
Fir	9	

The rank which the different woods hold in this list of Mr Emerson's is very different from what we find in Muschenbroeck's. But precise measures must not be expected in this matter. It is wonderful, that in a matter of such unquestionable importance the public has not enabled some persons of judgment to make proper trials. They are beyond the abilities of private persons.

II.—BODIES MAY BE CRUSHED.

It is of importance to know what will crush bodies.

It is of equal, perhaps greater, importance to know the strain which may be laid on solid bodies without danger of crushing them. Pillars and posts of all kinds are exposed to this strain in its simplest form; and there are cases where the strain is enormous, viz. where it arises from the oblique position of the parts, as in the struts, braces, and trusses, which occur very frequently in our great works. It is therefore most desirable to have some general knowledge of the principle which determines the strength of bodies, in opposition to this kind of strain. But, unfortunately, we are much more at a loss in this than in the last case. The mechanism of nature is, in the present case, much more complicated. It must be in some circuitous way that compression can have any tendency to tear asunder the parts of a solid body, and it is very difficult to trace the steps.

If we suppose the particles insuperably hard and in contact, and disposed in lines which are in the direction of the external pressures, it does not appear how any pressure can disunite the particles; but this is a gratuitous supposition. There are infinite odds against this precise arrangement of the lines of particles; and the compressibility of all kinds of matter in some degree shows that the particles are in a situation equivalent to distance. This being the case, and the particles, with their intervals, or what is equivalent to intervals, being in situations that are oblique with respect to the pressures, it must follow, that by squeezing them together in one direction, they are made to bulge out or separate in other directions. This may proceed so far that some may be thus pushed laterally beyond their limits of cohesion. The moment that this happens the resistance to compression is diminished, and the body will now be crushed together. We may form some notion of this by supposing a number of spherules, like small shot, sticking together by means of a cement. Compressing this in some particular direction causes the spherules to act among each other like so many wedges, each tending to penetrate through between the three which lie below it: and this is the simplest, and perhaps the only distinct, notion we can have of the matter. We have reason to think that the constitution of very homogeneous bodies, such as glass, is not very different from this.

Their streng or po of resi ance t such a force,

If this be the constitution of bodies, it appears probable that the strength, or the resistance which they are capable of making to an attempt to crush them to pieces, is proportional to the area of the section whose plane is perpendicular to the external force; for each particle being similarly and equally acted on and resisted, the whole resistance must be as their number, that is, as the extent of the section.

Accordingly this principle is assumed by the few writers who have considered the subject; but we confess that it appears to us very doubtful. Suppose a number of brittle or friable balls lying on a table uniformly arranged, but not cohering nor in contact, and that a board is laid over them and loaded with a weight; we have no hesitation in saying that the weight necessary to crush the whole collection is proportional to their number or to the area of the section. But when they are in contact, and still more if they cohere, we imagine that the case is materially altered. Any individual ball is crushed only in consequence of its being bulged outwards in the direction perpendicular to the pressure employed. If this could be prevented by a hoop put round the ball like an equator, we cannot see how any force can crush it. Any thing therefore which makes this bulging outwards more difficult, makes a greater force necessary. Now this effect will be produced by the mere contact of the balls before the pressure is applied; for the central ball cannot swell outward laterally without pushing away the balls on all sides of it. This is prevented by the friction on the table and upper board, which is at least equal to one third of the pressure. Thus any interior ball becomes stronger by the mere vicinity of the others; and if we further suppose them to cohere laterally, we think that its strength will be still more increased.

The analogy between these balls and the cohering particles of a friable body is very perfect. We should therefore expect that the strength by which it resists being crushed will increase in a greater ratio than that of the section, or the square of the diameter of similar sections; and that a square inch of any matter will bear a greater weight in proportion as it makes a part of a greater section. Accordingly this appears in many experiments, as will afterwards be noticed. Muschenbroeck, Euler, and some others, have supposed the strength of columns to be as the biquadrates of their diameters. Euler deduced this from formulæ which occurred to him in the course of his algebraic analysis; and he boldly adopts it as a principle, without looking for its foundation in the physical assumptions which he had made in the beginning of his investigation. But some of his original assumptions were as paradoxical, or at least as gratuitous, as these results; and those, in particular, from which this proportion of the strength of columns was deduced, were almost foreign to the case; and therefore the inference was of no value. Yet it was received as a principle by Muschenbroeck and by the academicians of St Petersburg. We make these very few observations, because the subject is of great practical importance; and it is a great obstacle to improvements when deference to a great name, joined to incapacity or indolence, causes authors to adopt his careless reveries as principles from which they are afterwards to draw important consequences. It must be acknowledged that we have not as yet established, on solid mechanical principles, the relation between the dimensions and the strength of a pillar. Experience plainly contradicts the general opinion, that the strength is proportional to the area of the section; but it is still more inconsistent with the opinion, that it is in the quadruplicate ratio of the diameters of similar sections. It would seem that the ratio depends much on the internal structure of the body; and experiment seems the only method for ascertaining its general laws.

If we suppose the body to be of a fibrous texture, having the fibres situated in the direction of the pressure, and slightly adhering to each other by some kind of cement, such a body will fail only by the bending of the fibres, by which they will break the cement and be detached from each other. Something like this may be supposed in wooden pillars. In such cases, too, it would appear that the resistance must be as the number of equally resisting fibres, and as their mutual support, jointly; and, therefore, as some function of the area of the section. The same thing must happen if the fibres be naturally crooked or undulated, as is observed in many woods, provided we suppose some similarity in their form. Similarity of some kind must always be supposed, otherwise we need never aim at any general inferences.

In all cases therefore we can hardly refuse admitting that the strength in opposition to compression is proportional to a function of the area of the section.

As the whole length of a cylinder or prism is equally pressed, it does not appear that the strength of a pillar is at all affected by its length. If indeed it be supposed to bend under the pressure, the case is greatly changed, because it is then exposed to a transverse strain; and this increases with the length of the pillar. But this will be considered with due attention under the next class of strains.

Few experiments have been made on this species of strength and strain. Mr Pitot says that his experiments and those of Mr Parent show that the force necessary for crushing a body is nearly equal to that which will tear it asunder. He says that it requires something more than sixty pounds on every square line to crush a piece of sound oak. But the rule is by no means general: glass, for instance, will carry a hundred times as much as oak in this way, that is, resting on it; but will not *suspend* four or five times as much. Oak will suspend a great deal more than fir; but fir, as a pillar, will carry twice as much. Woods of a soft texture, although consisting of very tenacious fibres, are more easily crushed by their load. This softness of texture is chiefly owing to their fibres not being straight but undulated, and there being considerable vacuities between them, so that they are easily bent laterally and crushed. When a post is overstrained by its load, it is observed to swell sensibly in diameter. Increasing the load causes longitudinal cracks or shivers to appear, and it presently after gives way. This is called *crippling*.

In all cases where the fibres lie oblique to the strain, the strength is greatly diminished, because the parts can then be made to slide on each other when the cohesion of the cementing matter is overcome.

Muschenbroeck has given some experiments on this subject; but they are cases of long pillars, and therefore do not belong to this place. They will be considered afterwards.

The only experiments of which we have seen any detail (and it is useless to insert mere assertions) are those of Mr Gauthey, in the fourth volume of Rozier's *Journal de Physique*. This engineer exposed to great pressures small rectangular parallelopipeds, cut from a great variety of stones, and noted the weights which crushed them. The following table exhibits the medium results of many trials on two very uniform kinds of freestone, one of them among the hardest and the other among the softest used in building.

Column first expresses the length AB of the section, in French lines or 12ths of an inch; column second expresses the breadth BC; column third is the area of the section, in square lines; column fourth is the number of ounces required to crush the piece; column fifth is the weight which was then borne by each square line of the section; and column sixth is the round numbers to which Mr Gauthey imagines that those in column fifth approximate.

Experiments for this purpose made on freestone

Hard Stone.

	AB.	BC.	AB×BC.	Weight.	Force.	
1	8	8	64	736	11·5	12
2	8	12	96	2625	27·3	24
3	8	16	128	4496	35·1	36
			Soft Stone.			
4	9	16	144	560	3·9	4·
5	9	18	162	848	5·3	4·5
6	18	18	324	2928	9·	9·
7	18	24	432	5296	12·2	12·

Little can be deduced from these experiments: the first and third, compared with the fifth and sixth, should furnish similar results; for the first and fifth are respectively half of the third and sixth; but the third is three times stronger (that is, a line of the third) than the first, whereas the sixth is only twice as strong as the fifth.

It is evident, however, that the strength increases much faster than the area of the section, and that a square line can carry more and more weight, according as it makes a part of a larger and larger section. In this series of experiments on the soft stone, the individual strength of a square line seems to increase nearly in the proportion of the section of which it makes a part.

Mr Gauthey deduces, from the whole of his numerous experiments, that a pillar of hard stone of Givry, whose section is a square foot, will bear with perfect safety 664,000 pounds, and that its extreme strength is 871,000; and the smallest strength observed in any of his experiments was 460,000. The soft bed of Givry stone had for its smallest strength 187,000, for its greatest 311,000, and for its safe load 249,000. Good brick will carry with safety 320,000; chalk will carry only 9000. The boldest piece of architecture in this respect which he has seen is a pillar in the church of All-Saints at Angers. It is twenty-four feet long and eleven inches square, and is loaded with 60,000, which is not one seventh of what is necessary for crushing it.

We may observe here by the way, that Mr Gauthey's measure of the suspending strength of stone is vastly small in proportion to its power of supporting a load laid above it. He finds that a prism of the hard bed of Givry, of a foot section, is torn asunder by 4600 pounds; and if it be firmly fixed horizontally in a wall, it will be broken by a weight of 56,000 suspended a foot from the wall. If it rest on two props at a foot distance, it will be broken by 206,000 laid on its middle. These experiments agree so ill with each other, that little use can be made of them. The subject is of great importance, and well deserves the attention of the patriotic philosopher.

not satisfactory.

Good experiments much wanted.

A set of good experiments would be very valuable, because it is against this kind of strain that we must guard by judicious construction in the most delicate and difficult problems which come through the hands of the civil and military engineer. The construction of stone arches, and the construction of great wooden bridges, and particularly the construction of the frames of carpentry called *centres* in the erection of stone bridges, are the most difficult jobs that occur. In the centres on which the arches of the bridge of Orleans were built, some of the pieces of oak were carrying upwards of two tons on every square inch of their scantling. All who saw it said that it was not able to carry the fourth part of the intended load. But the engineer understood the principles of his art, and ran the risk, and the result completely justified his confidence; for the centre did not complain in any part, only it was found too supple; so that it went out of shape while the haunches only of the arch were laid on it. The engineer corrected this by loading it at the crown, and thus kept it completely in shape during the progress of the work.

In the Memoirs of the Academy of St Petersburg for

1778, there is a dissertation by Euler on this subject, but particularly limited to the strain on columns, in which the bending is taken into the account. Mr Fuss has treated the same subject with relation to carpentry in a subsequent volume. But there is little in these papers besides a dry mathematical disquisition, proceeding on assumptions which (to speak favourably) are extremely gratuitous. The most important consequence of the compression is wholly overlooked, as we shall presently see. Our knowledge of the mechanism of cohesion is as yet far too imperfect to entitle us to a confident application of mathematics. Experiments should be multiplied.

How they are to be made useful.

The only way in which we can hope to make these experiments useful, is to pay a careful attention to the *manner* in which the fracture is produced. By discovering the general resemblances in this particular, we advance a step in our power of introducing mathematical measurement. Thus, when a cubical piece of chalk is slowly crushed between the chaps of a vice, we see it uniformly split in a surface oblique to the pressure, and the two parts then slide along the surface of fracture. This should lead us to examine mathematically what relation there is between this surface of fracture and the necessary force; then we should endeavour to determine experimentally the position of this surface. Having discovered some general law or resemblance in this circumstance, we should try what mathematical hypothesis will agree with this. Having found one, we may then apply our simplest notions of cohesion, and compare the result of our computations with experiment.

III.—A BODY MAY BE BROKEN ACROSS.

It is of importance to know what strain will break a body transversely.

The most usual, and the greatest strain, to which materials are exposed, is that which tends to break them transversely. It is seldom, however, that this is done in a manner perfectly simple; for when a beam projects horizontally from a wall, and a weight is suspended from its extremity, the beam is commonly broken near the wall, and the intermediate part has performed the functions of a lever. It sometimes, though rarely, happens that the pin in the joint of a pair of pincers or scissors is cut through by the strain; and this is almost the only case of a simple transverse fracture. Being so rare, we may content ourselves with saying, that in this case the strength of the piece is proportional to the area of the section.

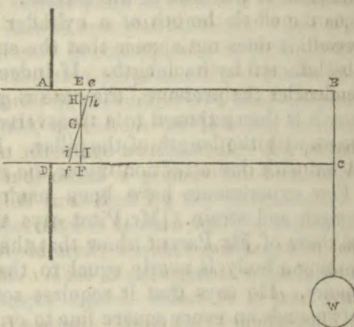
Experiments made to ascertain it.

Experiments were made for discovering the resistances made by bodies to this kind of strain in the following manner. Two iron bars were disposed horizontally at an inch distance; a third hung perpendicularly between them, being supported by a pin made of the substance to be examined. This pin was made of a prismatic form, so as to fit exactly the holes in the three bars, which were made very exact, and of the same size and shape. A scale was suspended at the lower end of the perpendicular bar, and loaded till it tore out that part of the pin which filled the middle hole. This weight was evidently the measure of the lateral cohesion of two sections. The side-bars were made to grasp the middle bar pretty strongly between them, that there might be no distance interposed between the opposite pressures. This would have combined the energy of a lever with the purely transverse pressure. For the same reason it was necessary that the internal parts of the holes should be no smaller than the edges. Great irregularities occurred in our first experiments from this cause, because the pins were somewhat tighter within than at the edges; but when this was corrected they were extremely regular. We employed three sets of holes, viz. a circle, a square (which was occasionally made a rectangle whose length was twice its breadth), and an equilateral triangle. We found in all our experiments the strength exactly proportional to the area of the section, and quite independent of its figure or position, and we found it considerably above the direct cohesion; that is, it took considerably more than twice the force to tear out this middle piece that it did to tear the pin asunder by a direct pull. A piece of fine freestone required 205 pounds to pull it directly asunder, and 575 to break it in this way. The difference was very constant in any one substance, but varied from four thirds to six thirds in different kinds of matter, being smallest in bodies of a fibrous texture. But indeed we could not make the trial on any bodies of considerable cohesion, because they required such forces as our apparatus could not support. Chalk, clay baked in the sun, baked sugar, brick, and freestone, were the strongest that we could examine.

Their sult.

But the more common case, where the energy of a lever intervenes, demands a minute examination. (B. B. B.)

Fig. 3.



Let ABCD (fig. 3) be the longitudinal section of a beam inserted into a wall at the end AD, and supporting a weight at the free end BC: it is required to find what tendency the weight will have to break the beam over at the section EF.

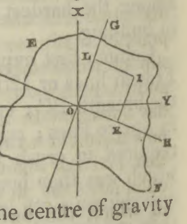
The weight at C will, in the first place, cause a tendency of the part EBCF to slide down on the surface EF, but the strength of the beam in resisting this kind of dislocation is much greater than its power of resisting common fracture: it is therefore unnecessary to examine this case.

The weight at C will cause the beam to bend; that is, it will distend the upper and compress the under part of the beam, and, acting at the extremity of the lever FC, its power of causing such compression and distention will be W × FC. Since the weight at C acts in a vertical direction, it cannot tend either to lengthen or to shorten the beam, and thus the repulsion of the compressed part must be exactly equal to the attraction of the distended parts.

Let G be the neutral point, and draw through it the line *f* G *e*, contiguous to FGE; draw also H*h* and I*i* parallel to CD. The lines I*i*, in the under side of the cross section, will represent the degrees of compression, and also (since within the limits of security the repulsion is proportional to the degree of compression) the force of repulsion, while the lines H*h* on the upper side will serve to represent the attractions. The sum of all the lines on the upper side, that is, the wedge EG*e*, will thus represent the entire amount of attraction, while the wedge FG*f* will represent the total amount of repulsion. These two wedges, then, must be equal to each other; and this equality determines the position of the axis of flexure represented by the point G. In the case of a rectangular beam, G must clearly be in the middle of the line EF; but when the cross section of the beam is irregular, the position of the axis of flexure is not quite so easily found.

Let EF be the cross section of an irregular beam, and OH the axis of flexure, or the place where the beam is neither compressed nor distended. Then the wedges generated by turning the section EF upon OH as an axis must be equal to each other. This is always the case when OH passes through the centre of gravity of the cross section, and thus it follows that those points which are neither compressed nor distended are always ranged in a straight line drawn through the centre of gravity of the cross section.

Fig. 4.



The position of the fulcrum of the lever being now known, we can proceed to ascertain the effects of the various forces.

Returning, for the sake of simplicity, to the rectangular beam; the sum of the repulsions iI will be represented by the triangle GfF: but the rectangle under GF and Ff would measure the entire strength of the under half of the beam, and therefore the force actually exerted when the beam is about to be broken across, is just half of the absolute strength of the beam; one quarter being exhibited as attraction, another quarter as repulsion. These forces act at different distances from the fulcrum G, and it is well known that the influence of a number of weights in turning a lever round is the same as if all these weights were to act at their common centre of gravity; so that to find the entire action in this case, we have to suppose one fourth of the whole strength of the beam to act at the distance $\frac{2}{3}$ of GF or $\frac{1}{3}$ of EF from the fulcrum G, and another quarter of the strength at $\frac{2}{3}$ of GE. Now, if s be the strength of one square inch of the beam, and if D, B, and L be its depth, breadth, and length, measured in inches, D B s will be the absolute strength of the whole beam; and therefore the tendencies of the above forces to straighten the beam will be

$$\tfrac{1}{4}\,\mathrm{DB}s \times \tfrac{1}{3}\,\mathrm{D} + \tfrac{1}{4}\,\mathrm{DB}s \times \tfrac{1}{3}\,\mathrm{D};$$

that is, $\frac{1}{6}\,\mathrm{D}^2 \cdot \mathrm{B} \cdot s$. And again, the tendency of the weight W to bend the beam is WL; so that

$$\tfrac{1}{6}\,\mathrm{D}^2 \cdot \mathrm{B} \cdot s = \mathrm{WL},$$

$$\text{or } 6\mathrm{L} : \mathrm{D} :: \mathrm{DB}s : \mathrm{W};$$

that is, *as six times the length of the beam is to its depth, so is the absolute strength of the beam to the weight which it can carry at the free end.*

Throughout this investigation we have supposed that the force needed to extend or compress a fibre is exactly proportional to the quantity of extension or compression. This hypothesis, though not perhaps strictly true, and though it certainly errs when we approach to dislocation or fracture, is yet confirmed by all experiments when the extensions have been kept within the limits of safety: the results of this hypothesis therefore are what must guide us in forming any structure.

It may now be interesting to inquire into the strength of a beam when bent in different directions.

EF being, as before, the cross section of an irregular beam, let that beam be bent in the direction OG, the axis of flexure being OH perpendicular to OG; and let us consider the action of a small portion ds of the surface situated at I. Having drawn the perpendiculars IK and IL, it is clear that the compression of the fibre I must be proportional to KI; and therefore the force exerted by it may be denoted by $\mathrm{C} \cdot \mathrm{IK} \cdot ds$, C being some constant depending on the nature of the material and the degree of flexure. This force, conceived to act at the extremity of the lever KI, will tend to bend the beam round the axis OH; but again acting at the end of the lever LI, it will tend to bend the beam on OG as an axis. Putting Σ to denote the integral for the entire surface, $\mathrm{C} \cdot \Sigma \cdot \mathrm{IK}^2 ds$ will be the entire tendency to rectify the form of the beam, and $\mathrm{C}\Sigma\mathrm{IK} \cdot \mathrm{IL} \cdot ds$ will be the entire tendency to take a flexure in a plane at right angles to that which it actually has. A beam therefore will not bend in the direction in which the pressure is applied to it unless $\Sigma \cdot \mathrm{IK} \cdot \mathrm{IL} ds = 0$. This is a circumstance overlooked in all treatises on flexure; but it is one that must be carefully attended to in practice. It may easily be illustrated thus: Take a thin slip of wood, such perhaps as is used for Venetian blinds, and fix it in a vice so that while its length is horizontal its flat sides may be inclined at a considerable angle. Attach now a weight to the free end, and it will be found that that end does not descend vertically, but that it moves obliquely, the flexure not happening in that direction in which the force is applied. The force necessary to bend the beam in the plane of OG is not a force in that direction, but is the resultant of two forces, $\Sigma\, \mathrm{IK}^2 \cdot ds$ in the direction OG, and $\Sigma \cdot \mathrm{IK} \cdot \mathrm{IL} \cdot ds$ in the direction OH. For the present we shall call $\Sigma\mathrm{IK}^2 ds$ the *stiffness in the direction* OG, and $\Sigma \cdot \mathrm{IL}^2 ds$ of course the stiffness in the direction OH. The sum of these two stiffnesses is manifestly $\Sigma \cdot \mathrm{OI}^2 ds$, which is a constant quantity, depending not at all upon the directions of OG, OH, but only on the form of the cross section: hence follows the remarkable law, that the sum of the stiffnesses of a beam in two directions perpendicular to each other is constant; and that therefore, whatever may be the form of the beam, its directions of greatest and least stiffness are always perpendicular to each other.

For the purpose of discovering in what directions the greatest and least stiffness lie, let us refer all the points in the cross section to the axes OX and OY, putting the angle $\mathrm{XOG} = \varphi$. We have then $\mathrm{IK} = x \cos.\varphi + y \sin.\varphi$, $\mathrm{IL} = -x \sin.\varphi + y \cos.\varphi$; and thus the tendency of the beam to redress itself in the direction GO is $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)^2 ds$, while the deflecting tendency in the direction HO is $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)(-x \sin.\varphi + y \cos.\varphi)\, ds$. Regarding φ as the variable quantity, and differentiating the former for the purpose of discovering its maximum, we obtain $\Sigma \cdot (x \cos.\varphi + y \sin.\varphi)(-x \sin.\varphi + y \cos.\varphi)\, ds = 0$; now it will be observed that this expression is just that for the deflecting tendency, and hence this law,

That when a beam is bent in the direction of greatest or of least stiffness, the pressure to be applied is exactly in the direction of the bending.

The value of φ may easily be found from the above equation; the result is

$$\tan.\, 2\varphi = \frac{2\,\Sigma \cdot xy\, ds}{\Sigma x^2 ds - \Sigma y^2 ds}.$$

The lines OX and OY will coincide with the directions of greatest and least stiffness when $\varphi = 0$, or when $\tan.\, 2\varphi = 0$, that is, when $\Sigma \cdot xy\, ds = 0$.

If, then, the directions of greatest and least stiffness be taken for the axes of xy and of y, we shall have $\Sigma \cdot xy\, ds = 0$, $\Sigma\, x^2 ds =$ greatest stiffness $=$ A, $\Sigma\, y^2 ds =$ least stiffness $=$ B. These being once known, the stiffness in any other direction, as well as the deflecting tendency, can readily be obtained. Putting P and Q respectively for these quantities, we have

$$\mathrm{P} = \mathrm{A} \cos.\varphi^2 + \mathrm{B} \sin.\varphi^2,$$

$$\mathrm{Q} = \tfrac{1}{2}(\mathrm{B} - \mathrm{A}) \sin.\, 2\varphi.$$

The deflecting tendency is thus greatest when $\varphi = 45°$, that is, when the actual direction of flexure is equally inclined to the directions of greatest and least stiffness. In this case

$$\mathrm{P}^1 = \tfrac{1}{2}(\mathrm{A} + \mathrm{B}),\ \mathrm{Q} = \tfrac{1}{2}(\mathrm{B} - \mathrm{A}).$$

Galileo, who was the first to investigate the law of transverse strain, conceived the lower edge of the beam to be the fulcrum, and each fibre to be exerting its whole strength; Professor Robison, in the former editions of this work, corrected the supposition in the case of rectangular beams: the above investigation extends it to beams of all forms.

(C. E.)

We must now remark, that this correction of the Galilean hypothesis of equal forces was suggested by the bending which is observed in all bodies which are strained transversely. Because they are bent, the fibres on the convex side have been extended. We cannot say in what proportion this obtains in the different fibres. Our most distinct notions of the internal equilibrium between the particles render it highly probable that their extension is proportional to their distance from that fibre which retains its former dimensions. But by whatever law this is regulated, we see plainly that the actions of the stretched fibres must follow the proportions of some function of this distance, and that therefore the relative strength of a beam is in all cases susceptible of mathematical determination.

Bernoulli's problem of the elastic curve.

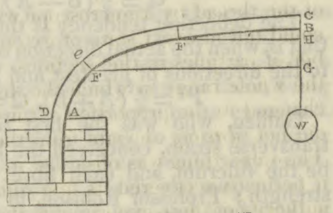
We also see an intimate connection between the strain and the curvature. This suggested to the celebrated James Bernoulli the problem of the *elastic curve, i. e.* the curve into which an extensible rigid body will be bent by a transverse strain. His solution in the *Acta Eruditorum* 1694 and 1695, is a very beautiful specimen of mathematical discussion, and we recommend it to the perusal of the curious reader. He will find it very perspicuously treated in the first volume of his works, published after his death, where the wide steps which he had taken in his investigation are explained so as to be easily comprehended. His nephew, Daniel Bernoulli, has given an elegant abridgement in the Petersburg Memoirs for 1729. The problem is too intricate to be fully discussed in a work like ours, but it is also too intimately connected with our present subject to be entirely omitted. We must content ourselves with showing the leading mechanical properties of this curve, from which the mathematician may deduce all its geometrical properties.

Its leading mechanical property described.

When a bar of uniform depth and breadth, and of a given length, is bent into an arch of a circle, the extension of the outer fibres is proportional to the curvature; for, because the curves formed by the inner and outer sides of the beam are similar, the circumferences are as the radii, and the radius of the inner circle is to the difference of the radii as the length of the inner circumference is to the difference of the circumferences. The difference of the radii is the depth of the beam, the difference of the circumferences is the extension of the outer fibres, and the inner circumference is supposed to be the primitive length of the beam. Now the second and third quantities of the above analogy, viz. the depth and length of the beam, are constant quantities, as is also their product. Therefore the product of the inner radius and the extension of the outer fibre is also a constant quantity, and the whole extension of the outer fibre is inversely as the radius of curvature, or is directly as the curvature of the beam.

The mathematical reader will readily see, that into whatever curve the elastic bar is bent, the whole extension of the outer fibre is equal to the length of a similar curve having the same proportion to the thickness of the beam that the length of the beam has to the radius of curvature.

Fig. 5.



Now let ADCB (fig. 5) be such a rod of uniform breadth and thickness, firmly fixed in a vertical position, and bent into a curve AEFB by a weight W suspended at B, and of such magnitude that the extremity B has its tangent perpendicular to the action of the weight, or parallel to the horizon. Suppose, too, that the extensions are proportional to the extending forces. From any two points E and F draw the horizontal ordinates EG, FH. It is evident that the exterior fibres of the sections E*e* and F*f* are stretched by forces which are in the proportion of EG to FH (these being the long arms of the levers, and the equal thicknesses E*e*, F*f* being the short arms). Therefore (by the hypothesis) their extensions are in the same proportion. But because the extensions are proportional to some similar functions of the distance from the axes of fracture E and F, the extension of any fibre in the section E*e* is to the contemporaneous extension of the similarly situated fibre in the section F*f*, as the extension of the exterior fibre in the section E*e* is to the extension of the exterior fibre in the section F*f*: therefore the whole extension of E*e* is to the whole extension of F*f* as EG to FH, and EG is to FH as the curvature in E to the curvature in F.

Here let it be remarked, that this proportionality of the curvature to the extension of the fibres is not limited to the hypothesis of the proportionality of the extensions to the extending forces: it follows from the extension in the different sections being as some similar function of the distance from the axis of fracture; an assumption which cannot be refused.

This, then, is the fundamental property of the elastic curve, from which its equation, or relation between the abscissa and ordinate, may be deduced in the usual forms, and all its other geometrical properties. These are foreign to our purpose; and we shall notice only such properties as have an immediate relation to the strain and strength of the different parts of a flexible body, and which in particular serve to explain some difficulties in the valuable experiments of Buffon on the Strength of Beams.

It is n
circle.

We observe, in the first place, that the elastic curve cannot be a circle, but is gradually more incurvated as it recedes from the point of application B of the straining forces. At B it has no curvature; and if the bar were extended beyond B there would be no curvature there. In like manner, when a beam is supported at the ends and loaded in the middle, the curvature is greatest in the middle; but at the props, or beyond them, if the beam extend farther, there is no curvature. Therefore, when a beam projecting twenty feet from a wall is bent to a certain curvature at the wall by a weight suspended at the end, and a beam of the same size projecting twenty feet is bent to the very same curvature at the wall by a greater weight at ten feet distance, the figure and the mechanical state of the beam in the vicinity of the wall is different in these two cases, though the curvature at the very wall is the same in both. In the first case every part of the beam is incurvated; in the second, all beyond the ten feet is without curvature. In the first experiment the curvature at the distance of five feet from the wall is three fourths of the curvature at the wall; in the second, the curvature at the same place is but one half of that at the wall. This must weaken the long beam in this whole interval of five feet, because the greater curvature is the result of a greater extension of the fibres.

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In the next place we may remark, that there is a certain determinate curvature for every beam, which cannot be exceeded without breaking it; for there is a certain separation of two adjoining particles that puts an end to their cohesion. A fibre can therefore be extended only a certain proportion of its length. The ultimate extension of the outer fibres must bear a certain determinate proportion to its length, and this proportion is the same with that of the thickness (or what we have hitherto called the depth) to the radius of ultimate curvature, which is therefore determinate.

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A beam of uniform breadth and depth is therefore most incurvated where the strain is greatest, and will break in the most incurvated part. But by changing its form, so as to make the strength of its different sections in the ratio of the strain, it is evident that the curvature may be the same throughout, or may be made to vary according to any law. This is a remark worthy of the attention of the watchmaker. The most delicate problem in practical mechanics is so to taper the balance-spring of a watch that its wide and narrow vibrations may be isochronous. Hooke's principle *ut tensio sic vis* is not sufficient when we take the *inertia* and motion of the spring itself into the account. The figure into which it bends and unbends has also an influence. Our readers will take notice that the artist aims at an accuracy which will not admit an error of $\frac{1}{86400}$th, and that Harrison and Arnold have actually attained it in several instances. The taper of a spring is at present a nostrum in the hands of each artist, and he is careful not to impart its secret.

Again, since the depth of the beam is thus proportional to the radius of ultimate curvature, this ultimate or breaking curvature is inversely as the depth. It may be expressed by $\frac{1}{d}$.

When a weight is hung on the end of a prismatic beam, the curvature is nearly as the weight and the length directly, and as the breadth and the cube of the depth inversely; for the strength is $=f\frac{bd^2}{6l}$. Let us suppose that this produces the ultimate curvature $\frac{1}{d}$. Now let the beam be loaded with a smaller weight w, and let the curvature produced be C; we have this analogy, $f\frac{bd^2}{6l} : w = \frac{1}{d} : \text{C}$, and $\text{C} = \frac{6lw}{fbd^3}$. It is evident that this is also true of a beam supported at the ends and loaded between the props; and we see how to determine the curvature in its different parts, whether arising from the load, or from its own weight, or from both.

When a beam is thus loaded at the end or middle, the loaded point is pulled down, and the space through which it is drawn may be called the *deflection*. This may be considered as the subtense of the angle of contact, or as the versed sine of the arch into which the beam is bent, and is therefore as the curvature when the length of the arches is given (the flexure being moderate), and as the square of the length of the arch when the curvature is given. The deflection therefore is as the curvature and as the square of the length of the arch jointly; that is, as $\frac{6lw}{fbd^3} \times l^2$, or as $\frac{6l^3w}{fbd^3}$. The deflection from the primitive shape is therefore as the bending weight and the cube of the length directly, and as the breadth and cube of the depth inversely.

In beams just ready to break, the curvature is as the depth inversely, and the deflection is as the square of the length divided by the depth; for the ultimate curvature at the breaking part is the same whatever is the length; and in this case the deflection is as the square of the length.

We have been the more particular in our consideration of this subject, because the resulting theorems afford us the finest methods of examining the laws of corpuscular action, that is, for discovering the variation of the force of cohesion by a change of distance. It is true it is not the atomical law, or *hylarchic principle* as it may justly be called, which is thus made accessible, but the specific law of the particles of the substance or kind of matter under examination. But even this is a very great point; and coincidences in this respect among the different kinds of matter are of great moment. We may thus learn the nature of the corpuscular action of different substances, and perhaps approach to a discovery of the *mechanism* of chemical affinities. For that chemical actions are insensible cases of local motion is undeniable, and local motion is the province of mechanical discussion; nay, we see that these hidden changes are produced by mechanical forces in many important cases, for we see them promoted or prevented by means purely mechanical. The conversion of bodies into elastic vapour by heat can at all times be prevented by a *sufficient* external pressure. A strong solution of Glauber's salts will congeal in an instant by agitation, giving out its latent heat; and it will remain fluid for ever, and retain its latent heat in a close vessel which it completely fills. Even water will by such treatment freeze in an instant by agitation, or remain fluid for ever by confinement. We know that heat is produced or extricated by friction, that certain compounds of gold or silver with saline matters explode with irresistible violence by the smallest pressure or agitation. Such facts should rouse the mathematical philosopher, and excite him to follow out the conjectures of the illustrious Newton, encouraged by the ingenious attempts of Boscovich; and the proper beginning of this study is to attend to the laws of attraction and repulsion exerted by the particles of cohering bodies, discoverable by experiments made on their actual extensions and compressions. The experiments of simple extensions and compressions are quite insufficient, because the total stretching of a wire is so small a quantity, that the mistake of the 1000th part of an inch occasions an irregularity which deranges any progression so as to make it useless. But by the bending of bodies a distention of $\frac{1}{100}$th of an inch may be easily magnified in the deflection of the spring ten thousand times. We know that the investigation is intricate and difficult, but not beyond the reach of our present mathematical attainments; and it will give very fine opportunities of employing all the address of analysis. In the 17th century and the beginning of the 18th this was a sufficient excitement to the first geniuses of Europe. The cycloid, the catenaria, the elastic curve, the velaria, the caustics, were reckoned an abundant recompense for much study; and James Bernoulli requested, as an honourable monument, that the logarithmic spiral might be inscribed on his tombstone. The reward for the study to which we now presume to incite the mathematicians is the almost unlimited extension of natural science, important in every particular branch. To go no further than our present subject, a great deal of important practical knowledge respecting the strength of bodies is derived from the single observation, that in the moderate extensions which happen before the parts are overstrained, the forces are nearly in the proportion of the extensions or separations of the particles. To return to our subject.

Bernoulli calls in question this law,

James Bernoulli, in his second dissertation on the elastic curve, calls in question this law, and accommodates his investigation to any hypothesis concerning the relation of the forces and extensions. He relates some experiments of lute-strings where the relation was considerably different. Strings of three feet long,

stretched by	2,	4,	6,	8,	10 pounds,
were lengthened	9,	17,	23,	27,	30 lines.

But this is a most exceptionable form of the experiment. The strings were twisted, and the mechanism of the extensions is here exceedingly complicated, combined with compressions and with transverse twists, &c. We made experiments on fine slips of the gum caoutchouc, and on the juice of the berries of the white bryony, of which a single grain will draw to a thread of two feet long, and again return into a perfectly round sphere. We measured the diameter of the thread by a microscope with a micrometer, and thus could tell in every state of extension the proportional number of particles in the sections. We found, that through the whole range in which the distance of the particles was changed in the proportion of thirteen to one, the extensions did not *sensibly* deviate from the proportion of the forces. The same thing was observed in the caoutchouc as long as it perfectly recovered its first dimensions. And it is on the authority of these experiments that we presume to announce this as a law of nature.

which was first assumed by Dr Hooke.

Dr Robert Hooke was undoubtedly the first who attended to this subject, and assumed this as a law of nature. Mariotte indeed was the first who expressly used it for determining the strength of beams: this he did about the year 1679, correcting the simple theory of Galileo. Leibnitz, indeed, in his dissertation in the *Acta Eruditorum* 1684, *De Resistentia Solidorum*, introduces this consideration, and wishes to be considered as the discoverer; and he is always acknowledged as such by the Bernoullis, and others who adhered to his peculiar doctrines. But Mariotte had published the doctrine in the most express terms long before; and Bulfinger, in the *Comment. Petropol.* 1729, completely vindicates his claim. But Hooke was unquestionably the discoverer of this law. It made the foundation of his theory of springs, announced to the Royal Society about the year 1661, and read in 1666. On this occasion he mentions many things on the strength of bodies as quite familiar to his thoughts, which are immediate deductions from this principle; and among these *all* the facts which John Bernoulli so vauntingly adduces in support of Leibnitz's finical dogmas about the force of bodies in motion; a doctrine which Hooke might have claimed as his own, had he not perceived its frivolous inanity.

Though corrected by Mariotte, it does not properly explain the mechanism of transverse strain,

But even with this first correction of Mariotte, the mechanism of transverse strain is not fully nor justly explained. The force acting in the direction BW (fig 3), and bending the body ABCD, not only stretches the fibres on the side opposite to the axis of fracture, but compresses the side CD, which becomes concave by the strain. Indeed it cannot do the one without doing the other; for, in order to stretch the fibres at D, there must be some fulcrum, some support, on which the virtual lever BAD may press, that it may tear asunder the stretched fibres. This fulcrum must sustain both the pressure arising from the cohesion of the distended fibres, and also the action of the external force, which immediately tends to cause the prominent part of the beam to slide along the section EF.

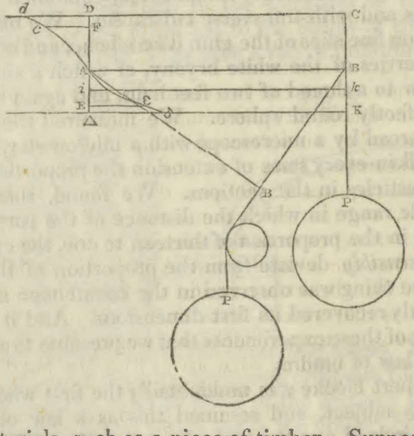
as is fully verified by experiment.

This is fully verified by experiment. If we attempt to break a long slip of cork, or any such very compressible body, we always observe it to bulge out on the concave side before it cracks on the other side. If it is a body of fibrous or foliated texture, it seldom fails splintering off on the concave side; and in many cases this splintering is very deep, even reaching half way through the piece. In hard and granulated bodies, such as a piece of freestone, chalk, dry clay, sugar, and the like, we generally see a considerable splinter or shiver fly off from the hollow side. If the fracture be slowly made by a force at B gradually augmented, the formation of the splinter is very distinctly seen. It forms a triangular piece, which generally breaks in the middle.

Consequences resulting from the state of the case.

Let us see what consequences result from this state of the case respecting the strength of bodies. Let DΔKC (fig. 6) represent a vertical section of a prism of compressible materials, such as a piece of timber. Suppose it loaded with a weight P hung at its extremity. Suppose it of such a constitution that all the fibres in AD are in a state of dilatation, while those in AΔ are in a state of compression. In the instant of fracture the particles at D and E are withheld by forces D*d*, E*e*, and the particles at Δ and E repel, resist, or support, with forces Δδ, Fε.

Fig. 6.



Some line, such as *de*Aεδ, will limit all these ordinates, which represent the forces actually exerted in the instant of fracture. If the forces be as the extensions and compressions, as we have great reason to believe, *de*A and Aεδ will be two straight lines. They will form *one* straight line *d*Aδ, if the forces which resist a certain dilatation are equal to the forces which resist an equal compression. But this is quite accidental, and is not strictly true in any body. In most bodies which have any considerable firmness, the compressions made by any external force are not so great as the dilatations which the same force would produce; that is, the repulsions which are excited by any supposed degree of compression are greater than the attractions excited by the same degree of dilatation. Hence it will generally follow, that the angle *d*AD is less than the angle δAΔ, and the ordinates D*d*, E*e*, &c. are less than the corresponding ordinates Δδ, Eε, &c.

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But whatever be the nature of the line *d*Aδ, we are certain of this, that the whole area AD*d* is equal to the whole area AΔδ; for as the force at B is gradually increased, and the parts between A and D are more extended, and greater cohesive forces are excited, there is always such a degree of repulsive forces excited in the particles between A and Δ that the one set precisely balances the other. The force at B, acting perpendicularly to AB, has no tendency to push the whole piece closer on the part next the wall, or to pull it away. The sum of the attractive and repulsive forces actually excited must therefore be equal. These sums are represented by the two triangular areas, which are therefore equal.

The greater we suppose the repulsive forces corresponding to any degree of compression, in comparison with the attractive forces corresponding to the same degree of extension, the smaller will AΔ be in comparison of AD. In a piece of cork or sponge, AΔ may chance to be equal to AD, or even to exceed it; but in a piece of marble, AΔ will perhaps be very small in comparison of AD.

Now it is evident that the repulsive forces excited between A and Δ have no share in preventing the fracture. They rather contribute to it, by furnishing a fulcrum to the lever by whose energy the cohesion of the particles in AD is overcome. Hence we see an important consequence of the compressibility of the body. Its power of resisting this transverse strain is diminished by it, and so much the more diminished as the stuff is more compressible.

This is fully verified by some very curious experiments made by Duhamel. He took sixteen bars of willow two feet long and half an inch square, and supporting them by props under the ends, he broke them by weights hung on the middle. He broke four of them by weights of 40, 41, 47, and 52 pounds: the mean is 45. He then cut four of them one third through on the upper side, and filled up the cut with a thin piece of harder wood stuck in pretty tight. These were broken by 48, 54, 50, and 52 pounds; the mean of which is 51. He cut other four half through, and they were broken by 47, 49, 50, 46; the mean of which is 48. The remaining four were cut two thirds, and their mean strength was 42.

Another set of his experiments is still more remarkable.

Six battens of willow thirty-six inches long and one and a half square were broken by 525 pounds at a medium.

Six bars were cut one third through, and the cut filled with a wedge of hard wood stuck in with a little force: these broke with 551.

Six bars were cut half through, and the cut was filled in the same manner: they broke with 542.

Six bars were cut three fourths through: these broke with 530.

A batten cut three fourths through, and loaded till nearly broken, was unloaded, and the wedge taken out of the cut. A thicker wedge was put in tight, so as to make the batten straight again by filling up the space left by the compression of the wood: this batten broke with 577 pounds.

From this it is plain that more than two thirds of the thickness (perhaps nearly three fourths) contributed nothing to the strength.

The point A is the centre of fracture in this case; and in order to estimate the strength of the piece, we may suppose that the crooked lever virtually concerned in the strain is DAB. We must find the point I, which is the centre of effort of all the attractive forces, or that point where the full cohesion of AD must be applied, so as to have a momentum equal to the accumulated momenta of all the variable forces. We must in like manner find the centre of effort i of the repulsive or supporting forces exerted by the fibres lying between A and Δ.

It is plain, and the remark is important, that this last centre of effort is the real fulcrum of the lever, although A is the point where there is neither extension nor contraction; for the lever is supported in the same manner as if the repulsions of the whole line AΔ were exerted at that point. Therefore let S represent the surface of fracture from A to D, and f represent the absolute cohesion of a fibre at D in the instant of fracture. We shall have $fS\times\overline{I+i}=pl$, or $l:I+i=fS:p$; that is, the length AB is to the distance between the two centres of effort I and i, as the absolute cohesion of the section between A and D is to the relative strength of the section.

It would be perhaps more accurate to make AI and Ai equal to the distances of A from the horizontal lines passing through the centres of gravity of the triangles of dAD and δAΔ. It is only in this construction that the points I and i are the centres of real effort of the accumulated attractions and repulsions. But I and i, determined as we have done, are the points where the full equal actions may be all applied, so as to produce the same momenta. The final results are the same in both cases. The attentive and duly informed reader will see that Mr Bulfinger, in a very elaborate dissertation on the strength of beams, in the *Comment. Petropolitan.* 1729, has committed several mistakes in his estimation of the actions of the fibres. We mention this because his reasonings are quoted and appealed to as authorities by Muschenbroeck and other authors of note. The subject has been considered by many authors on the continent. We recommend to the reader's perusal the very minute discussions in the Memoirs of the Academy of Paris for 1702 by Varignon, the Memoirs for 1708 by Parent, and particularly that of Coulomb in the *Mém. par les Sçavans Etrangers*, tom. vii.

It is evident from what has been said above, that if S and s represent the surfaces of the sections above and below A, and if G and g are the distances of their centres of gravity from A, and O and o the distances of their centres of oscillation, and D and d their whole depths, the momentum of cohesion will be $\frac{fS\cdot G\cdot O}{D}=\frac{fs\cdot g\cdot o}{d}=pl$.

If, as is most likely, the forces are proportional to the extensions and compressions, the distances AI and Ai, which are respectively $=\frac{G\cdot O}{D}$ and $\frac{g\cdot o}{d}$, are respectively $=\frac{1}{3}$DA and $\frac{1}{3}$ΔA, and when taken together are $=\frac{1}{3}$DΔ. If, moreover, the extensions are equal to the compressions in the instant of fracture, and the body is a rectangular prism like a common joist or beam, then DA and ΔA are also equal; and therefore the momentum of cohesion is $fb\times\frac{1}{2}d\times\frac{1}{3}d=\frac{fbd^2}{6}=fbd\times\frac{1}{6}d=pl$. Hence we obtain this analogy: "six times the length is to the depth as the absolute cohesion of the section is to its relative strength."

Thus we see that the compressibility of bodies has a very great influence on their power of withstanding a transverse strain. We see that in this most favourable supposition of equal dilatations and compressions, the strength is reduced to one half of the value of what it would have been had the body been incompressible. This is by no means obvious; for it does not readily appear how compressibility, which does not diminish the cohesion of a single fibre, should impair the strength of the whole. The reason, however, is sufficiently convincing when pointed out. In the instant of fracture, a smaller portion of the section is actually exerting cohesive forces, while a part of it is only serving as a fulcrum to the lever by whose means the strain on the section is produced. We see, too, that this diminution of strength does not so much depend on the sensible compressibility, as on its proportion to the dilatability by equal forces. When this proportion is small, AΔ is small in comparison of AD, and a greater portion of the whole fibre is exerting attractive forces. The experiments already mentioned, of Duhamel de Monceau, on battens of willow, show that its compressibility is nearly equal to its dilatability. But the case is not very different in tempered steel. The famous Harrison, in the delicate experiments which he made while occupied in making his longitude watch, discovered that a rod of tempered steel was nearly as much diminished in its length as it was augmented by the same external force. But it is not by any means certain that this is the proportion of dilatation and compression which obtains in the very instant of fracture. We rather imagine that it is not. The forces are nearly as the dilatations till very near breaking; but we think that they diminish when the body is just going to break. But it seems certain that the forces which resist compression increase faster than the compressions, even before fracture. We know incontestably that the ultimate resistances to compression are insuperable by any force which we can employ. The repulsive forces, therefore, in their whole extent, increase faster than the compressions, and are expressed by an assymptotic branch of the Boscovician curve formerly explained. It is therefore probable, especially in the more simple substances, that they increase faster, even in such compressions as frequently obtain in the breaking of hard bodies. We are disposed to think that this is always the case in such bodies as do not fly off in splinters on the concave side; but this must be understood with the exception of the permanent changes which may be made by compression when the bodies are crippled by it. This always increases the compression itself, and causes the neutral point to shift still more towards D. The effect of this is sometimes very great and fatal.

Experiment alone can help us to discover the proportion between the dilatability and compressibility of bodies. The strain now under consideration seems the best calculated for this research. Thus if we find that a piece of wood an inch square requires 12,000 pounds to tear it asunder by a direct pull, and that 200 pounds will break it transversely by acting 10 inches from the section of fracture, we must conclude that the neutral point A is in the middle of the depth, and that the attractive and repulsive forces are equal. Any notions that we can form of the constitution of such fibrous bodies as timber, make us imagine that the *sensible* compressions, including what arises from the bending up of the compressed fibres, is much greater than the real corpuscular extensions. One may get a general conviction of this unexpected proposition by reflecting on what must happen during the fracture. An undulated fibre can only be drawn straight, and then the corpuscular extension begins; but it may be bent up by compression to any degree, the corpuscular compression being little affected all the while. This observation is very important; and though the forces of corpuscular repulsion may be almost insuperable by any compression that we can employ, a *sensible* compression may be produced by forces not enormous, sufficient to cripple the beam. Of this we shall see very important instances afterwards.

It deserves to be noticed, that although the relative strength of a prismatic solid is extremely different in the three hypotheses now considered, yet the proportional

The proportional strengths of different pieces follow the same ratio.

strengths of different pieces follow the same ratio, namely, the direct ratio of the breadth, the direct ratio of the square of the depth, and the inverse ratio of the length. In the first hypothesis (of equal forces) the strength of a rectangular beam was $\frac{fbd^2}{2l}$; in the second (of attractive forces proportioned to the extensions) it was $\frac{fbd^2}{3l}$; and in the third (equal attractions and repulsions proportional to the extensions and compressions) it was $\frac{fbd^2}{6l}$, or more generally $\frac{fbd^2}{ml}$, where m expresses the unknown proportion between the attractions and repulsions corresponding to an equal extension and compression.

The strength of a piece depends chiefly on its depth;

Hence we derive a piece of useful information, which is confirmed by unexceptionable experience, that the strength of a piece depends chiefly on its depth, that is, on that dimension which is in the direction of the strain. A bar of timber of one inch in breadth and two inches in depth is four times as strong as a bar only one inch deep, and it is twice as strong as a bar two inches broad and one deep; that is, a joist or lever is always strongest when laid on its edge.

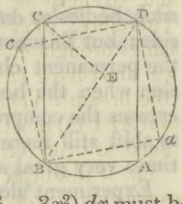
and therefore a choice in the manner in which the cohesion is opposed to the strain.

There is therefore a choice in the manner in which the cohesion is opposed to the strain. The general aim must be to put the centre of effort I as far from the fulcrum or the neutral point A as possible, so as to give the greatest energy or momentum to the cohesion. Thus if a triangular bar projecting from a wall is loaded with a weight at its extremity, it will bear thrice as much when one of the sides is uppermost as when it is undermost.

The strongest joist has not the greatest quantity of timber.

Hence it follows that the strongest joist that can be cut out of a round tree is not the one which has the greatest quantity of timber in it, but such that the product of its breadth by the square of its depth shall be the greatest possible. Let ABCD (fig. 7) be the section of this joist inscribed in the circle, AB being the breadth and AD the depth. Since it is a rectangular section, the diagonal BD is a diameter of the circle, and BAD is a right-angled triangle. Let BD be called a, and BA be called x; then $\mathrm{AD} = \sqrt{a^2 - x^2}$. Now we must have $\mathrm{AB} \cdot \mathrm{AD}^2$, or $x\ (a^2 - x^2)$, or $a^2 x - x^3$, a minimum; its differential $(a^2 - 3x^2)\,dx$ must be 0, or $a^2 = 3x^2$, or $x^2 = \frac{a^2}{3}$. If therefore we make $\mathrm{DE} = \frac{1}{3}$ DB, and draw EC perpendicular to BD, it will cut the circumference in the point C, which determines the depth BC and the breadth CD.

Fig. 7.



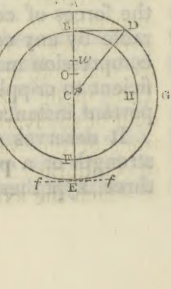
Because BD : BC = CD : CE, we have the area of the section BC·CD = BD·CE. Therefore the different sections having the same diagonal BD, are proportional to their heights CE. Therefore the section BCDA is less than the section Bc Da, whose four sides are equal. The joist so shaped, therefore, is stronger, lighter, and cheaper.

The strength of ABCD is to that of a B c D as 10,000 to 9186, and the weight and expense as 10,000 to 10,607; so that ABCD is preferable to a B c D, in the proportion of 10,607 to 9186, or nearly 115 to 100.

A hollow tube stronger than a solid rod containing the same quantity of matter,

From the same principles it follows that a hollow tube is stronger than a solid rod containing the same quantity of matter. Let fig. 8 represent the section of a cylindric tube, of which AF and BE are the exterior and interior diameters, and C the centre. Draw BD perpendicular to BC, and join DC. Then, because $\mathrm{BD}^2 = \mathrm{CD}^2 - \mathrm{CB}^2$, BD is the radius of a circle containing the same quantity of matter with the ring. If we estimate the strength by the first hypothesis, it is evident that the strength of the tube will be to that of the solid cylinder, whose radius is BD, as $\mathrm{BD}^2 \times \mathrm{AC}$ to $\mathrm{BD}^2 \times \mathrm{BD}$; that is, as AC to BD; for BD^2 expresses the cohesion of the ring of the circle, and AC and BD are equal to distances of the centres of effort (the same with the centres of gravity) of the ring and circle from the axis of the fracture.

Fig. 8.



The proportion of these strengths will be different in the other hypothesis, and is not easily expressed by a general formula; but in both it is still more in favour of the ring or hollow tube.

The following very simple solution will be readily understood by the intelligent reader. Let O be the centre of oscillation of the exterior circle, o the centre of oscillation of the inner circle, and w the centre of oscillation of the ring included between them. Let M be the quantity of surface of the exterior circle, m that of the inner circle, and μ that of the ring.

We have $\mathrm{F}w = \frac{\mathrm{M \cdot FO} - m \cdot \mathrm{F}o}{\mu} = \frac{5\ \mathrm{FC}^2 + \mathrm{EC}^2}{4\,\mathrm{FC}}$, and the strength of the ring $= \frac{f\,\mu \times \mathrm{F}w}{2}$, and the strength of the same quantity of matter in the form of a solid cylinder is $f\,\mu \times \frac{5}{8}\,\mathrm{BD}$; so that the strength of the ring is to that of the solid rod of equal weight as F w to $\frac{5}{4}$ BD, or nearly as FC to BD. This will easily appear by recollecting that FO is $= \frac{\text{sum of } p \cdot r^2}{m \cdot \mathrm{FC}}$ (see Rotation), and that the momentum of cohesion is $\frac{fm \cdot \mathrm{FC} \cdot \mathrm{C}a}{2\,\mathrm{FC}} = \frac{fm \cdot \mathrm{F}o}{2}$ for the inner circle, &c.

Emerson has given a very inaccurate approximation to this value in his Mechanics, 4to.

and stiff.

This property of hollow tubes is accompanied also with greater stiffness; and the superiority in strength and stiffness is so much the greater as the surrounding shell is thinner in proportion to its diameter.

Hen wisd God form bone holl

Here we see the admirable wisdom of the Author of nature in forming the bones of animal limbs hollow. The bones of the arms and legs have to perform the office of levers, and are thus opposed to very great transverse strains. By this form they become incomparably stronger and stiffer, and give more room for the insertion of muscles, while they are lighter and therefore more agile; and the same wisdom has made use of this hollow for other valuable purposes of the animal economy. In like manner the quills in the wings of birds acquire by their thinness the very great strength which is necessary, while they are so light as to give sufficient buoyancy to the animal in the rare medium in which it must live and fly about. The stalks of many plants, such as all the grasses, and many reeds, are in like manner hollow, and thus possess an extraordinary strength. Our best engineers now begin to imitate nature by making many parts of their machines hollow, such as their axles of cast iron, &c.; and the ingenious Mr Ramsden made the axes and framings of his great astronomical instruments in the same manner.

In the supposition of homogeneous texture, it is plain that the fracture happens as soon as the particles at D are separated beyond their utmost limit of cohesion. This is a determined quantity, and the piece bends till this degree of extension is produced in the uttermost fibre. It follows, that the smaller we suppose the distance between A and D, the greater will be the curvature which the beam will acquire before it breaks. Greater depth therefore makes a beam not only stronger, but also stiffer. But if the parallel fibres can slide on each other, both the strength and the stiffness will be diminished. Therefore, if, instead of one beam D∆KC (fig. 6), we suppose two, DABC and of AΔKB, not cohering, each of them will bend, and the extension of the fibres AB of the under beam will not hinder the compression of the adjoining fibres AB of the upper beam. The two together therefore will not be more than twice as strong as one of them (supposing DA = AΔ), instead of being four times as strong; and they will bend as much as either of them alone would bend by half the load. This may be prevented, if it were possible to unite the two beams all along the seam AB, so that the one shall not slide on the other. This may be done in small works by gluing them together with a cement as strong as the natural lateral cohesion of the fibres. If this cannot be done (as it cannot in large works), the sliding is prevented by *joggling* the beams together, that is, by cutting down several rectangular notches in the upper side of the lower beam, and making similar notches in the under side of the upper beam, and filling up the square spaces with pieces of very hard wood firmly driven in, as represented in fig. 9. Some employ iron bolts by way of joggles. But when the joggle is much harder than the wood into which it is driven, it is very apt to work loose, by widening the hole into which it is lodged. The same thing is sometimes done by scarphing the one upon the other, as represented in fig. 10; but this wastes more timber, and is not so strong, because the mutual hooks which this method form on each beam are very apt to tear each other up. By one or other of these methods, or something similar, may a compound beam be formed, of any depth, which will be almost as stiff and strong as an entire piece.

Fig. 9.

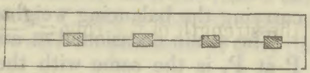
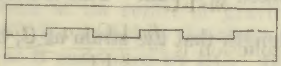
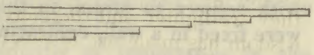


Fig. 10.



On the other hand, we may combine strength with pliableness, by composing our beam of several thin planks laid on each other, till they make a proper depth, and leaving them at full liberty to slide on each other. It is in this manner that coach-springs are formed, as is represented in fig. 11. In this assemblage there must be no joggles nor bolts of any kind put through the planks or plates, for this would hinder their mutual sliding. They must be kept together by straps which surround them, or by something equivalent.

Fig. 11.



The preceding observations show the propriety of some maxims of construction, which the artists have derived from long experience.

Thus, if a mortise is to be cut out of a piece which is exposed to a cross strain, it should be cut out from that side which becomes concave by the strain.

If a piece is to be strengthened by the addition of another, the added piece must be joined to the side which grows convex by the strain.

Before we proceed any farther, it will be convenient to recall the reader's attention to the analogy between the strain on a beam projecting from a wall and loaded at the extremity, and a beam supported at both ends and loaded in some intermediate point. It is sufficient on this occasion to read attentively what is delivered in the article Roof. We learn there that the strain on the middle point C (fig. 16 of the present article) of a rectangular beam AB, supported on props at A and B, is the same as if the part CA projected from a wall, and were loaded with the half of the weight W suspended at A. The momentum of the strain is therefore $\frac{1}{2}W \times \frac{1}{2}AB = W \times \frac{1}{4}AB = p\frac{1}{4}l$, or $\frac{pl}{4}$. The momentum of cohesion must be equal to this in every hypothesis.

Strength of Materials.

Having now considered in sufficient detail the circumstances which affect the strength of any section of a solid body that is strained transversely, it is necessary to take notice of some of the chief modifications of the strain itself. We shall consider only those that occur most frequently in our constructions.

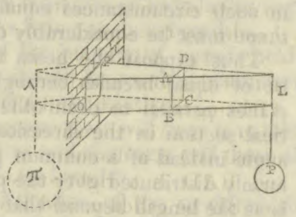
The strain depends on the external force, and also on the lever by which it acts.

The strain depends on the external force,

It is evidently of importance, that since the strain is exerted in any section by means of the cohesion of the parts intervening between the section under consideration and the point of application of the external force, the body must be able in all these intervening parts to propagate or excite the strain in the remote section. In every part it must be able to resist the strain excited in that part. It should therefore be equally strong; and it is useless to have any part stronger, because the piece will nevertheless break where it is not stronger throughout; and it is useless to make it stronger (relatively to its strain) in any part, for it will nevertheless equally fail in the part that is too weak.

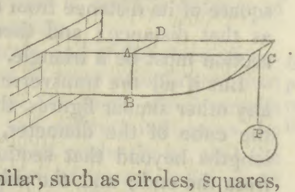
Suppose, then, in the first place, that the strain arises from a weight suspended at one extremity, while the other end is firmly fixed in a wall. Supposing also the cross sections to be all rectangular, there are several ways of shaping the beam so that it shall be equally strong throughout. Thus it may be equally deep in every part, the upper and under surfaces being horizontal planes. The condition will be fulfilled by making all the horizontal sections triangles, as in fig. 12. The two sides are vertical planes, meeting in an edge at the extremity L. For the equation expressing the balance of strain and strength is $pl = fbd^2$. Therefore, since d^2 is the same throughout, and also p, we must have $fb = l$, and b (the breadth AD of any section ABCD) must be proportional to l (or AL), which it evidently is.

Fig. 12.



Or, if the beam be of uniform breadth, we must have d^2 everywhere proportional to l. This will be obtained by making the depths the ordinates of a common parabola, of which L is the vertex and the length is the axis. The upper or under side may be a straight line, as in fig. 13, or the middle line may be straight, and then both upper and under surfaces will be curved. It is almost indifferent what is the shape of the upper and under surfaces, provided the distances between them in every part be at the ordinates of a common parabola.

Fig. 13.



Or, if the sections are all similar, such as circles, squares, or any other similar polygons, we must have d^2 or b^3 proportional to l, and the depths or breadths must be as the ordinates of a cubical parabola.

and on the form of the levers by which it acts.

It is evident that these are also the proper forms for a lever moveable round a fulcrum, and acted on by a force at the extremity. The force comes in the place of the weight suspended in the cases already considered; and as such levers always are connected with another arm, we readily see that both arms should be fashioned in the same manner. Thus in fig. 12 the piece of timber may be supposed a kind of steelyard, moveable round a horizontal axis in the front of the wall, and having the two weights P and π in equilibrio. The strain occasioned by each at the section in which the axis OP is placed must be the same, and each arm OL and Oλ must be equally strong in all its parts. The longitudinal sections of each arm must be a triangle, a common parabola, or a cubic parabola, according to the conditions previously given.

And, moreover, all these forms are equally strong; for any one of them is equally strong in all its parts, and they are all supposed to have the same section at the front of the wall or at the fulcrum. They are not, however, equally stiff. The first, represented in fig. 12, will bend least upon the whole, and the one formed by the cubic parabola will bend most. But their curvature at the very fulcrum will be the same in all.

It is also plain, that if the lever is of the second or third kind, that is, having the fulcrum at one extremity, it must still be of the same shape; for in abstract mechanics it is indifferent which of the three points is considered as the axis of motion. In every lever the two forces at the extremities act in one direction, and the force in the middle acts in the opposite direction, and the great strain is always at that point. Therefore a lever such as fig. 12, moveable round an axis passing horizontally through λ, and acting against an obstacle at OP, is equally able in all its parts to resist the strains excited in those parts.

The same principles and the same construction will apply to beams, such as joists, supported at the ends L and λ (fig. 12), and loaded at some intermediate part OP. This will appear evident by merely inverting the directions of the forces at these three points, or by recurring to the article Roof, p. 444.

The external straining force may be distributed over the beam.

Hitherto we have supposed the external straining force as acting only in one point of the beam. But it may be uniformly distributed all over the beam. To make a beam in such circumstances equally strong in all its parts, the shape must be considerably different from the former.

To make a beam strong which projects from a wall.

Thus suppose the beam to project from a wall. If it be of equal breadth throughout, its sides being vertical planes parallel to each other and to the length, the vertical section in the direction of its length must be a triangle instead of a common parabola; for the weight uniformly distributed over the part lying beyond any section, is as the length beyond that section: and since it may all be conceived as collected at its centre of gravity, which is the middle of that length, the lever by which this load acts or strains the section is also proportioned to the same length. The strain on the section (or momentum of the load) is as the square of that length. The section must have strength in the same proportion. Its strength being as the breadth and the square of the depth, and the breadth being constant, the square of the depth of any section must be as the square of its distance from the end, and the depth must be as that distance; and therefore the longitudinal vertical section must be a triangle.

But if all the transverse sections are circles, squares, or any other similar figures, the strength of every section, or the cube of the diameter, must be as the square of the lengths beyond that section, or the square of its distance from the end; and the sides of the beam must be a semicubical parabola.

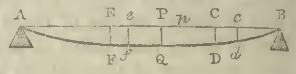
If the upper and under surfaces are horizontal planes, it is evident that the breadth must be as the square of the distance from the end, and the horizontal sections may be formed by arches of the common parabola, having the length for their tangent at the vertex.

By recurring to the analogy so often quoted between a projecting beam and a joist, we may determine the proper form of joists which are uniformly loaded through their whole length.

The strain upon a beam supported at both ends.

This is a frequent and important case, being the office of joists, rafters, &c.; and there are some circumstances which must be particularly noticed, because they are not so obvious, and have been misunderstood. When a beam AB (fig. 14) is supported at the ends, and a weight is laid on any point P, a strain is excited in every part of the beam. The load on P causes the beam to press on A and B, and the props re-act with forces equal and opposite to these pressures. The load at P is to the pressures at A and B as AB to PB and PA, and the pressure at A is to that at B as BP to PA; the beam therefore is in the same state, with respect to strain in every part of it, as if it were resting on a prop at P, and were loaded at the ends with weights equal to the two pressures on the props: and observe, these pressures are such as will balance each other, being inversely as their distances from P. Let P represent the weight or load at P. The pressure on the prop P must be $P \times \frac{PA}{AB}$. This is therefore the re-action of the prop B, and is the weight which we may suppose suspended at B, when we conceive the beam resting on a prop at P, and carrying the balancing weights at A and B.

Fig. 14.



The strain occasioned at any other point C, by the load P at P, is the same with the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, when the beam rests on P, in the manner now supposed; and it is the same if the beam, instead of being balanced on a prop at P, had its part AP fixed in a wall. This is evident. Now we have shown at length that the strain at C, by the weight $P \times \frac{PA}{AB}$ hanging at B, is $P \times \frac{PA}{AB} \times BC$. We desire it to be particularly remarked, that the pressure at A has no influence on the strain at C, arising from the action of any load between A and C; for it is indifferent how the part AP of the projecting beam PB is supported. The weight at A just performs the same office with the wall in which we suppose the beam to be fixed. We are thus particular, because we have seen even persons not unaccustomed to discussions of this kind puzzled in their conceptions of this strain.

Now let the load P be laid on some point p between C and B. The same reasoning shows us that the point is, with respect to strain, in the same state as if the beam were fixed in a wall, embracing the part pB, and a weight $= P \times \frac{pB}{AB}$ were hung on at A, and the strain at C is $P \times \frac{pB}{AB} \times AC$.

A ge propo tion.

In general, therefore, the strain on any point C, arising from a load P laid on another point P, is proportional to the rectangle of the distances of P and C from the ends nearest to each. It is $P \times \frac{PA \times CB}{AB}$, or $P \times \frac{pB \times CA}{AB}$, according as the load lies between C and A or between C and B.

Cor. 1. The strains which a load on any point P occasions on the points C, c, lying on the same side of P, are as the distances of these points from the end B. In like manner the strains on E and e are as EA and eA.

Cor. 2. The strain which a load occasions in the part on which it rests is as the rectangle of the parts on each side. Thus the strain occasioned at C by a load is to that at D by the same load as AC × CB to AD × DB. It is therefore greatest in the middle.

The arisin a load buted the b

Let us now consider the strain on any point C arising from a load uniformly distributed along the beam. Let AP be represented by x, and Pp by dx, and the whole weight on the beam by a. Then

The weight on Pp is.....................$= a\dfrac{dx}{\text{AB}}$.

Pressure on B by the weight on P$p = a\dfrac{dx}{\text{AB}} \times \dfrac{\text{AP}}{\text{AB}}$,

Or..$= a\dfrac{x dx}{\text{AB}^2}$.

Pressure on B by whole wt. on AC $= a\dfrac{\frac{1}{2}\text{AC}^2}{\text{AC}^2} = a\dfrac{\text{AC}^2}{2\text{AB}^2}$.

Strain at C by the weight on AC $= a\dfrac{\text{AC}^2 \times \text{BC}}{2\text{AB}^2}$.

Strain at C by the weight on BC $= a\dfrac{\text{BC}^2 \times \text{AC}}{2\text{AB}^2}$.

Do. by whole weight on AB $= a\dfrac{\text{AC}^2 \times \text{BC} + \text{BC}^2 \times \text{AC}}{2\text{AB}^2}$

$$= a\frac{\text{AC} \times \text{BC} \times \overline{\text{AC} + \text{CB}}}{2\text{AB}^2} = a\frac{\text{AC} \times \text{BC}}{2\text{AB}}.$$

Thus we see that the strain is proportional to the rectangle of the parts, in the same manner as if the load a had been laid directly on the point C, and is indeed equal to one half of the strain which would be produced at C by the load a laid on there.

Mist es on this s ject comm ed by au ors of re a- tion.

It was necessary to be thus particular, because we see in some elementary treatises on mechanics, published by authors of reputation, mistakes which are very plausible, and mislead the learner. It is there said that the pressure at B from a weight uniformly diffused along AB, is the same as if it were collected at its centre of gravity, which would be the middle of AB; and then the strain at C is said to be this pressure at B multiplied by BC. But surely it is not difficult to see the difference of these strains. It is plain that the pressure of gravity downwards on any point between the end A and the point C has no tendency to diminish the strain at C, arising from the upward re-action of the prop B; whereas the pressure of gravity between C and B is almost in direct opposition to it, and must diminish it. We may however avoid the fluxionary calculus with safety by the consideration of the centre of gravity, by supposing the weights of AC and BC to be collected at their respective centres of gravity; and the result of this computation will be the same as above: and we may use either method, although the weight be not uniformly distributed, provided only that we know in what manner it is distributed.

This investigation is evidently of importance in the practice of the engineer and architect, informing them what support is necessary in the different parts of their constructions. We considered some cases of this kind in the article Roof.

To fo a joist w h may h the sa relativ streng all its p ts.

It is now easy to form a joist so that it shall have the same relative strength in all its parts.

I. To make it equally able in all its parts to carry a given weight laid on any point C taken at random, or uniformly diffused over the whole length, the strength of the section at the point C must be as AC × CB. Therefore,

1. If the sides be parallel vertical planes, the square of the depth (which is the only variable dimension), or CD^2, must be as AC × CB, and the depths must be ordinates of an ellipse.

2. If the transverse sections be similar, we must make CD^3 as AC × CB.

3. If the upper and under surfaces be parallel, the breadth must be as AC × CB.

II. If the beam be necessarily loaded at some given point C, and we would have the beam equally able in all its parts to resist the strain arising from the weight at C, we must make the strength of every transverse section between C and either end as its distance from that end. Therefore,

1. If the sides be parallel vertical planes, we must make $\text{CD}^2 : \text{EF}^2 = \text{AC} : \text{AE}$.

2. If the sections be similar, then $\text{CD}^3 : \text{EF}^3 = \text{AC} : \text{AE}$.

3. If the upper and under surfaces be parallel, then breadth at C : breadth at E = AC : AE.

The strain and strength of square or circular plates of different extent but of equal thickness may be determined from the same principles.

The same principles enable us to determine the strain and strength of square or circular plates of different extent but equal thickness. This may be comprehended in this general proposition.

Similar plates of equal thickness supported all round will carry the same absolute weight, uniformly distributed, or resting on similar points, whatever be their extent.

Suppose two similar oblong plates of equal thickness, and let their lengths and breadths be L, l, and B, b. Let their strength or momentum of cohesion be C, c, and the strains from the weights W, w, be S, s.

Suppose the plates supported at the ends only, and resisting fracture transversely. The strains, being as the weights and lengths, are as W L and wl, but their cohesions are as the breadths; and since they are of equal relative strength, we have $\text{WL} : wl = \text{B} : b$, and $\text{WL}b = wl\text{B}$, and $\text{L} : l = w\text{B} : \text{W}b$; but since they are of similar shapes, $\text{L} : l = \text{B} : b$, and therefore $w = \text{W}$.

The same reasoning holds again when they are also supported along the sides, and therefore holds when they are supported all round (in which case the strength is doubled).

And if the plates be of any other figure, such as circles or ellipses, we need only conceive similar rectangles inscribed in them. These are supported all around by the continuity of the plates, and therefore will sustain equal weights; and the same may be said of the segments which lie without them, because the strengths of any similar segments are equal, their lengths being as their breadths.

Therefore the thickness of the bottoms of vessels holding heavy liquors or grains should be as their diameters and as the square root of their depths jointly.

Also the weight which a square plate will bear is to that which a bar of the same matter and thickness will bear as twice the length of the bar to its breadth.

The strain of a beam arising from its own weight.

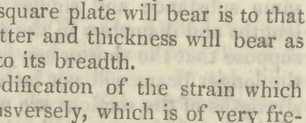
There is yet another modification of the strain which tends to break a body transversely, which is of very frequent occurrence, and in some cases must be very carefully attended to, viz. the strain arising from its own weight.

When a beam projects from a wall, every section is strained by the weight of all that projects beyond it. This may be considered as all collected at its centre of gravity. Therefore the strain on any section is in the joint ratio of the weight of what projects beyond it, and the distance of its centre of gravity from the section.

General principle respecting it.

The determination of this strain, and of the strength necessary for withstanding it, must be more complicated than the former, because the form of the piece which results from this adjustment of strain and strength influences the strain. The general principle must evidently be, that the strength or momentum of cohesion of every section must be as the product of the weight beyond it, multiplied by the distance of its centre of gravity. For example:

Fig. 15.



Suppose the beam DLA (fig. 15) to project from the wall, and that its sides are parallel vertical planes, so that the depth is the only variable dimension. Let LB $= x$ and B$b = y$. The element B$bc$C is $= xy$. Let G be the centre of gravity of the part lying without Bb, and g be its distance from the extremity L. Then $x - g$ is the arm of the lever by which the strain is excited in the section Bb.

Strength of Materials.

Let Bb or y be as some power m of LB; that is, let $y=x^m$. Then the contents of LBb is $\frac{x^{m+1}}{m+1}$. The momentum of gravity round a horizontal axis at L is $yxdx=x^{m+2}dx$, and the whole momentum round the axis is $\frac{x}{m+2}$. The distance of the centre of gravity from L is had by dividing this momentum by the whole weight, which is $\frac{x^{m+1}}{m+1}$. The quotient or g is $\frac{x \times \overline{m+1}}{m+2}$, and the distance of the centre of gravity from the section Bb is $x-\frac{x \times \overline{m+1}}{m+2}=\frac{x \times \overline{m+2}-x \times \overline{m+1}}{m+2}=\frac{x}{m+2}$. Therefore the strain on the section Bb is had by multiplying $\frac{x^{m+1}}{m+1}$ by $\frac{x}{m+2}$. The product is $\frac{x^{m+2}}{\overline{m+2} \times \overline{m+1}}$. This must be as the square of the depth, or as y^2. But y is as x^m, and y^2 as x^{2m}. Therefore we have $m+2=2m$, and $m=2$; that is, the depth must be as the square of the distance from the extremity, and the curve LbA is a parabola touching the horizontal line in L.

A conoid equally able in every section to bear its own weight.

It is easy to see that a conoid formed by the rotation of this figure round DL will also be equally able in every section to bear its own weight.

We need not prosecute this farther. When the figure of the piece is given, there is no difficulty in finding the strain; and the circumstance of equal strength to resist this strain is chiefly a matter of curiosity.

The more a beam projects, the less able it is to bear its own weight.

It is evident, from what has been already said, that a projecting beam becomes less able to bear its own weight as it projects farther. Whatever may be the strength of the section DA, the length may be such that it will break by its own weight. If we suppose two beams A and B of the same substance and similar shapes, that is, having their lengths and diameters in the same proportion; and further suppose that the shorter can just bear its own weight; then the longer beam will not be able to do the same; for the strengths of the sections are as the cubes of the diameters, while the strains are as the biquadrates of the diameters; because the weights are as the cubes, and the levers by which these weights act in producing the strain are as the lengths or as the diameters.

Small bodies more able to withstand the strain produced by the weight of the machine than great bodies.

These considerations show us, that in all cases where strain is affected by the weight of the parts of the machine or structure of any kind, the smaller bodies are more able to withstand it than the greater; and there seem to be bounds set by nature to the size of machines constructed of any given materials. Even when the weight of the parts of the machine is not taken into the account, we cannot enlarge them in the same proportion in all their parts. Thus a steam-engine cannot be doubled in all its parts, so as to be still efficient. The pressure on the piston is quadrupled. If the lift of the pump be also doubled in height while it is doubled in diameter, the load will be increased eight times, and will therefore exceed the power. The depth of lift, therefore, must remain unchanged; and in this case the machine will be of the same relative strength as before, independent of its own weight. For the beam being doubled in all its dimensions, its momentum of cohesion is eight times greater, which is again a balance for a quadruple load acting by a double lever. But if we now consider the increase of the weight of the machine itself, which must be supported, and which must be put in motion by the intervention of its cohesion, we see that the large machine is weaker and less efficient than the small one.

There is a similar limit set by nature to the size of plants and animals formed of the same matter. The cohesion of an herb could not support it if it were increased to the size of a tree, nor could an oak support itself if forty or fifty times bigger; nor could an animal of the make of a long-legged spider be increased to the size of a man; the articulations of its legs could not support it.

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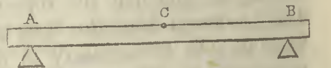
Hence may be understood the prodigious superiority of the small animals both in strength and agility. A man by falling twice his own height may break his firmest bones. A mouse may fall twenty times its height without risk; and even the tender mite or wood-louse may fall unhurt from the top of a steeple. But their greatest superiority is in respect of nimbleness and agility. A flea can leap above 500 times its own length, while the strength of the human muscles could not raise the trunk from the ground on limbs of the same construction.

The angular motions of small animals (in which consists their nimbleness or agility) must be greater than those of large animals, supposing the force of the muscular fibre to be the same in both. For supposing them similar, the number of equal fibres will be as the square of their linear dimensions; and the levers by which they act are as their linear dimensions. The energy therefore of the moving force is as the cube of these dimensions. But the momentum of inertia, or $\int p \cdot r^2$, is as the fourth power; therefore the angular velocity of the greater animals is smaller. The number of strokes which a fly makes with its wings in a second is astonishingly great; yet, being voluntary, they are the effects of its agility.

We have hitherto confined our attention to the simplest form in which this transverse strain can be produced. This was quite sufficient for showing us the mechanism of nature by which the strain is resisted; and a very slight attention is sufficient for enabling us to reduce to this every other way in which the strain can be produced. We shall not take up the reader's time with the application of the same principles to other cases of this strain, but refer him to what has been said in the article Roof. In that article we have shown the analogy between the strain on the section of a beam projecting from a wall and loaded at the extremity, and the strain on the same section of a beam simply resting on supports at the ends, and loaded at some intermediate point or points. The strain on the middle C of a beam AB (fig. 16) so supported, arising from a weight laid on there, is the same with the strain which half that weight hanging at B would produce on the same section C, if the other end of the beam were fixed in a wall. If therefore 1000 pounds hung on the end of a beam projecting ten feet from a wall will just break it at the wall, it will require 4000 pounds on its middle to break the same beam resting on two props ten feet asunder. We have also shown in that article the additional strength which will be given to this beam by extending both ends beyond the props, and there framing it firmly into other pillars or supports. We can hardly add any thing to what has been said in that article, except a few observations on the effects of the obliquity of the external force. We have hitherto supposed it to act in the direction BP (fig. 6) perpendicular to the length of the beam. Suppose it to act in the direction BP′, oblique to BA. In the article Roof we supposed the strain to be the same as if the force p acted at the distance AB′, but still perpendicular to AB: so it is. But the strength of the section AΔ is not the same in both cases; for by the obliquity of the action the piece DCKΔ is pressed to the other. We are not sufficiently acquainted with the corpuscular forces to say precisely what will be the effect of the pressure arising from this obliquity; but we can clearly see in general, that the point A, which in the instant of fracture

Fig. 16.



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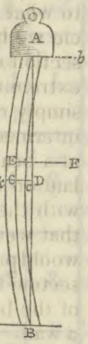
of is neither stretched nor compressed, must now be farther up, or nearer to D; and therefore the number of particles which are exerting cohesive forces is smaller, and therefore the strength is diminished. Therefore, when we endeavour to proportion the strength of a beam to the strain arising from an external force acting obliquely, we make too liberal allowance by increasing this external force in the ratio of AB to AB′. We acknowledge our inability to assign the proper correction. But this circumstance is of very great influence. In many machines, and many framings of carpentry, this oblique action of the straining force is unavoidable; and the most enormous strains to which materials are exposed are generally of this kind. In the frames set up for carrying the ringstones of arches, it is hardly possible to avoid them; for although the judicious engineer dispose his beams so as to sustain only pressures in the direction of their lengths, tending either to crush them or to tear them asunder, it frequently happens that, by the settling of the work, the pieces come to check and bear on each other transversely, tending to break each other across. This we have remarked upon in the article Roof, with respect to a truss by Mr Price (see Roof, p. 452–54). Now when a cross strain is thus combined with an enormous pressure in the direction of the length of the beam, it is in the utmost danger of snapping suddenly across. This is one great cause of the carrying away of masts. They are compressed in the direction of their length by the united force of the shrouds, and in this state the transverse action of the wind soon completes the fracture.

When considering the compressing strains to which materials are exposed, we deferred the discussion of the strain on columns, observing that it was not, in the cases which usually occur, a simple compression, but was combined with a transverse strain, arising from the bending of the column. When the column ACB (fig. 17), resting on the ground at B, and loaded at top with a weight A, acting in the vertical direction AB, is bent into a curve ACB, so that the tangent at C is perpendicular to the horizon, its condition somewhat resembles that of a beam firmly fixed between B and C, and strongly pulled by the end A, so as to bend it between C and A. Although we cannot conceive how a force acting on a straight column AB in the direction AB can bend it, we may suppose that the force acted first in the horizontal direction *Ab* till it was bent to this degree, and that the rope was then gradually removed from the direction *Ab* to the direction AB, increasing the force as much as is necessary for preserving the same quantity of flexure.

Fig. 17.



The first author, we believe, who considered this important subject with scrupulous attention was the celebrated Euler, who published in the Berlin Memoirs for 1757 his Theory of the Strength of Columns. The general proposition established by this theory is, that the strength of prismatical columns is in the direct quadruplicate ratio of their diameters, and the inverse duplicate ratio of their lengths. He prosecuted this subject in the Petersburg Commentaries for 1778, confirming his former theory. We do not find that any other author has bestowed much attention on it, all seeming to acquiesce in the determinations of Euler, and to consider the subject as of very great difficulty, requiring the application of the most refined mathematics. Muschenbroeck has compared the theory with experiment; but the comparison has been very unsatisfactory, the difference from the theory being so enormous as to afford no argument for its justness. But the experiments do not contradict it, for they are so anomalous as to afford no conclusion or general rule whatever.

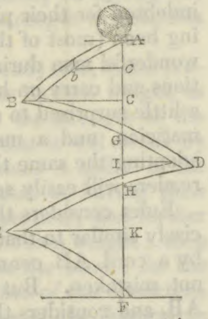
To say the truth, the theory can be considered in no other light than as a specimen of ingenious and very artful algebraic analysis. Euler was unquestionably the first analyst in Europe for resource and address. He knew this, and enjoyed his superiority, and without scruple admitted any physical assumptions which gave him an opportunity of displaying his skill. The inconsistency of his assumptions with the known laws of mechanism gave him no concern; and when his algebraic processes led him to any conclusion which would make his readers stare, being contrary to all our usual notions, he frankly owned the paradox, but went on in his analysis, saying, *Sed analysi magis fidendum.* Mr Robins has given some very risible instances of this confidence in his analysis, or rather of his confidence in the indolent submission of his readers. Nay, so fond was he of this kind of amusement, that after having published an untenable Theory of Light and Colours, he published several Memoirs, explaining the aberration of the heavenly bodies, deducing some very wonderful consequences, fully confirmed by experience, from the Newtonian principles, which were opposite and totally inconsistent with his own theory, merely because the Newtonian theory gave him *occasionem analyseos promovendæ.* We are thus severe in our observations, because his Theory of the Strength of Columns is one of the strongest instances of this wanton kind of proceeding, and because his followers in the Academy of St Petersburg, such as Fuss, Lexill, and others, adopt his conclusions, and merely echo his words. Since the death of Daniel Bernoulli, no member of that academy has controverted any thing advanced by their *Professor sublimis Geometriæ*, to whom they had been indebted for their places and for all their knowledge, having been (most of them) his amanuenses, employed by this wonderful man during his blindness, to make his computations and carry on his algebraic investigations. We are not a little surprised to see Mr Emerson, a considerable mathematician, and a man of very independent spirit, hastily adopting the same theory, of which we doubt not but our readers will easily see the falsity.

Euler considers the column ACB as in a condition precisely similar to that of an elastic rod bent into the curve by a cord AB connecting its extremities. In this he is not mistaken. But he then draws CD perpendicular to AB, and considers the strain on the section C as equal to the momentum or mechanical energy of the weight A, acting in the direction DE, upon the lever *kc*D, moveable round the fulcrum *c*, and tending to tear asunder the particles which cohere along the section *c*C*k*. This is the same principle (as Euler admits) employed by James Bernoulli in his investigation of the elastic curve ACB. Euler considers the strain on the section *ck* as the same with what it would sustain if the same power acted in the horizontal direction EF on a point E, as far removed from C as the point D is. We reasoned in the same manner (as has been observed) in the article Roof, where the obliquity of action was inconsiderable. But in the present case this substitution leads to the greatest mistakes, and has rendered the whole of this theory false and useless. It would be just if the column were of materials which are incompressible. But it is evident, by what has been said above, that by the compression of the parts the real fulcrum of the lever shifts away from the point *c*, so much the more as the compression is greater. In the great compressions of loaded columns, and the almost unmeasurable compressions of the truss-beams in the centres of bridges, and other cases of chief importance, the fulcrum is shifted far over towards *k*, so that very few fibres resist the fracture by their cohesion, and these few have a very feeble energy or momentum, on account of the short arm of the lever by which they act. This is a most important consideration in carpentry, yet makes no element of Euler's theory. The consequence of this is, that a very small degree of curvature is sufficient to cause the column or strut to snap in an instant, as is well known to every experienced carpenter. The experiment by Muschenbroeck, which Euler makes use of in order to obtain a measure of strength in a particular instance, from which he might deduce all others by his theorem, is an incontestable proof of this. The force which broke the column is not the twentieth part of what is necessary for breaking it by acting at E in the direction EF. Euler takes no notice of this immense discrepancy, because it must have caused him to abandon the speculation with which he was then amusing himself.

This theory false and useless.

The limits of this work do not afford room to enter minutely upon the refutation of this theory; but we can easily show its uselessness, by its total inconsistency with common observation. It results legitimately from this theory, that if CD have no magnitude, the weight A can have no momentum, and the column cannot be broken. True, it cannot be broken in this way, snapped by a transverse fracture, if it do not bend; but we know very well that it can be crushed or crippled, and we see this frequently happen. This circumstance or event does not enter into Euler's investigation, and therefore the theory is at least imperfect and useless. Had this crippling been introduced in the form of a physical assumption, every topic of reasoning employed in the process must have been laid aside, as the intelligent reader will easily see. But the theory is not only imperfect, but false. The ordinary reader will be convinced of this by another legitimate consequence of it. Fig. 18 is the same with fig. 106 of Emerson's Mechanics, where this subject is treated on Euler's principles, and represents a crooked piece of matter resting on the ground at F, and loaded at A with a weight acting in the vertical direction AF. It results from Euler's theory that the strains at *b*, B, D, E, &c. are as *bc*, BC, DI, EK, &c. Therefore the strains at G and H are nothing; and this is asserted by Emerson and Euler as a serious truth; and the piece may be thinned *ad infinitum* in these two places, or even cut through, without any diminution of its strength. The absurdity of this assertion strikes at first hearing. Euler asserts the same thing with respect to a point of contrary flexure. Farther discussion is, we apprehend, needless.

Fig. 18.



Yet Euler's dissertations deserve a perusal.

This theory must therefore be given up. Yet these dissertations of Euler in the Petersburg Commentaries deserve a perusal, both as very ingenious specimens of analysis, and because they contain maxims of practice which are important. Although they give an erroneous measure of the comparative strength of columns, they show the immense importance of preventing all bendings, and point out with accuracy where the tendencies to bend are greatest, and how this may be prevented by very small forces, and what a prodigious accession of force this gives the column. There is a valuable paper in the same volume by Fuss on the Strains on framed Carpentry, which may also be read with advantage.

A new theory cannot be substituted in place of Euler's till many experiments be made.

It will now be asked, what shall be substituted in place of this erroneous theory? what is the true proportion of the strength of columns? We acknowledge our inability to give a satisfactory answer. This can only be obtained by a previous knowledge of the proportion between the extensions and compressions produced by equal forces, by the knowledge of the absolute compressions producible by a given force, and by a knowledge of the degree of that derangement of parts which is termed crippling. These circumstances are but imperfectly known to us, and there lies before us a wide field of experimental inquiry. Fortunately the force requisite for crippling a beam is prodigious, and a very small lateral support is sufficient to prevent that bending which puts the beam in imminent danger. A judicious engineer will always employ transverse bridles, as they are called, to stay the middle of long beams which are employed as pillars, struts, or truss-beams, and are exposed, by their position, to enormous pressures in the direction of their lengths. Such stays may be observed, disposed with great judgment and economy, in the centres employed by Mr Perronet in the erection of his great stone arches. He was obliged to correct this omission made by his ingenious predecessor in the beautiful centres of the bridge of Orleans, which we have no hesitation in affirming to be the finest piece of carpentry in the world.

It only remains on this head to compare these theoretical deductions with experiment.

Experiments on the transverse strength of bodies are easily made, and accordingly are very numerous, especially those made on timber, which is the case most common and most interesting. But in this great number of experiments there are very few from which we can draw much practical information. The experiments have in general been made on such small scantlings, that the unavoidable natural inequalities bear too great a proportion to the strength of the whole piece. Accordingly, when we compare the experiments of different authors, we find them differ enormously, and even the experiments by the same author are very anomalous. The completest series that we have yet seen is that detailed by Belidor in his *Science des Ingenieurs.* They are contained in the following table. The pieces were sound, even-grained oak. The column *b* contains the breadths of the pieces in inches; the column *d* contains their depths; the column *l* contains their lengths; column *p* contains the weights (in pounds) which broke them when hung on their middles; and *m* is the column of averages or mediums.

Table experi- ments by Be

No.	*b*	*d*	*l*	*p*	*m*	
1	1	1	18	400 415 405	406	The ends lying loose.
2	1	1	18	600 600 624	608	The ends firmly fixed.
3	2	1	18	810 795 812	805	Loose.
4	1	2	18	1570 1580 1590	1580	Loose.
5	1	1	36	185 195 180	187	Loose.
6	1	1	36	285 280 285	283	Fixed.
7	2	2	36	1550 1620 1585	1585	Loose.
8	$2\frac{1}{3}$	$2\frac{1}{3}$	36	1665 1675 1640	1660	Loose.

By comparing Experiments 1st and 3d, the strength appears proportional to the breadth.

Experiments 3d and 4th show the strength proportional to the square of the depth.

Experiments 1st and 5th show the strength nearly in the inverse proportion of the lengths, but with a sensible deficiency in the longer pieces.

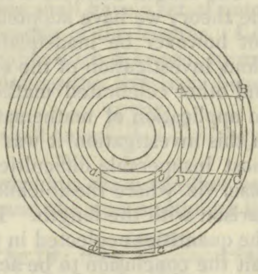
Experiments 5th and 7th show the strengths proportional to the breadths and the square of the depth.

Experiments 1st and 7th show the same thing, compounded with the inverse proportion of the length: here the deficiency relative to the length is not so remarkable.

Experiments 1st and 2d, and experiments 5th and 6th, show the increase of strength, by fastening the ends, to be in the proportion of two to three. The theory gives the proportion of two to four. But a difference in the manner of fixing may produce this deviation from the theory, which only supposed them to be held down at places beyond the props, as when a joist is held in the walls, and also rests on two pillars between the walls.

The chief source of irregularity in such experiments is the fibrous, or rather plated texture of timber. It consists of annual additions, whose cohesion with each other is vastly weaker than that of their own fibres. Let fig. 19 represent the section of a tree, and ABCD, *abcd* the section of two battens that are to be cut out of it for experiment, and let AD and *ad* be the depths, and DC, *dc* the breadths. The batten ABCD will be the stronger, for the same reason that an assemblage of planks set edgewise will form a stronger joist than planks laid above each other like the plates of a coach-spring. M. Buffon found by many trials that the strength of ABCD was to that of *abcd* (in oak) nearly as eight to seven. The authors of the different experiments were not careful that their battens had their plates all disposed similarly with respect to the strain. But even with this precaution they would not have afforded sure grounds of computation for large works; for great beams occupy much, if not the whole, of the section of the tree; and from this it has happened that their strength is less than in proportion to that of a small lath or batten. In short, we can trust no experiments but such as have been made on large beams. These must be very rare, for they are most expensive and laborious, and exceed the abilities of most of those who are disposed to study this subject.

Fig. 19.



But we are not wholly without such authority. M. Buffon and M. Duhamel, two of the first philosophers and mechanicians of the age, were directed by government to make experiments on this subject, and were supplied with ample funds and apparatus. The relation of their experiments is to be found in the Memoirs of the French Academy for 1740, 1741, 1742, 1768; as also in Duhamel's valuable performances *Sur l'Exploitation des Arbres, et sur la Conservation et le Transport de Bois*. We earnestly recommend these dissertations to the perusal of our readers, as containing much useful information relative to the strength of timber, and the best methods of employing it. We shall here give an abstract of M. Buffon's experiments.

He relates a great number which, during two years, he had prosecuted on small battens. He found that the odds of a single layer, or part of a layer, more or less, or even a different disposition of them, had such influence that he was obliged to abandon this method, and to have recourse to the largest beams that he was able to break. The following table exhibits one series of experiments on bars of sound oak, clear of knots, and four inches square. This is a specimen of all the rest.

Column 1st is the length of the bar in clear feet between the supports.

Column 2d is the weight of the bar (the second day after it was felled) in pounds. Two bars were tried of each length. Each of the first three pairs consisted of two cuts of the same tree. The one next the root was always found the heaviest, stiffest, and strongest. Indeed M. Buffon says that this was invariably true, that the heaviest was always the strongest; and he recommends it as a certain (or sure) rule for the choice of timber. He finds that this is always the case when the timber has grown vigorously, forming very thick annual layers. But he also observes that this is only during the advances of the tree to maturity; for the strength of the different circles approaches gradually to equality during the tree's healthy growth, and then it decays in these parts in a contrary order. Our tool-makers assert the same thing with respect to beech: yet a contrary opinion is very prevalent; and wood with a fine, that is, a small grain, is frequently preferred. Perhaps no person has ever made the trial with such minuteness as M. Buffon, and we think that much deference is due to his opinion.

Column 3d is the number of pounds necessary for breaking the tree in the course of a few minutes.

Column 4th is the number of inches which it bent down before breaking.

Column 5th is the time at which it broke.

1	2	3	4	5
7	60 56	5350 5275	3·5 4·5	29 22
8	68 63	4600 4500	3·75 4·7	15 13
9	77 71	4100 3950	4·85 5·5	14 12
10	84 82	3625 3600	5·83 6·5	15 15
12	100 98	3050 2925	7· 8·	... ...

The experiments on other sizes were made in the same way. A pair at least of each length and size was taken. The mean results are contained in the following table. The beams were all square, and their sizes in inches are placed at the head of the columns, and their lengths in feet are in the first column.

	4	5	6	7	8	A
7	5312	11525	18950	32200	47649	11525
8	4550	9787	15525	26050	39750	10085
9	4025	8308	13150	22350	32800	8964
10	3612	7125	11250	19475	27750	8068
12	2987	6075	9100	16175	23450	6723
14	...	5300	7475	13225	19775	5763
16	...	4350	6362	11000	16375	5042
18	...	3700	5562	9245	13200	4482
20	...	3225	4950	8375	11487	4034
22	...	2975	...	...	...	3667
24	...	2162	...	...	...	3362
28	...	1775	...	...	...	2881

M. Buffon had found, by numerous trials, that oak-timber lost much of its strength in the course of drying or seasoning; and therefore, in order to secure uniformity, his trees were all felled in the same season of the year, were squared the day after, and tried the third day. Trying them in this green state gave him an opportunity of observing a very curious and unaccountable phenomenon. When the weights were laid briskly on, nearly sufficient to break the log, a very sensible smoke was observed to issue from the two ends with a sharp hissing noise. This continued all the while the tree was bending and cracking. This shows that the log is affected or strained through its whole length. Indeed this must be inferred from its bending through its whole length. It also shows us the great effects of the compression. It is a pity M. Buffon did not take notice whether this smoke issued from the upper or compressed half of the section only, or whether it came from the whole.

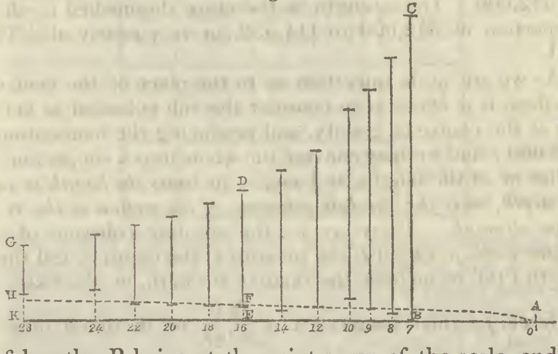
Observations on M. Buffon's experiments.

We must now make some observations on these experiments, in order to compare them with the theory which we have endeavoured to establish.

M. Buffon considers the experiments with the five-inch bars as the standard of comparison, having both extended these to greater lengths, and having tried more pieces of each length.

Our theory determines the relative strength of bars of the same section to be inversely as their lengths. But, if we except the five experiments in the first column, we find a very great deviation from this rule. Thus the five-inch bar of twenty-eight feet long should have half the strength of that of fourteen feet, or 2650; whereas it is but 1775. The bar of fourteen feet should have half the strength of that of seven feet, or 5762; whereas it is but 5300. In like manner, the fourth of 11,525 is 2881; but the real strength of the twenty-eight feet bar is 1775. We have added a column A, which exhibits the strength which each of the five-inch bars ought to have by the theory. This deviation is most distinctly seen in fig. 20, where BK is the scale of lengths, B being at the point seven of the scale, and K at twenty-eight. The ordinate CB is $=11,525$, and the other ordinates DE, GK, &c. are respectively $=\frac{7\text{CB}}{\text{length}}$. The lines DF, GH, &c. are made $=4350$, 1775, &c., expressing the strengths given by experiment. The ten-feet bar and the twenty-four feet bar are remarkably anomalous. But all are deficient, and the defect has an evident progression from the first to the last. The same thing may be shown of the other columns, and even of the first, though it is very small in that column. It may also be observed in the experiments of Belidor, and in all that we have seen. We cannot doubt therefore of its being a law of nature, depending on the true principles of cohesion and the laws of mechanics.

Fig. 20.



But it is very puzzling, and we cannot pretend to give a satisfactory explanation of the difficulty. The only effect which we can conceive the length of a beam to have, is to increase the strain at the section of fracture, by employing the intervening beam as a lever. But we do not distinctly see what change this can produce in the mode of action of the fibres in this section, so as either to change their cohesion or the place of its centre of effort: yet something of this kind must happen.

We see indeed some circumstances which must contribute to make a smaller weight sufficient, in M. Buffon's experiments, to break a long beam, than in the exact inverse proportion of its length.

In the first place, the weight of the beam itself augments the strain as much as if half of it were added in the form of a weight. M. Buffon has given the weights of every beam on which he made experiments, which is very nearly seventy-four pounds per cubic foot. But they are much too small to account for the deviation from the theory. The half weights of the five-inch beams of seven, fourteen, and twenty-eight feet length, are only forty-five, ninety-two, and 182 pounds; which makes the real strains in the experiments 11,560, 5390, and 1956; which are far from having the proportions of four, two, and one.

Buffon says that healthy trees are universally strongest at the root end; therefore, when we use a longer beam, its middle point, where it is broken in the experiment, is in a weaker part of the tree. But the trials of the four-inch beams show that the difference from this cause is almost insensible.

The length must have some mechanical influence which the theory we have adopted has not yet explained. It may not however be inadequate to the task. The very ingenious investigation of the elastic curve by James Bernoulli and other celebrated mathematicians is perhaps as refined an application of mathematical analysis as we know. Yet in this investigation it was necessary, in order to avoid almost insuperable difficulties, to take the simplest possible case, viz. where the thickness is exceedingly small in comparison with the length. If the thickness be considerable, the quantities neglected in the calculus are too great to permit the conclusion to be accurate, or very nearly so. Without being able to define the form into which an elastic body of considerable thickness will be bent, we can say with confidence, that in an extreme case, where the compression in the concave side is very great, the curvature differs considerably from the Bernoullian curve. But as our investigation is incomplete and very long, we do not offer it to the reader. The following more familiar considerations will, we apprehend, render it highly probable that the relative strength of beams decreases faster than in the inverse ratio of their length. The curious observation by M. Buffon, of the vapour which issued with the hissing noise from the ends of a beam of green oak, while it was breaking by the load on its middle, shows that the whole length of the piece was affected: indeed it must be, since it is bent throughout. We have shown above, that a certain definite curvature of a beam of a given form is always accompanied by rupture. Now suppose the beam A of ten feet long, and the beam B of twenty feet long, bent to the same degree, at the place of their fixture in the wall; the weight which hangs on A is nearly double of that which must hang on B. The form of any portion, suppose five feet, of these two beams, immediately adjoining to the wall, is considerably different. At the distance of five feet the curvature of A is half of its curvature at the wall. The curvature of B in the corresponding point is three fourths of the same curvature at the wall. Through the whole of the intermediate five feet, therefore, the curvature of B is greater than that of A. This must make it weaker throughout. It must occasion the fibres to slide more on each other (that it may acquire *this* greater curvature), and thus affect their lateral union; and therefore those which are stronger will not assist their weaker neighbours. To this we must add, that in the shorter beams the force with which the fibres are pressed laterally on each other is double. This must impede the

Probabl that th relative strength beams d creases faster th in the i verse ra of their length.

of mutual sliding of the fibres which we mentioned a little ago; nay, this lateral compression may change the law of longitudinal cohesion (as will readily appear to the reader who is acquainted with Boscovich's doctrines), and increase the strength of the very surface of fracture, in the same way (however inexplicable) as it does in metals when they are hammered or drawn into wire.

The reader must judge how far these remarks are worthy of his attention. The engineer will carefully keep in mind the important fact, that a beam of quadruple length, instead of having one fourth of the strength, has only about one sixth; and the philosopher should endeavour to discover the cause of this diminution, that he may give the artist a more accurate rule of computation.

Our ignorance of the law by which the cohesion of the particles changes by a change of distance, hinders us from discovering the precise relation between the curvature and the momentum of cohesion; and all we can do is to multiply experiments, upon which we may establish some *empirical* rules for calculating the strength of solids. Those from which we must reason at present are too few and too anomalous to be the foundation of such an empirical formula. We may however observe, that M. Buffon's experiments gave us considerable assistance in this particular; for if to each of the numbers of the column for the five-inch beams, corrected by adding half the weight of the beam, we add the constant number 1245, we shall have a set of numbers which are very nearly reciprocals of the lengths. Let 1245 be called c, and let the weight which is known by experiment to be necessary for breaking the five-inch beam of the length a be called P. We shall have $\frac{\overline{P+c}\times a}{l}-c=p$.

Thus the weight necessary for breaking the seven-feet bar is 11,560. This added to 1245, and the sum multiplied by 7, gives $\overline{P+c}\times a=89{,}635$. Let l be 18; then $\frac{89{,}635}{18}-1245$ $=3725=p$, which differs not more than $\frac{1}{40}$th from what experiment gives us. This rule holds equally well in all the other lengths except the 10 and 24 feet beams, which are very anomalous. Such a formula is abundantly exact for practice, and will answer through a much greater variety of length, though it cannot be admitted as a true one; because, in a certain very great length, the strength will be nothing. For other sizes the constant number must change in the proportion of d^3, or perhaps of p.

The next comparison which we have to make with the theory is the relation between the strength and the square of the depth of the section. This is made by comparing with each other the numbers in any horizontal line of the table. In making this comparison we find the numbers of the five-inch bars uniformly greater than the rest. We imagine that there is something peculiar to these bars; they are in general heavier than in the proportion of their section, but not so much so as to account for all their superiority. We imagine that this set of experiments, intended as a standard for the rest, has been made at one time, and that the season has had a considerable influence. The fact however is, that if this column be kept out, or uniformly diminished about one sixteenth in their strength, the different sizes will deviate very little from the ratio of the square of the depth, as determined by theory. There is however a small deficiency in the bigger beams.

We have been thus anxious in the examination of these experiments, because they are the only ones which have been related in sufficient detail, and made on a proper scale for giving us data from which we can deduce confidential maxims for practice. They are so troublesome and expensive that we have little hopes of seeing their number greatly increased; yet surely our navy board would do an unspeakable service to the public by appropriating a fund for such experiments under the management of some man of science.

Proportion between the absolute cohesion and the relative strength.

There remains another comparison which is of chief importance, namely, the proportion between the *absolute cohesion* and the *relative strength*. It may be guessed, from the very nature of the thing, that this must be very uncertain. Experiments on the absolute strength must be confined to very small pieces, by reason of the very great forces which are required for tearing them asunder. The values therefore deduced from them must be subject to great inequalities. Unfortunately we possess no detail of any experiments; all that we have to depend on are two passages of Muschenbroeck's *Essais de Physique;* in one of which he says, that a piece of sound oak $\frac{27}{100}$ths of an inch square is torn asunder by 1150 pounds; and in the other, that an oak plank twelve inches broad and one thick will just suspend 189,163 pounds. These give for the cohesion of an inch square 15,755 and 15,763 pounds. Bouguer, in his *Traité du Navire*, says that it is very well known that a rod of sound oak one fourth of an inch square will be torn asunder by 1000 pounds. This gives 16,000 for the cohesion of a square inch. We shall take this as a round number, easily used in our computations. Let us compare this with M. Buffon's trials of beams four inches square.

The absolute cohesion of this section is $16{,}000\times16=256{,}000$. Did every fibre exert its whole force in the instant of fracture, the momentum of cohesion would be the same as if it had all acted at the centre of gravity of the section at two inches from the axis of fracture, and is therefore 512,000. The four-inch beam, seven feet long, was broken by 5312 pounds hung on its middle. The half of this, or 2656 pounds, would have broken it, if suspended at its extremity, projecting $3\frac{1}{2}$ feet, or 42 inches, from a wall. The momentum of this strain is therefore $2656\times42=111{,}552$. Now this is in equilibrio with the actual momentum of cohesion, which is therefore 111,552 instead of 512,000. The strength is therefore diminished in the proportion of 512,000 to 111,552, or very nearly of 4·59 to 1.

As we are quite uncertain as to the place of the centre of effort, it is needless to consider the full cohesion as acting at the centre of gravity, and producing the momentum 512,000; and we may convert the whole into a simple multiplier m of the length, and say, *as* m *times the length is to the depth, so is the absolute cohesion of the section to the relative strength.* Therefore let the absolute cohesion of a square inch be called f, the breadth b, the depth d, and the length l (all in inches), the relative strength, or the external force, p, which balances it, is $\frac{fbd^2}{9{\cdot}18l}$, or, in round numbers, $\frac{fbd^2}{9l}$; for $m=2\times4{\cdot}59$.

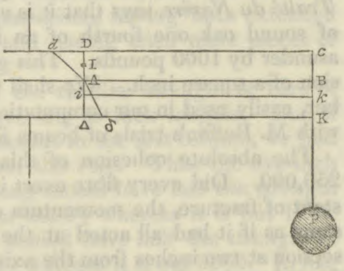
This great diminution of strength cannot be wholly accounted for by the inequality of the cohesive forces exerted in the instant of fracture; for in this case we know that the centre of effort is at one third of the height in a rectangular section (because the forces really exerted are as the extensions of the fibres). The relative strength would be $\frac{fbd^2}{3l}$, and p would have been 8127 instead of 2656.

We must ascribe this diminution (which is three times greater than that produced by the inequality of the cohesive forces) to the compression of the under part of the beam; and we must endeavour to explain in what manner this compression produces an effect which seems so little explicable by such means.

As we have repeatedly observed, it is a matter of nearly universal experience that the forces *actually* exerted by the particles of bodies, when stretched or compressed, are very nearly in the proportion of the distances to which the particles are drawn from their natural positions. Now, although we are certain that, in enormous compressions, the forces increase faster than in this proportion, this makes no sensible change in the present question, because the body is broken before the compressions have gone so far; nay, we imagine that the compressed parts are crippled in most cases even before the extended parts are torn asunder Muschenbroeck asserts this with great confidence with respect to oak, on the authority of his own experiments. He says, that although oak will suspend half as much again as fir, it will not support, as a pillar, two thirds of the load which fir will support in that form.

We imagine therefore that the mechanism in the *present* case is nearly as follows:

Fig. 21.



Let the beam DCKΔ (fig. 21) be loaded at its extremity with the weight P, acting in the direction KP perpendicular to DC. Let DΔ be the section of fracture. Let DA be about one third of DΔ. A will be the particle or fibre which is neither extended nor compressed. Make Δδ : D*d* = DA : AΔ. The triangles DA*d*, ΔAδ, will represent the accumulated attracting and repelling forces. Make AI and A*i* = $\frac{1}{3}$ DA and $\frac{1}{3}$ ΔA. The point I will be that to which the full cohesion D*d* or *f* of the particles in AD must be applied, so as to produce the same momentum which the variable forces at I, D, &c. really produce at their several points of application. In like manner, *i* is the circle of similar effort of the repulsive forces excited by the compression between A and Δ, and it is the real fulcrum of a bended lever I*i*K, by which the whole effect is produced. The effect is the same as if the full cohesion of the stretched fibres in AD were accumulated in I, and the full repulsion of all the compressed fibres in AΔ were accumulated in *i*. The forces which are balanced in the operation are the weight P, acting by the arm *ki*, and the full cohesion of AD acting by the arm I*i*. The forces exerted by the compressed fibres between A and Δ only serve to give support to the lever, that it may exert its strain.

We imagine that this does not differ much from the real procedure of nature. The position of the point A may be different from what we have deduced from Buffon's experiments, compared with Muschenbroeck's value of the absolute cohesion of a square inch. If this last should be only 12,000, DA must be greater than we have here made it, in the proportion of 12,000 to 16,000. For I*i* must still be made = $\frac{1}{3}$ AΔ, supposing the forces to be proportional to the extensions and compressions. There can be no doubt that a part only of the cohesion of DΔ operates in resisting the fracture in all substances which have any compressibility; and it is confirmed by the experiments of M. Duhamel on willow, and the inferences are by no means confined to that species of timber. We say, therefore, that when the beam is broken, the cohesion of AD alone is exerted, and that each fibre exerts a force proportional to its extension; and the accumulated momentum is the same as if the full cohesion of AD were acting by the lever I*i* = $\frac{1}{3}$d of DΔ.

It may be said, that if only one third of the cohesion of oak be exerted, it may be cut two thirds through without weakening it. But this cannot be, because the cohesion of the whole is employed in preventing the lateral slide so often mentioned. We have no experiments to determine that it *may not* be cut through one third without loss of its strength.

This must not be considered as a subject of mere speculative curiosity. It is intimately connected with all the practical uses which we can make of this knowledge; for it is almost the only way that we can learn the compressibility of timber. Experiments on the direct cohesion are indeed difficult, and exceedingly expensive if we attempt them in large pieces. But experiments on compression are almost impracticable. The most instructive experiments would be, first to establish, by a great number of trials, the transverse force of a moderate batten; and then to make a great number of trials of the diminution of its strength, by cutting it through on the concave side. This would very nearly give us the proportion of the cohesion which really operates in resisting fractures. Thus if it be found that one half of the beam may be cut on the under side without diminution of its strength (taking care to drive in a slice of harder wood), we may conclude that the point A is at the middle, or somewhat above it.

Much lies before the curious mechanician, and we are as yet very far from a scientific knowledge of the strength of timber.

A use practic rule ma deduce from M Buffon experiments.

In the mean time, we may derive from these experiments of Buffon a very useful practical rule, without relying on any value of the absolute cohesion of oak. We see that the strength is nearly as the breadth, as the square of the depth, and as the inverse of the length. It is most convenient to measure the breadth and depth of the beam in inches, and its length in feet. Since, then, a beam four inches square and seven feet between the supports is broken by 5312 pounds, we must conclude that a batten one inch square and one foot between the supports will be broken by 581 pounds. Then the strength of any other beam of oak, or the weight which will just break it when hung on its middle, is $581\,\frac{bd^2}{l}$.

But we have seen that there is a very considerable deviation from the inverse proportion of the lengths, and we must endeavour to accommodate our rule to this deviation. We found, that by adding 1245 to each of the ordinates or numbers in the column of the five-inch bars, we had a set of numbers very nearly reciprocal of the lengths; and if we make a similar addition to the other columns in the proportion of the cubes of the sixes, we have nearly the same result. The greatest error (except in the case of experiments which are very irregular) does not exceed $\frac{1}{13}$th of the whole. Therefore, for a radical number, add to the 5312 the number 640, which is to 1245 very nearly as 4^3 to 5^3. This gives 5952. The 64th of this is 93, which corresponds to a bar of one inch square and seven feet long. Therefore 93 × 7 will be the reciprocal corresponding to a bar of one foot. This is 651. Take from this the present empirical correction, which is $\frac{b\,40}{b\,4}$, or 10, and there remains 641 for the strength of the bar. This gives us for a general rule $p = 651\,\frac{bd^2}{l} - 10\,bd^2$.

Example. Required the weight necessary to break an oak beam eight inches square and twenty feet between the props, $p = 651 \times \frac{8 \times 8^2}{20}\ 10 \times 8 \times 8^2$. This is 11,545, whereas the experiment gives 11,487. The error is very small indeed. The rule is most deficient in comparison with the five-inch bars, which, we have already said, appear stronger than the rest.

The following process is easily remembered by such as are not algebraists.

Multiply the breadth in inches twice by the depth, and call this product *f*. Multiply *f* by 651, and divide by the length in feet. From the quotient take 10 times *f*. The remainder is the number of pounds which will break the beam.

We are not sufficiently sensible of our principles to be confident that the correction 10 *f* should be in the proportion of the section, although we think it most probable. It is quite empirical, founded on Buffon's experiments. Therefore the safe way of using this rule is to suppose the beam square, by increasing or diminishing its breadth till equal to the depth. Then find the strength by this rule, and diminish or increase it for the change which has been made in its breadth. Thus, there can be no doubt that the strength of the beam given as an example is double of that of a beam of the same depth and half the breadth.

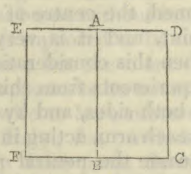
The reader cannot but observe that all this calculation relates to the very greatest weight which a beam will bear for a very few minutes. M. Buffon uniformly found that two thirds of this weight sensibly impaired its strength, and frequently broke at the end of two or three months. One half of this weight brought the beam to a certain bend, which did not increase after the first minute or two, and may be borne by the beam for any length of time. But the beam contracted a bend, of which it did not recover any considerable portion. One third seemed to have no permanent effect on the beam; but it recovered its rectilineal shape completely, even after having been loaded several months, provided that the timber was seasoned when first loaded; that is to say, one third of the weight which would quickly break a seasoned beam, or one fourth of what would break one just felled, may lie on it for ever without giving the beam a set.

We have no detail of experiments on the strength of other kinds of timber: only M. Buffon says, that fir has about $\frac{6}{10}$ths of the strength of oak; Mr Parent makes it $\frac{10}{12}$ths; Emerson, $\frac{2}{3}$ds, &c.

We have been thus minute in our examination of the mechanism of this transverse strain, because it is the greatest to which the parts of our machines are exposed. We wish to impress on the minds of artists the necessity of avoiding this as much as possible. They are improving in this respect, as may be seen by comparing the centres on which stone arches of great span are now turned with those of former times. They were formerly a load of mere joists resting on a multitude of posts, which obstructed the navigation, and were frequently losing their shape by some of the posts sinking into the ground. Now they are more generally trusses, where the beams abut on each other, and are relieved from transverse strains. But many performances of eminent artists are still very injudiciously exposed to cross strains. We may instance one which is considered as a fine work, viz. the bridge at Walton on Thames. Here every beam of the great arch is a joist, and it hangs together by framing. The finest piece of carpentry that we have seen is the centre employed in turning the arches of the bridge at Orleans, described by Perronet. In the whole there is not one cross strain. The beam, too, of Hornblower's steam-engine is very scientifically constructed.

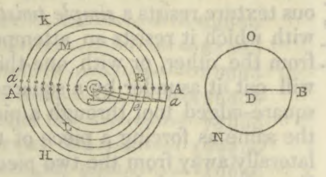
IV. The last species of strain which we are to examine is that produced by twisting. This takes place in all axles which connect the working parts of machines.

Fig. 22.



Although we cannot pretend to have a very distinct conception of that modification of the cohesion of a body by which it resists this kind of strain, we can have no doubt that, when all the particles act alike, the resistance must be proportional to the number. Therefore if we suppose the two parts ABCD, ABFE (fig. 22), of the body EFCD to be of insuperable strength, but cohering more weakly in the common surface AB, and that one part ABCD is pushed laterally in the direction AB, there can be no doubt that it will yield only there, and that the resistance will be proportional to the surface.

Fig. 23.



In like manner, we can conceive a thin cylindrical tube, of which KAH (fig. 23) is the section, as cohering more weakly in that section than anywhere else. Suppose it to be grasped in both hands, and the two parts twisted round the axis in opposite directions, as we would twist the joints of a flute; it is plain that it will first fail in this section, which is the circumference of a circle, and the particles of the two parts which are contiguous to this circumference will be drawn from each other laterally. The total resistance will be as the number of equally resisting particles, that is, as the circumference (for the tube being supposed very thin, there can be no sensible difference between the dilatation of the external and internal particles). We can now suppose another tube within this, and a third within the second, and so on till we reach the centre. If the particles of each ring exerted the same force (by suffering the same dilatation in the direction of the circumference), the resistance of each ring of the section would be as its circumference and its breadth (supposed indefinitely small), and the whole resistance would be as the surface; and this would represent the resistance of a solid cylinder. But when a cylinder is twisted in this manner by an external force applied to its circumference, the external parts will suffer a greater circular extension than the internal; and it appears that this extension (like the extension of a beam strained transversely) will be proportional to the distance of the particles from the axis. We cannot say that this is demonstrable, but we can assign no proportion that is more probable. This being the case, the forces simultaneously exerted by each particle will be as its distance from the axis. Therefore the whole force exerted by each ring will be as the square of its radius, and the accumulated force actually exerted will be as the cube of the radius; that is, the accumulated force exerted by the whole cylinder, whose radius is CA, is to the accumulated force exerted *at the same time* by the part whose radius is CE, as CA^3 to CE^3.

The whole cohesion now exerted is just two thirds of what it would be if all the particles were exerting the same attractive forces which are just now exerted by the particles in the external circumference. This is plain to any person in the least familiar with the fluxionary calculus. But such as are not may easily see it in this way.

Let the rectangle AC*ca* be set upright on the surface of the circle along the line CA, and revolve round the axis C*c*. It will generate a cylinder whose height is C*c* or A*a*, and having the circle KAH for its base. If the diagonal C*a* be supposed also to revolve, it is plain that the triangle *c*C*a* will generate a cone of the same height, and having for its base the circle described by the revolution of *ca*, and the point C for its apex. The cylindrical surface generated by A*a* will express the whole cohesion exerted by the circumference AHK, and the cylindrical surface generated by E*e* will represent the cohesion exerted by the circumference ELM, and the solid generated by the triangle CA*a* will represent the cohesion exerted by the whole circle AHK, and the cylinder generated by the rectangle AC*ca* will represent the cohesion exerted by the same surface if each particle had suffered the extension A*a*.

Now it is plain, in the first place, that the solid generated by the triangle *e*EC is to that generated by *a*AC as EC^3 to

AC^3. In the next place, the solid generated by aAC is two thirds of the cylinder, because the cone generated by cCa is one third of it.

With what force a body of a homogeneous texture resists a simple twist.

We may now suppose the cylinder twisted till the particles in the external circumference lose their cohesion. There can be no doubt that it will now be wrenched asunder, all the inner circles yielding in succession. Thus we obtain one useful information, viz. that a body of homogeneous texture resists a *simple twist* with two thirds of the force with which it resists an attempt to force one part laterally from the other, or with one-third part of the force which will cut it asunder by a square-edged tool; for to drive a square-edged tool through a piece of lead, for instance, is the same as forcing a piece of the lead as thick as the tool laterally away from the two pieces on each side of the tool. Experiments of this kind do not seem difficult, and they would give us very useful information.

The forces exerted in breaking two cylinders are as the squares of the diameters.

When two cylinders AHK and BNO are wrenched asunder, we must conclude that the external particles of each are just put beyond their limits of cohesion, are equally extended, and are exerting equal forces. Hence it follows, that in the instant of fracture the sum-total of the forces actually exerted are as the squares of the diameters.

For drawing the diagonal Ce, it is plain that $Ee = Aa$ expresses the distension of the circumference ELM, and that the solid generated by the triangle CEe expresses the cohesion exerted by the surface of the circle ELM, when the particles in the circumference suffer the extension Ee equal to Aa. Now the solids generated by CAa and CEe being respectively two thirds of the corresponding cylinders, are as the squares of the diameters.

Relative strength of the section to the external force employed to break it.

Having thus ascertained the real strength of the section, and its relation to its absolute lateral strength, let us examine its strength relative to the external force employed to break it. This examination is very simple in the case under consideration. The straining force must act by some lever, and the cohesion must oppose it by acting on some other lever. The centre of the section may be the neutral point, whose position is not disturbed.

Let F be the force exerted laterally by an exterior particle. Let a be the radius of the cylinder, and x the indeterminate distance of any circumference, and dx the indefinitely small interval between the concentric arches; that is, let dx be the breadth of a ring and x its radius. The forces being as the extensions, and the extensions as the distances from the axis, the cohesion actually exerted at any part of any ring will be $f\frac{xdx}{a}$. The force exerted by the whole ring (being as the circumference or as the radius) will be $f\frac{x^2dx}{a}$. The momentum of cohesion of a ring, being as the force multiplied by its lever, will be $f\frac{x^3dx}{a}$. The accumulated momentum will be the sum or fluent of $f\frac{x^3dx}{a}$; that is, when $x = a$, it will be $\frac{1}{4}f\frac{a^4}{a} = \frac{1}{4}fa^3$.

The resistance of the axle is as the cube of its diameter.

Hence we learn that the strength of an axle, by which it resists being wrenched asunder by a force acting at a given distance from the axis, is as the cube of its diameter.

But, further, $\frac{1}{4}fa^3$ is $= fa^2 \times \frac{1}{4}a$. Now fa^2 represents the full lateral cohesion of the section. The momentum therefore is the same as if the full lateral cohesion were accumulated at a point distant from the axis by one fourth of the radius, or one eighth of the diameter of the cylinder.

Therefore let F be the number of pounds which measure the lateral cohesion of a circular inch, d the diameter of the cylinder in inches, and l the length of the lever by which the straining force p is supposed to act; we shall have $F \times \frac{1}{8}d^3 = pl$, and $F\frac{d^3}{8l} = p$.

We see in general that the strength of an axle, by which it resists being wrenched asunder by twisting, is as the cube of its diameter.

Hollov axles n proper solid on

We see also that the internal parts are not acting so powerfully as the external. If a hole be bored out of the axle of half its diameter, the strength is diminished only one eighth, while the quantity of matter is diminished one fourth. Therefore hollow axles are stronger than solid ones containing the same quantity of matter. Thus let the diameter be 5, and that of the hollow 4; then the diameter of another solid cylinder having the same quantity of matter with the tube is 3. The strength of the solid cylinder of the diameter 5 may be expressed by 5^3, or 125. Of this the internal part (of the diameter 4) exerts 64; therefore the strength of the tube is $125 - 64 = 61$. But the strength of the solid axle of the same quantity of matter and diameter 3 is 3^3, or 27, which is not half of that of the tube.

and no generali used.

Engineers, therefore, have of late introduced this improvement in their machines, and the axles of cast iron are all made hollow when their size will admit of it. They have the additional advantage of being much stiffer, and of affording much better fixture for the flanches which are used for connecting them with the wheels or levers by which they are turned and strained. The superiority of strength of hollow tubes over solid cylinders is much greater in this kind of strain than in the former or transverse. In this last case the strength of this tube would be to that of the solid cylinder of equal weight as 61 to 32 and a half nearly.

The rat of resist ance to twisting the simp lateral r sistence pears di ferent.

The apparatus which we mentioned on a former occasion for trying the lateral strength of a square inch of solid matter, enabled us to try this theory of twist with all desirable accuracy. The bar which hung down from the pin in the former trials was now placed in a horizontal position, and loaded with a weight at the extremity. Thus it acted as a powerful lever, and enabled us to wrench asunder specimens of the strongest materials. We found the results perfectly conformable to the theory, in as far as it determined the proportional strength of different sizes and forms; but we found the ratio of the resistance to twisting to the simple lateral resistance considerably different, and it was some time before we discovered the cause.

We had here taken the simplest view that is possible of the action of cohesion in resisting a twist. It is frequently exerted in a very different way. When, for instance, an iron axle is joined to a wooden one by being driven into one end of it, the extensions of the different circles of particles are in a very different proportion. A little consideration will show that the particles in immediate contact with the iron axle are in a state of violent extension; so are the particles of the exterior surface of the wooden part, and the intermediate parts are less strained. It is almost impossible to assign the exact proportion of the cohesive forces exerted in the different parts. Numberless cases can be pointed out where parts of the axle are in a state of compression, and where it is still more difficult to determine the state of the other particles. We must content ourselves with the deductions made from this simple case, which is fortunately the most common. In the experiments just now mentioned, the centre of the circle is by no means the neutral point, and it is very difficult to ascertain its place; but when this consideration occurred to us, we easily freed the experiments from this uncertainty, by extending the lever to both sides, and by means of a pulley applied equal force to each arm, acting in opposite directions. Thus the centre became the neutral point, and the resistance to twist was found to be two thirds of the simple lateral strength.

But whe the expe ment wa altered, i was exac ly the sam

We beg leave to mention here, that our success in these experiments encouraged us to extend them much farther. We hoped by these means to discover the absolute cohesion of many substances, which would have required an enormous apparatus and a most unmanageable force to tear them asunder directly. But we could reason with confidence from the resistance to twist (which we could easily measure), provided that we could ascertain the proportion of the direct and the lateral strengths. Our experiments on chalk, finely prepared clay, and white bee's wax (of one melting and one temperature), were very consistent and satisfactory. But we have hitherto found great irregularities in this proportion in bodies of a fibrous texture like timber. These are the most important cases, and we still hope to be able to accomplish our project, and to give the public some valuable information. This being our sole object, it was our duty to mention the method which promises success, and thus excite others to the task; and it will be no mortification to us to be deprived of the honour of being the first who thus adds to the stock of experimental knowledge.

When the matter of the axle is of the most simple texture, such as that of metals, we do not conceive that the length of the axle has any influence on the fracture. It is otherwise if it be of a fibrous texture like timber; the fibres are bent before breaking, being twisted into spirals like a cork-screw. The length of the axle has somewhat of the influence of a lever in this case, and it is easier wrenched asunder if long. Accordingly we have found it so; but we have not been able to reduce this influence to calculation.

Many useful deductions might be made from these premises respecting the manner of disposing and combining the strength of materials in our structures. The best form of joints, mortises, tenons, scarphs, the rules for joggling, tabling, faying, fishing, &c. practised in the delicate art of mast-making, are all founded on this doctrine; but the discussion of these would be equivalent to writing a complete treatise of carpentry. (B. B. B.)

The most recent experiments on the strength and elasticity of material give the results entered in the following tables.

TABLE I.—*Distensions of Rods for a Strain of one Pound per Square Inch; computed from the results given in Tredgold, edition of* 1840, *as deduced from observations on transverse strain.*

British timber	Oak	$\frac{1}{92000}$
	Larch	$\frac{1}{86000}$
	Scotch fir	$\frac{1}{80000}$
	Ash	$\frac{1}{120000}$
Foreign timber	Memel fir	$\frac{1}{75000}$
	Norway fir	$\frac{1}{109000}$
	American pine	$\frac{1}{50000}$
	White spruce	$\frac{1}{92000}$
	Riga oak	$\frac{1}{100000}$
	American oak	$\frac{1}{96000}$
English malleable iron		$\frac{1}{24200000}$

TABLE II.—*Cohesive Strengths of Bars per Square Inch.*

		lbs.		lbs.
Oak	from	14,000	to	19,000
Beech	from	11,000	to	22,000
Ash	from	12,000	to	17,000
Elm	from	13,000	to	14,000
Mahogany	from	8,000	to	21,000
Teak	from	8,000	to	15,000
Pine (Norway)	from	7,000	to	14,000
Larch	from	9,000	to	10,000
Iron wire	from	94,000	to	113,000
Swedish iron	from	53,000	to	78,000
English iron	from	55,000	to	66,000
Cast iron	from	16,000	to	33,000

STRETCHING, in *Navigation*, is generally understood to imply the progression of a ship under a great surface of sail, when close-hauled.

STRETTA (Ital.), a musical term, often applied to the last allegro of a finale, &c. in an opera. It signifies also a kind of peroration or winding up of a piece of music, particularly of a fugue. See MUSIC.

STRETTO, or *più Stretto* (Ital.), indicates an acceleration of the time of a piece of music.

STRIATED LEAF, among botanists, one that has a number of longitudinal furrows on its surface.

STRIKE, a measure of capacity, containing four bushels. Also an instrument used in measuring corn.

STROMBOLI, the most northern island of the Lipari group, in the Mediterranean, being a part of the kingdom of Naples. It was known to the ancients by the name of Strongyle; a name implying a conical mountain with an irregular base. The mountain is bifurcated, upwards of 2000 feet in height, and about nine miles in circumference, and is evidently a monstrous product of subterraneous fires. The crater of this mountain is on the north-west side, about two thirds of the whole height from the base; it is of a circular form, and about one hundred and seventy yards in diameter, and has a yellow efflorescence adhering to its sides, as to those of Mount Ætna. This crater has burnt without intermission from the earliest periods, and is supposed to be supported by oxygen, pyrites, and sulphur; but there are not any traces of the aid of bitumen. It appears to be not only the vent of all these islands, but likewise to have subterraneous communication with Sicily and Italy; for, previously to a severe earthquake taking place in those parts, Stromboli has been observed to be covered with dense clouds of smoke, and to emit with increased activity unusually ardent flames. The access to the summit, though fatiguing, is not dangerous. When a person approaches the crater, and the smoke clears away, as it does at intervals, he can observe an undulating igneous substance, which at short periods rises and falls with great agitation, and when swollen to the utmost height bursts with a violent explosion and a discharge of red-hot stones in a semi-fluid state, accompanied with showers of ashes, and a strong sulphureous smell. These masses are thrown up to the height of from sixty or seventy to three hundred feet, and some few even to a thousand. In the moderate ejections the stones in their ascent gradually diverge like a grand pyrotechnical exhibition, and fall again into the abyss, except on the side next the sea, where they roll down in quick succession to the water.

The island contains about 1200 inhabitants. The principal places are St Bartolo and St Vincenzo. The soil is a black mold, very fertile, consisting of argilaceous tufa, scoriæ, puzzolana, and sand. Stromboli produces some good wine, with excellent wheat, barley, cotton, rasins, currants, and figs. The church of St Bartolo is in long. 15. 13. 10. E., and lat. 38. 48. 12. N.

STROMNESS, a town in the parish of the same name in the island of Pomona, Orkney, in long. 3. 38. W. and lat. 58. 58. N. The town is situated on the western side of the island, and was formerly an insignificant village, dependent on the borough of Kirkwall, which kept it completely under; but by a decision of the House of Lords, Stromness and all other villages were declared free from being assessed, and otherwise independent of royal boroughs. The present town consists of one long rambling street, built round the bay on which it is placed. The greater portion of the houses are built so close on the water that they require to be defended by bulwarks, jetties, and quays, to keep them from being overwhelmed by the sea. At these small vessels load and unload. The harbour is formed by the bay, which is about a mile in length, and half of that in breadth. It forms one of the most secure harbours in the north of Scotland, and affords safe anchorage for vessels of 1000 tons burden; and it is the chief resort for shipping in the northern isles. The wealth of the inhabitants is chiefly derived from the Greenland whalers, which touch here to complete their crews from the sailors belonging to the place, as well as to supply the vessels with provisions and stores. The Hudson Bay vessels also touch here. A number of ships and boats are built at Stromness; and the manufacture of straw-plait is carried on to a considerable extent. It was erected into a borough of barony in the year 1817, and it is governed by two bailies and nine councillors. The population in 1831 amounted to 2182.

STROPHE, in ancient poetry, a certain number of verses, including a perfect sense, and making the first part of an ode.

STROUD, a town of the hundred of Shamwell, in the lathe of Aylesford and county of Kent, twenty-nine miles from London. It stands on the river Medway, over which is a bridge connecting it with Rochester, so as in appearance to make it merely a suburb to that city. It consists of a single long street. The church is a fine old building, which formerly belonged to the Knights Templars, who had a palace near this town. The ruins of it are still visible on the banks of the river. The inhabitants amounted in 1801 to 1172, in 1811 to 1394, in 1821 to 1461, and in 1831 to 1549.

STROUD, a town in the hundred of Bisley and county of Gloucester, 102 miles from London. It stands on a hill near the Stroud water, which empties itself into the Severn. The Stroud is brought into communication with the Thames by means of a canal. It is a considerable clothing town, especially esteemed for the excellence of its dark-blue cloths. It was created a borough by the act of 1832, and returns two members to the House of Commons. It has a well-frequented market on Friday. The inhabitants amounted in 1801 to 5422, in 1811 to 5321, in 1821 to 7097, and in 1831 to 8607.

STRYPE, JOHN, a most industrious and meritorious labourer in the department of ecclesiastical and literary history, was born at Stepney on the first of November 1643. His father, John van Stryp, was a native of Brabant, and sought refuge in England on account of his religion. He was a merchant and silk-thrower. The son received his early education at St Paul's school, where he remained for six years. In 1662 he proceeded to Jesus College, Cambridge, from which he was transferred to Catherine Hall. In 1665, he there took the degree of A.B., and that of A.M. four years afterwards. He was appointed to the perpetual curacy of Theydon-Boys, in the county of Essex, in 1669; but he only retained it for a few months, having been appointed minister of Low Leyton, in the same county. He was elected by the parishioners, whom the patrons had left to make their own choice of a spiritual guide. His emoluments were not secured to him in the usual way, but by a bond for his maintenance entered into by his parishioners. Their annual subscriptions amounted to sixty-nine pounds sterling. Five years after his appointment to that parish, he was licensed by the bishop of London to preach the word of God in Low Leyton; and the bishop's license was the only credential which he had to produce. This undisturbed enjoyment of questionable rights may be attributed to the favour which the ecclesiastical dignitaries felt for a man who had made many valuable additions to the annals of the church. When far advanced in life, Strype was presented by Archbishop Tenison to the sinecure of Terring in Sussex. He was also appointed to the lectureship of Hackney, which he resigned in 1724. At Hackney he resided, in his old age, under the roof of Mr Harris, an apothecary, who was married to his grand-daughter. In his house he died on the 11th of December 1737, at the patriarchal age of ninety-four.

Strype's principal works are, The Life of Archbishop Cranmer, 1694, fol.: The Life of Sir Thomas Smith, 1698, 8vo: The Life of Dr John Aylmer, bishop of London, 1701, 8vo: The Life of Sir John Cheke, 1705, 8vo: Annals of the Reformation, 4 vols.; vol. i. 1709, reprinted 1725; vol. ii. 1725; vol. iii. 1728; vol. iv. 1731: The Life of Archbishop Grindal, 1710, fol.: The Life and Letters of Archbishop Parker, 1711, fol.: The Life of Archbishop Whitgift, 1718, fol.: Ecclesiastical Memorials, 1721, 3 vols. fol.

The writings of Strype were for many years neglected, but they are now held in deserved estimation; and they have all been reprinted at the Clarendon press. He is not remarkable for the methodical arrangement of his materials, nor did he ever attain to much proficiency in the art of composition; but no one ever denied him the praise of diligence and fidelity. Beside these works, he published Lessons for Youth and Old Age, 1699, 12mo. He likewise published the second volume of Dr Lightfoot's Works, in 1684; and an elaborate edition of Stow's Survey of London, 1720, 2 vols. fol.

STUART, GILBERT, an eminent jurist and historian, was born at Edinburgh in the year 1742. His father, George Stuart, LL. D., had succeeded John Ker as professor of humanity during the preceding year. According to the tradition of the university, he was an excellent Latinist, but of his proficiency he has left no public proofs. He had prepared an amended and enlarged edition of Ainsworth's Latin Dictionary; but it was never committed to the press, and its suppression may perhaps have been occasioned by the too high estimate which the professor had formed of its pecuniary value.

The son was educated in the public school and in the university of his native city. Of his proficiency in several branches of study, his various works afford a sufficient criterion. To the pursuit of jurisprudence he devoted himself with uncommon ardour; but although he had a strong relish for law as a science, he anticipated no delight from its practice, and he was never called to the bar. Of his early progress in this study he exhibited a very conspicuous specimen in a work published without his name; "An Historical Dissertation concerning the Antiquity of the English Constitution." Edinb. 1768, 8vo. It has been asserted that when he produced this work, he was little more than twenty years of age; but the statement is not sufficiently accurate, for he had then attained his twenty-sixth year. For a writer of that age, or indeed of any age, it is an ingenious and able performance. His chief favourites and models are Tacitus and Montesquieu. With no mean talents for research and disquisition, he has endeavoured to evince that "the parts which compose our constitution arose more immediately from the forests of Germany." The same ground had recently been occupied by the learned Dr Squire, bishop of St David's; of whose Inquiry into the Foundation of the English Constitution a second edition appeared in the year 1753. Stuart's Dissertation, distinguished by so much vigour of intellect and maturity of juridical learning, procured him from the university the degree of LL. D., which is very rarely bestowed upon so young a scholar. A second edition, bearing the author's name, was published at London in the year 1771, and he then prefixed a dedication to the earl of Mansfield.

The dedication is dated at London in the month of January 1770; and before this period he had become a regular contributor to the Monthly Review, with which he continued his connexion from 1768 to 1774. We likewise find him employed as the editor of "An Historical Treatise on the Feudal Law, and the Constitution and Laws of England; with a Commentary on Magna Charta, and necessary Illustrations of many of the English Statutes: in a

Course of Lectures read in the University of Dublin, by the late Francis Stoughton Sullivan, LL. D., Royal Professor of the Common Law in that University." Lond. 1772, 4to. Dr Sullivan had obtained a fellowship at the early age of nineteen; and, as his editor informs us, he "was not less remarkable for his knowledge in history and chronology than for his skill in his profession as a barrister and civilian." Towards the close of his life, he was engaged in preparing a History of Ireland; but this task was reserved for Dr Leland, another distinguished fellow of Trinity College. The editor, whose name does not appear, has prefixed a preface of four pages, and has particularly extolled the author for his "admirable vindication of the original freedom of our constitution, and his excellent commentary on *Magna Charta*."

A pseudonymous work, of a very different denomination, has been ascribed to Dr Stuart. It bears the title of "Animadversions on Mr Adam's Latin and English Grammar; being an Exhibition of its Defects, and an Illustration of the Danger of Introducing it into Schools. By John Richard Busby, Master of Arts." Edinb. 1773, 8vo. This grammar, at its first appearance, was doomed to encounter a very fierce and general opposition. The other four masters of the school to which the author belonged, presented to the town-council a remonstrance against it; and the use of it in that seminary was formally prohibited.[1] Stuart's zeal might be excited by his relationship to Ruddiman, whose elementary works, both excellent in their kind, had for half a century retained their place in the grammar schools. That the writer has detected and specified errors and omissions, it would not be safe to deny; but the spirit as well as the style of his animadversions is such as no unprejudiced reader could approve. They conclude with the subsequent passage: "These strictures will, it is thought, be sufficient to evince the entire frivolity of Mr Adam's grammar, and the danger that must attend its adoption into our schools. To point out all the errors of his performance, would require several volumes; and I am not ambitious of performing a task that would vie with any of the labours of Hercules. It is the peculiar infelicity of this grammarian, that he exhibits every defect which it is possible for an author to possess; a sterile invention, an unhappy method, a cold and inauspicious manner, an inaccurate and nerveless expression, a perverted judgment, a defective understanding, a corrupted taste.—Education is not a matter to be trifled with. The mistakes and miscarriage of our most generous youth have too frequently their rise in the negligence with which they have been treated in schools, where they have been sent to be initiated in the first principles of knowledge. It is also no groundless complaint, that the teacher often adds incapacity to neglect. And if this is, in general, a just representation of the matter, how must we pity, in particular, the pupils of Mr Adam! To disadvantages common to other boys, they must join the cruel and insuperable one of studying a work that advances in an unvaried progress from blunder to blunder, and from absurdity to absurdity." The merits and demerits of this grammar, which in spite of all opposition became very popular, were discussed in various articles of the Weekly Magazine. Here we find two Latin lucubrations on the subject, one of which was known to be the production of Stuart, and the other might perhaps be written by the same satirical pen. In the form of a description of a Roman funeral, he records the interment of Adam's Latin Grammar; nor does he neglect to introduce the well-known Jamie Duff, an idiot whose supreme delight was to place himself, an unhired attendant, at the head of a funeral procession: "Imus ad hortos scholasticos, præeunte Jacobo Duff, solita sua gravitate, densissimo ac lætissimo puerorum agmine cincto." The narrative closes with this monumental inscription:

In hac urna jacet quod reliquum est
Libelli inauspicati,
nunquam resurrecturi,
invita et irata Minerva editi;
qui miserabiliter
in tenera ætate raptus,
triste præbet exemplum
fragilitatis humanæ,
nec non vanitatis auctorum,
qui Musis non rite litantes
longiorem expectant vitam.
Siste viator; et, si meliorem animæ partem
velis esse superstitem,
fatum meum tecum reputa.
Festina lentius, et vale.[2]

Dr Stuart now undertook the management of "The Edinburgh Magazine and Review," of which the first number bears the date of November 1773. In the commercial part of this enterprise his partners were Alexander Kincaid, his majesty's printer, William Creech, bookseller, William Smellie, printer, and William Kerr, surveyor of the post-office. The work was printed by Smellie, who was likewise to manage the business details of the concern, to furnish the last half-sheet of every number, and to review such books as the editor and he should select. The profits were to be distributed into six shares; one of which was allotted to Kincaid and Creech conjunctly; one each to Stuart, Smellie, and Kerr; and the remaining two to the editor and the printer, to be divided between them as they should mutually agree. Stuart was himself the principal writer. Various essays and reviews were furnished by Smellie. Lord Hailes, Dr Blacklock, Professor Richardson of Glasgow, and Professor Barron of St Andrews, were among the number of the contributors. The name of Dr Moor appears in the poetical department. An extraordinary lucubration, entitled "A modest Defence of the Accomplishment of Blasphemy," was written by the Rev. A. Gillies. The Rev. Mr Nimmo of Bothkennar wrote the Essay on the Antiquities of Stirlingshire, which he afterwards enlarged to the size of an octavo volume.[3]

A periodical work, supported by such contributors, might have run a long and prosperous career, if its success had not been marred by the editor's want of temper and discretion. At that period, the population of Edinburgh probably did not amount to one third of its present number; and the freedom of public discussion was circumscribed in at least an equal proportion. Dr Henry was one of those who had most reason to complain of injurious treatment. A single sermon of his was very unfavourably noticed by Smellie; and on the second volume of his History of Great Britain two articles were written by Stuart, in a style of unmitigated sarcasm and contempt; nor does it appear that there was any original ground of personal offence. In some fragments of his letters which have been published by D'Israeli, he speaks of this historian with a strange mixture of levity and virulence. Lord Monboddo did not experience better treatment. On the second volume of his Origin and Progress of Language they inserted two, and on the third volume three articles, each of them more offensive than another. These articles were written by Stuart, Smellie, and Gillies, but the greater portion of them by the latter. The editor lent his aid in the review of the third volume, and in the art of vituperation he greatly excelled his coadjutors. It is scarcely to be supposed that any of the disparaging expressions were attributable to Smellie. This attack on the learned judge gave great offence to him and his friends, and indeed it had a visible effect in precipitating the failure of the work. Of Lord Kames's Sketches of the History of Man the editor had prepared a very severe review; but when it was sent to the printer, he "counteracted the intentions of his colleague, by altering the whole into a totally opposite tendency, converting the far greater part from harsh invective into reasonable and merited panegyric." On discovering that the venom had thus been extracted, the writer was moved with violent anger; but he speedily moderated his feelings so far as to admit that his friend had acted rightly. Smellie, though he generally exercised a sounder discretion, could himself display a strong vein of satire. This remark was sufficiently verified in his controversy with Dr Nisbet, then minister of Montrose, and afterwards president of Dickinson College at Carlisle in Pennsylvania.[1] The controversy was occasioned by the mode of reporting a certain debate in the General Assembly. Nisbet printed two letters in a newspaper, and Smellie replied in the magazine. This publication was continued till the month of August 1776, when it terminated with the fifth volume. A closing notice informed the "numerous and respectable encouragers of this work," that its publication was only interrupted for some months, and that it would afterwards appear in an improved form. But the promise was never fulfilled, nor is it very probable that many readers expected its fulfilment.

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[1] Henderson's Account of the Life and Character of Alexander Adam, LL. D. Rector of the High School of Edinburgh, p. 42. Edinb. 1810, 8vo.

[2] Weekly Magazine, vol. xix. p 245. See likewise p. 53.

[3] Kerr's Memoirs of Smellie, vol. i. p. 401.

Notwithstanding the failure of this project, Dr Stuart had displayed so much talent in his principal articles, that his reputation as a man of letters suffered no diminution. He however felt a very painful mortification at the unsuccessful result of his labours; and his mind was so badly regulated that, instead of reflecting on the natural tendency of his own conduct, he continued to cherish a most bitter and indiscriminate resentment. In a letter, dated on the 17th of June 1774, and probably addressed to his London publisher, he expresses himself in these unseemly terms: "It is an infinite disappointment to me, that the Magazine does not grow in London; I thought the soil had been richer. But it is my constant fate to be disappointed in every thing I attempt; I do not think I ever had a wish that was gratified, and never dreaded an event that did not come. With this felicity of fate, I wonder how the devil I could turn projector. I am now sorry that I left London; and the moment that I have money enough to carry me back to it, I shall get off. I mortally detest and abhor this place, and every body in it. Never was there a city where there was so much pretension to knowledge, and that had so little of it. The solemn foppery, and the gross stupidity of the Scottish literati, are perfectly insupportable. I shall drop my idea of a Scots newspaper. Nothing will do in this country that has common sense in it; only cant, hypocrisy, and superstition, will flourish here. A curse on the country, and all the men, women, and children of it.... The publication is too good for the country. There are very few men of taste or erudition on this side the Tweed; yet every idiot one meets with lays claim to both. Yet the success of the Magazine is in reality greater than we could expect, considering that we have every clergyman in the kingdom to oppose it; and that the magistracy of the place are every moment threatening its destruction." All this exhibits a melancholy picture of a man of superior talents and attainments, deriving no wisdom from experience, but still indulging those very passions to which his want of success was chiefly to be attributed, and which always bear along with them their own punishment. Before he vented his spleen in terms of such unseemly import, he ought to have recollected, "It is a foul *corby* that bewrays its own nest." The fault that he here commits, is not one with which his countrymen are commonly chargeable; and the period which he thus describes as so barren in taste and erudition, was perhaps remarkable for its intellectual eminence beyond any former or succeeding period in the literary annals of Scotland.

Dr Stuart was still in the early vigour of manhood, and he speedily roused himself to new and greater exertions. After an interval of less than two years, he produced what we are disposed to regard as the best of his works, "A View of Society in Europe, in its Progress from Rudeness to Refinement: or, Inquiries concerning the History of Law, Government, and Manners." Edinb. 1778, 4to. This work, of which there are several other editions, excited much attention on its first appearance. Hayley, who was then a popular writer, described the author as possessing "all the energy of genius."[2] His researches are conducted with judgment and sagacity; he grasps his subject with much vigour, and always expresses himself with boldness and force. In the progress of his discussions, he points out various mistakes of recent writers. One of these was Blackstone, who silently rectified the errors which he detected.[3] The style of this work, though never languid or feeble, may however be considered as deficient in fluency and variety. His periods are too uniformly short, to be altogether pleasing to the ear. Long sentences he has elsewhere denounced in set terms. "This brevity," he avers, "is a conspicuous part of oratory, and is consistent with the greatest elevation and dignity. Where Cicero himself is most eloquent, and where the tide of his language is most rapid and powerful, his sentences are concise; and he avoids with care the periodic swell, as cold, artificial, and unnatural. And indeed it is to be laid down as a general rule, that where sentences are uniformly long, as in Milton and in Clarendon, there is no eloquence in the composition, and little connection in the argument."[4]

The chief value of the work consists in the vivid and striking picture which it exhibits of chivalry and the feudal system. In this respect it possesses some advantages over Dr Robertson's View of the Progress of Society in Europe, though it is not written with the same degree of classical elegance. "In the courtly and agreeable introduction to the History of Charles the Fifth," says Dr Stuart, "of which the scheme is so comprehensive, it is remarkable that, amidst a wide variety of other omissions, there is not even the slightest consideration of knight-service, and the knight's fee. Yet these circumstances were of a most powerful operation, both with respect to government and manners. I make not this remark to detract from the diligence of an author whose laboriousness is acknowledged, and whose total abstinence from all ideas and inventions of his own, permitted him to carry an undivided attention to other men's thoughts and speculations; but that, resting on these peculiarities, I may draw from them this general and humiliating, yet, I hope, not unuseful conclusion, that the study and knowledge of the dark ages are still in their infancy." This contemptuous mention of the great historian could scarcely fail to excite resentment, and of this resentment he speedily had occasion to prove the bitter effects.

The professorship of the law of nature and nations was at that period held by James Balfour; and in 1779, being then advanced in years, it was ascertained that he was willing to resign it for a valuable consideration. Here it is necessary to explain the very remarkable fact, that, under the sanction of the secretary of state, this professorship was regularly bought and sold. The price of his resignation had already been fixed, and the chair, thus to be vacated, had been promised to Dr Stuart, when the negociation was finally interrupted by a strong remonstrance from the principal; who might safely represent to the lord advocate that the habits of the candidate were not sufficiently academical, and that such an appointment would be highly unsatisfactory to himself, as well as to some of his colleagues. "While engaged in some of his studies and projected publications," we are informed, "he has been known to confine himself for many weeks to solitary literary labour, hardly ever stirring abroad for air and exercise; but he unfortunately indulged in occasional sallies of vastly too great latitude and even licentiousness."[1]

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[1] See Dr Allen's American Biographical and Historical Dictionary, p. 449.

[2] Hayley's Essay on History, p. 157. Lond. 1780, 4to.

[3] English Review, vol. ii. p. 169.

[4] Edinburgh Magazine and Review, vol. v. p. 250.

This professorship was founded by the crown in the year 1707. The salary, payable out of the tithes of the bishopric of Edinburgh, amounted in 1802 to about L.350; but it was then reduced so low as L.80 or L.90, by an augmentation of stipend adjudged to the minister of St Cuthbert's. As an indemnity for this reduction, the professor obtained in 1806 a pension of L.200, payable during his incumbency. He had "purchased his commission," and he never read a single lecture. He survived till the year 1831, and no successor has been appointed. A middle way might certainly have been found between the conduct of one administration and that of another. The number of lucrative offices in this university is not superabundant, nor was it necessary to reduce their number by so minute a fragment of public economy. Even on the admission of the chair having been inefficient, this treatment, unless extended to some better-endowed universities, can scarcely be regarded as impartial. The professorship of the civil law at Oxford has long been as inefficient as the professorship of public law at Edinburgh. Why should the one be suppressed, and the other spared?

His qualifications for the office which thus seemed to be within his reach, were very eminent; and this signal disappointment of his hopes proved the greatest misfortune of his life. His resentment against Dr Robertson appears to have suggested all the works in which he afterwards engaged. This spirit is very easily to be discerned in his next publication, "Observations concerning the Public Law and the Constitutional History of Scotland: with occasional Remarks concerning English Antiquity." Edinb. 1779, 8vo. His extensive researches for the View of Society must evidently have abridged his labour of preparing these Observations, which contain much disquisition of a similar kind. The work is able and elaborate, nor can it be safely overlooked by any student anxious to investigate the constitutional history of our country. His antipathy to Robertson is unequivocally displayed in many passages; and, at the conclusion, he thus concentrates his sentiments of disparagement: "A propensity to embellish other men's notions, without considering enough on what authority they are founded, how strong they are in themselves, and what inferences are to be deduced from them, is a constant and a teeming source of mistake to this showy and elegant historian. It is thence that he holds out many a frail opinion to glitter and to perish. To collect these cannot be interesting to me. But, though I could not submit to make a chronicle of his errors, I have been induced to wipe away, and to dispel, in part, the stains and the gloom they would fix upon our story, and to illustrate, by examples, the respect which is due to his authority. And, while I perform this service to truth, to liberty, and to our national antiquities, I disdain to be unjust, and am far from being insensible to the peculiarities of his merit. It must be a pain, I know, to many of his readers, that the most widely amusing of all our writers, is not at the same time the best informed, and the most able. They must regret that a work which forms so general, so easy, and so pleasing a pastime, is not also fraught with instruction, and loaded with wisdom; and that the author, who is deservedly so eminent in all the arts of courtly and popular composition, is not likewise remarkable for those superior qualities, which alone can secure and establish admiration, the power of thought, and the originality of sentiment." It is scarcely necessary for us to subjoin, that we are very far from being disposed to acquiesce in this general estimate.

This publication was speedily followed by "The History of the Establishment of the Reformation of Religion in Scotland." Lond. 1780, 4to. The work is written with his usual ability, but it cannot be affirmed that such an undertaking was peculiarly adapted to his habits of thinking. He however displays a greater degree of impartiality than could well have been anticipated. He is willing to admit that "a tribute of the highest panegyric and praise is justly to be paid to the actors in the Reformation. They gave way to the movements of a liberal and a resolute spirit. They taught the rulers of nations that the obedience of the subject is the child of justice, and that men must be governed by their opinions and their reason. Their magnanimity is illustrated by great and conspicuous exploits; which, at the same time that they awaken admiration, are an example to support and animate virtue in the hour of trial and peril. The existence of civil liberty was deeply connected with the doctrines for which they contended and fought. While they treated with scorn an abject and cruel superstition, and lifted and sublimed the dignity of man, by calling his attention to a simpler and wiser theology, they were strenuous to give a permanent security to the political constitution of their state."

Of this work, his next publication may be considered as the sequel: "The History of Scotland, from the Establishment of the Reformation till the Death of Queen Mary." Lond. 1782, 2 vols. 4to. Here the author has made a great, and indeed a splendid effort, to eclipse the reputation of Robertson, whom he both envied and hated. As the one historian considered Mary guilty of some of the foulest crimes laid to her charge, it was almost an obvious consequence that the other should represent her as innocent. Her innocence, he is willing to believe, has been demonstrated by Goodall and Tytler; but more recent writers, and especially Laing, have sufficiently disposed of their demonstrations; nor is it perhaps to be anticipated that any historian of eminence will hereafter desert the footsteps of Robertson to tread in those of Stuart. His work however displays great vigour of mind, and the style is more easy and flowing than that of his View of Society. Some of his characters are sketched with a powerful pencil. This history attracted no inconsiderable share of public attention on its first appearance, and, like his preceding volume, it reached a second edition, but it made little or no progress in supplanting the rival work; and the story of the ill-fated Mary's crimes and sufferings still continues to be chiefly read in the elegant and captivating pages of Robertson.

The preface to the History of Scotland is dated at London on the first of March 1782; and soon after this period, he undertook the management of the English Review, the property of the late John Murray, who had been the London publisher of his Magazine. Of "The English Review, or, an Abstract of English and Foreign Literature," the first number appeared at the commencement of the year 1783. One of his coadjutors was Whitaker, an uncandid and virulent critic, whose chief effort in this journal was a series of articles on Gibbon's History.[2] These he reprinted in a separate form in the year 1791. In this English Review, some Scottish authors do not find much favour. The historical works of Dr Ferguson and Dr Watson receive a liberal portion of praise; but the Lectures of Dr Blair and the Dissertations of Dr Beattie are treated as works of very inferior merit and importance. It is observable that Smellie's translation of Buffon is not honoured with much commendation. Stuart had dedicated one of his works to the chief justice; but the subsequent passage, which occurs in an article apparently written by him, affords a sufficient indication of his altered sentiments: "Lord Mansfield, during the course of his long life, has been uniformly the zealous champion of prerogative; and has exerted and prostituted his abilities to undermine the trial by jury, and the liberty of the press, those sacred and formidable bulwarks which support the glorious fabric of the English government."

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[1] Kerr's Memoirs of Smellie, vol. i. p. 500.

[2] D'Israeli states that "he negociated for Whitaker and himself a doctor of laws degree." (Calamities of Authors, vol. ii. p. 63.) This

How long he continued to conduct the English Review, we are not informed. In 1785 he became the editor of "The Political Herald and Review; or a Survey of domestic and foreign Politics, and a critical Account of political and historical Publications." This work, it is believed, only reached a second volume. One of his coadjutors, in this as well as the English Review, was Dr Thomson, who, like himself, was too great a lover of Burton ale. Their favourite haunt was the Peacock in Gray's Inn Lane.[1] It is too well known that Stuart's mode of life had been such as to impair his health and strength. With a constitution undermined by disease, and a mind soured by disappointment, he embarked for Leith, and sought a place of rest under the roof of his father, who having become emeritus professor in 1775, was then residing at Musselburgh. The son was labouring under a dropsy, from which the usual operation afforded him a temporary relief; but all medical aid was ineffectual, and he descended to his grave at the premature age of forty-four. He died on the 13th of August 1786, and his father survived till the 18th of June 1793.

Gilbert Stuart is thus described by a writer who seems to have had some personal knowledge of him: He "was about the middle size, and justly proportioned. His countenance was modest and expressive, sometimes announcing sentiments of glowing friendship, of which he is said to have been truly susceptible; at others, displaying strong indignation against folly and vice, which he had also shewn in his writings. With all his ardour for study, he yielded to the love of intemperance, to which, notwithstanding a strong constitution, he fell an early sacrifice."[2] (x.)

STUD, in the manège, a collection of breeding horses and mares.

STUDY (Ital. *Studio*), a piece of instrumental music composed for the purpose of familiarizing the player with some of the difficulties of his instrument. Thus we have studies for the violin by Fiorillo, Kreuzer, Rode, Spohr, Paganini; and for the pianoforte by Clementi, Cramer, Kalkbrenner, and others.

STUDDING-SAILS, certain light sails, extended, in moderate and steady breezes, beyond the skirts of the principal sails, where they appear as wings upon the yard-arms.

STUFF, in commerce, a general name for all kinds of fabrics of gold, silver, silk, wool, hair, cotton, or thread, manufactured on the loom; of which number are velvets, brocades, mohairs, satins, taffetas, cloths, serges, &c.

STUHLWEISSENBURG, a city of the kingdom of Hungary, in the province of the Farther Danube, the capital of a circle of the same name. It stands in a marshy situation on the river Sarvitz, is the seat of a Catholic bishop, and of several inferior courts of judicature. Besides a cathedral, it has several Catholic churches, and one for the United Greeks, and likewise two monasteries. It contains 1330 houses, with 12,380 inhabitants, who are chiefly dependent on agriculture, especially on vineyards, but are also employed in manufacturing flannel and other woollen goods. Long. 18. 19. 25. E. Lat. 47. 11. 34. N.

STUKELEY, WILLIAM, an eminent antiquary, descended from an ancient family in Lincolnshire, was born at Holbech in that county, on the 7th of November 1687. From the free school of his native town he was removed to Corpus Christi College, Cambridge, where he was admitted on the 7th of November 1703. Having chosen the medical profession, he took the degree of M. B. in 1709, and that of M. D. in 1719. He first settled as a practitioner at Boston; but in 1717 he removed to London, and was admitted a fellow of the College of Physicians in 1720. By the recommendation of Dr Mead, he was chosen a fellow of the Royal Society. He contributed to the re-establishment of the Society of Antiquaries; of which he officiated as secretary for many years. In 1726 he left the metropolis, and settled at Grantham in Lincolnshire, where he soon obtained extensive practice. In 1728 he married Frances, the daughter of Robert Williamson, Esq. of Allington, a lady of good family and fortune. Being much afflicted with the gout, he found the exercise of his profession very laborious, and therefore meditated a retreat into the church. On the 20th of July 1720, being then in the thirty-third year of his age, he received ordination from Archbishop Wake; and in the ensuing October was presented by the lord-chancellor King to the living of All-Saints in Stamford. He became a widower in 1737, and, in the course of the following year, married the only daughter of Dr Gale, the learned dean of York. In 1739 the living of Somerby near Grantham was bestowed upon him by the duke of Ancaster. In 1747 the duke of Montagu presented him to the rectory of St George, Queen Square, and he then vacated his other benefices. He survived till the 3d of March 1765. On the 27th of the preceding month, he had been struck with palsy, after attending a full vestry on a contested election for a lecturer. The apartment was much heated; and on returning through his garden, accompanied by Serjeant Eyre, "they both caught their deaths, for the serjeant never was abroad again, and the doctor's illness came on that night." By his first wife Dr Stukeley had three daughters, one of whom died young, and the other two survived him. The one was married to Mr Richard Fleming, an eminent solicitor, and the other to the Rev. Thomas Fairchild, rector of Pitsey in Essex. They both died in 1782. Of his second marriage there was no issue.

Dr Stukeley was a man of varied learning, but was chiefly distinguished by his knowledge of antiquities. His writings are numerous, and partly relate to medical, as well as theological subjects; but we shall confine ourselves to an enumeration of the most important or curious of his antiquarian publications. An Account of a Roman Temple near Graham's Dike. 1720, 4to. Of the Roman Amphitheater at Dorchester. Lond. 1723, 4to. *Itinerarium Curiosum*; or, an Account of the Antiquitys and remarkable Curiosities in Great Britain. Lond. 1724, fol. Lond. 1776, 2 vols. fol. Stonehenge; a Temple restor'd to the British Druids. Lond. 1740, fol. Abury; a Temple of the British Druids: with some others described. Lond. 1743, fol. *Palæographia Britannica*; or, Discourses on Antiquities in Britain. Lond. 1743–52, 4to. An Account of Richard of

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supposed negociation he apparently refers to the year 1783, or some period subsequent to the appearance of the English Review. The degree had very honourably been conferred upon Stuart many years before; and John Whitaker, on whom it was never conferred, was a B. D. of Oxford.

[1] Annual Obituary, vol. ii. p. 101.

[2] General Biographical Dictionary, vol. xxviii. p. 474.

Cirencester. Lond. 1757, 4to. The Medallic History of Marcus Aurelius Valerius Carausius, Emperor in Britain. Lond. 1757-9, 2 vols. 4to.

STUPOR, a numbness in any part of the body, whether occasioned by ligatures obstructing the blood's motion, by the palsy, or the like.

STURM, John, better known by the name of Sturmius, a learned philologer and rhetorician, was born at Schleiden in Eissel, near Cologne, on the 1st of October 1507. He studied at first in his native country with the sons of Count von Manderscheid, whose receiver his father was. He afterwards pursued his study at Liege, in the college of St Jerome, and then went to Louvain in 1524. He there spent five years, three in learning and two in teaching. He set up a printing-press with Rudger Rescius, professor of the Greek tongue, and printed several Greek authors. In 1529 he went to Paris, where he was highly esteemed, and read public lectures on the Greek and Latin writers, and on logic. There he married, and kept a great number of boarders: but as he was inclined to what were called the new opinions, he was more than once in danger; and this undoubtedly was the reason why he removed to Strasburg in 1537, in order to take possession of the place offered him by the magistrates. The year following he opened a school, which became famous, and by his means obtained of Maximilian II. the privileges of a university in the year 1566. He was very well skilled in polite literature, wrote Latin with great purity, and was an able teacher. His talents were not confined to the school; for he was frequently intrusted with deputations in Germany and foreign countries, and discharged these employments with great honour and diligence. He showed extreme charity to the refugees on account of religion: he not only laboured to assist them by his advice and recommendations, but he even impoverished himself for them. He died on the 3d of March 1589, in the eighty-second year of his age, after he had been for some time blind. Although he was thrice married, he left no children. He was a learned writer, and published various works, which were found to be useful and important by his contemporaries. One of these was an edition of Cicero in nine vols. 8vo. He bestowed much labour in elucidating the rhetorical works of Aristotle, Hermogenes, and Cicero. With the view of improving the system of education, he published several treatises; one of which was frequently reprinted. It is entitled "De Literarum Ludis recte aperiendis liber." Argent. 1538, 4to. F. A. Hallbauer edited a collection of his tracts, under the title "De Institutione Scholastica Opuscula omnia." Jenæ, 1730, 8vo. The name of Sturmius is familiar to the reader of Ascham's epistles. He must not be confounded with John Sturm, a native of Mechlin, and physician and professor of mathematics at Louvain, who also wrote several works.

STURMINSTER-MARSHAL, a town of the hundred of Cogdean and county of Dorset, 104 miles from London. It has a large church, and had formerly a market, which has of late years been disused. It stands on the river Stour. The number of inhabitants amounted in 1801 to 604, in 1811 to 662, in 1821 to 715, and in 1831 to 803.

STURMINSTER-NEWTON, a town in the hundred of the same name in the county of Dorset, 111 miles from London. It stands on the river Stour, and had once a considerable trade in making flannels, baize, and blankets; but of late it has declined. The buildings are indifferent, but it has a fine church, lately repaired. The market is held on Thursday. The inhabitants amounted in 1801 to 1406, in 1811 to 1461, in 1821 to 1612, and in 1831 to 1831.

STUTTGART, the capital of the kingdom of Wirtemberg, stands in a beautiful valley, and is surrounded on every side with hills of very moderate elevation, which are clothed to the tops with vineyards. The valley is watered by a clear and rapid but not copious river, which meanders through the walks at the extremity of the city. A great part of the city is composed of fine and modern buildings, and those streets are clean, well paved, and light. The royal palace is an extensive and magnificent pile of building; and the theatre, opera-house, the gymnasium, and the Catholic church, are fine specimens of architecture. Though there are no fortifications, the entrance to the city is through handsome gates, and one of them of most imposing beauty. Besides the gymnasium, there are other institutions for instruction; and the collection of ancient paintings, and the workshop of the sculptor Daneker, will be a treat to an amateur of the fine arts. The inhabitants amounted in 1817 to 26,016, and in 1831 had increased to 31,500. It is a place of little trade beyond what arises from supplying the court and the nobility that resort to it. Long. 9. 5. 33. E. Lat. 46. 48. 32. N.

STYLE, a word of various significations, originally deduced from *stylos*, a kind of bodkin wherewith the ancients wrote on plates of lead, or on wax, &c. and which is still used to write on ivory leaves and paper prepared for that purpose.

Style, in language, is the peculiar manner in which a man expresses his conceptions. It is a picture of the ideas which rise in his mind, and of the order in which they are there produced. See Rhetoric.

Old Style, the Julian method of computing time, as the *New Style* is the Gregorian method of computation. See Chronology.

STYLITES, Pillar Saints, in *Ecclesiastical History*, an appellation given to a kind of solitaries, who stood motionless upon the tops of pillars raised for this exercise of their patience, and remained there for several years, amidst the admiration and applause of the stupid populace. Of these we find several mentioned in ancient writers, and even as low as the twelfth century, when they were totally suppressed. The founder of the order was Simeon Stylites, a famous anchoret in the fifth century, who first took up his abode on a column six cubits high, then on a second of twelve cubits, a third of twenty-two, a fourth of thirty-six, and on another of forty cubits, where he thus passed thirty-seven years of his life. The tops of these columns were only three feet in diameter, and were defended by a rail that reached almost to the girdle, but did not permit the votary to lie down. The faquirs, or devout people of the east, imitate this insane mode of life to the present day.

STYX, in *Fabulous History*, a river of hell, round which it flows nine times. The gods held the waters of the Styx in such veneration, that to swear by them was reckoned an oath altogether inviolable. If any of the gods had perjured themselves, Jupiter obliged them to drink the waters of the Styx, which lulled them for one whole year into a senseless stupidity; for the nine following years they were deprived of the ambrosia and the nectar of the gods; and after the expiration of the years of their punishment, they were restored to the assembly of the deities, and to all their original privileges. It is said that this veneration was shown to the Styx, because it received its name from the nymph Styx, who with her three daughters assisted Jupiter in his war against the Titans.

Styx was a river which it was necessary for departed shades to pass before they could enter the infernal regions; and it was the office of Charon to ferry them over. Mythological writers have said that the Egyptians framed both this and some other fables relating to the dead, from certain customs peculiar to their country; that in particular there was, not far from Memphis, a famous burying-place, to which the dead bodies were conveyed in a boat across the lake Acherusia; and that Charon was a boatman who had long officiated in that service. The learned Dr Blackwell, in his Life of Homer, has observed, that, in the old Egyptian language, *Charoni* signified "ferryman."

SUAKIN, a seaport town of Nubia, situated on the western coast of the Red Sea, was formerly a place of great wealth and importance, but has long been in a declining state, and is now almost in ruins. Suakin looks better when seen at a distance than on a nearer view; the buildings all white-washed and on an elevated site, and two minarets, giving the town a handsome appearance. Like all the towns in the east, it has narrow and dirty streets. All that remains of its former grandeur is its capacious port, which is capable of containing 200 large vessels, that can anchor close to the island in seven fathoms water; but is so narrow at the mouth as to render an entrance impracticable, except with the most favourable wind. It is rather remarkable that this narrow passage should have so long remained open, considering the clouds of sand which are borne toward it at one season, and the action of the sea continually breaking over it, after having passed over sandbanks. The Turks obtained possession of Suakin at the same time that they occupied the opposite coast of Arabia. In the fifteenth century Suakin was a place of great importance and wealth, the emporium of the Red Sea, and one of the richest cities in the east. It derived its importance from its being in the middle ages the maritime capital of the Turks in the Red Sea, when that empire maintained here a powerful navy. Suakin has declined along with the Turkish power; and its only support is now derived from its being the channel of communication between Arabia and the interior of Africa. Pilgrims and slave-dealers, or persons who combine these two vocations, quit the Nile at Shendi, and proceed through Taka and other districts of Nubia to this port, where they embark for Jidda. They carry with them slaves, with a little ivory and gold, and take Indian goods in return. The surrounding country is arid and barren, and produces no grain except that coarse species called dhourra or juwarry. There is abundance of good water, which is preserved in wells and tanks. Fish are cheap and plentiful, and the mullets are particularly fine. Sheep are cheap, and do not cost above a dollar each. But fowls are scarce and dear. The country around, and the coast to a considerable extent, is occupied by a hardy race of Bedouin Arabs, called Suakini. Suakin is supposed to be the Soter Limen of Diodorus, the Theon Soter of Ptolemy; though it is not easy to conceive how these terms, signifying "the safe harbour," could apply to one of such difficult entrance. Long. 37. 33. E. Lat. 19. 48. N.

SUAN, a small town of Hindustan, in the province of Bahar, district of Rotas. It is twenty-five miles south-east from Patna. Long. 86. 25. E. Lat. 25. 16. N.

SUAREZ, Francis, a renowned Jesuit, was born at Grenada on the 5th of January 1548. He belonged to a noble family, and was sent to prosecute the study of law in the university of Salamanca; but when he had finished his course, he was induced to change his destination, and assume the habit of St Ignatius. He at first experienced much difficulty in comprehending the principles of the philosophy which was then taught; but having been placed under the guidance of Rodriguez, he soon began to be distinguished by the uncommon rapidity of his progress, and became one of the most distinguished members of the society. Having taught philosophy at Segovia, he was afterwards employed in teaching theology at Valladolid, Rome, Alcala, and Salamanca. Wherever he taught, his lectures attracted a numerous auditory. He was at length appointed to the first chair of divinity in the university of Coimbra; but before entering upon his office, he went to Evora, and took his doctor's degree. Here his reputation continued to increase. At the instigation of the pope, he prepared an elaborate work, entitled "Defensio Catholicæ Fidei contra Anglicanæ Sectæ Errores." Conimbricæ, 1613, fol. This work gave much offence to King James, and was burnt at St Paul's by the hands of the hangman. Nor did it receive better treatment from the parliament of Paris; who, by an *arrêt* pronounced on the 26th of June 1614, condemned it to the flames, as containing maxims contrary to the rights of sovereigns. It was ably refuted by Robert Abbot, afterwards bishop of Salisbury. Suarez, having been called to Lisbon for some weighty conference, died there on the 25th of September 1617. An instant before he expired, he said to those who surrounded his bed, "I never knew it was so pleasant to die."

Suarez was a great master of the scholastic philosophy and theology of his age, nor was he a mean or ordinary proficient in jurisprudence. Grotius has described him as the most acute of philosophers and divines. His treatise "De Legibus et Deo Legislatore," is commended by Sir James Mackintosh, "as exhibiting the most accessible and perspicuous abridgment of the theological philosophy in its latest form." According to the same competent authority, "he first saw that international law was composed, not only of the simple principles of justice applied to the intercourse between states, but of those usages, long observed in that intercourse by the European race, which have since been more exactly distinguished as the consuetudinary law acknowledged by the Christian nations of Europe and America." Of this learned Jesuit, the works are very numerous. An edition of them in twenty-three vols. fol. began to be published at Maintz and Lyon in the year 1630. An edition was published at Venice in the year 1740. (x.)

SUBAH, the general name of the viceroyships, or greater governments, into which the Mogul empire was divided, consisting of several provinces: the jurisdiction of a subahdar, the same as subahship, subaedaree, or nizamut.

SUBAHDAR, the viceroy, lord-lieutenant, or governor, holding a subah; the same as nabob or nazim. Also the black commander of a company of sepoys.

SUBALTERN, a subordinate officer, or one who discharges his post under the command and subject to the direction of another; such are lieutenants, sub-lieutenants, cornets, and ensigns, who serve under the captain.

SUBARKAN, a village of Diarbekir, in Asiatic Turkey, on the Euphrates, seventy-five miles east-south-east of Kerkesieh.

SUBBULGUR, a town of Hindustan, in the province of Agra. It is surrounded by a high stone wall in good repair, with a number of bastions; but has few cannon mounted. On one side of the fort is a deep precipice. The country in the vicinity is well cultivated. It is sixty-five miles south-west from the city of Agra. Long. 75. 25. E. Lat. 26. 22. N. There is another town of the same name in the province of Delhi, situated on the east side of the Ganges. The town is surrounded by a very extensive line of fortification, though it exhibits, as well as the walls, little more than falling ruins. The town is improving since it came under British authority. It is twelve miles south from Hurdwar. Long. 78. 10. E. Lat. 29. 48. N.

SUBDEACON, an inferior minister, who anciently attended at the altar, prepared the sacred vessels, delivered them to the deacons in time of divine service, attended the doors of the church during communion-service, and went on the bishop's embassies with his letters or messages to foreign churches. They were so subordinate to the superior rulers of the church, that, by a canon of the council of Laodicea, they were forbidden to sit in the presence of a deacon without his leave. According to the canon law, a person must be twenty-two years of age to be promoted to the order of sub-deacon.

SUBDOMINANT, in *Music*. See Music.

SUBDUPLE Ratio is when any number or quantity is contained in another twice. Thus 3 is said to be subduple of 6, as 6 is duple of 3.

SUBDUPLICATE Ratio of any two quantities, is the ratio of their square roots.

SUBJECT, in *Music.* See MUSIC.

SUBITO, in the Italian music, is used to signify that a thing is to be performed quickly and hastily; thus we meet with *volti subito*, turn over the leaf quickly.

SUBLIMATE, a chemical preparation, consisting of quicksilver united with muriatic acid.

SUBLIMATION, in *Chemistry*, the condensing and collecting, in a solid form, by means of vessels aptly constructed, the fumes of bodies raised from them by the application of a proper heat.

SUBMULTIPLE, in *Geometry*, &c. A submultiple number or quantity is that which is contained a certain number of times in another, and which, therefore, repeated a certain number of times, becomes exactly equal thereto. Thus 3 is a submultiple of 21. In this sense a submultiple coincides with an aliquot part.

SUBMULTIPLE RATIO, is that between the quantity contained and the quantity containing. Thus the ratio of 3 to 21 is submultiple. In both cases submultiple is the reverse of multiple: 21, *e. gr.* being a multiple of 3, and the ratio of 21 to 3 a multiple ratio.

SUBPŒNA, in *Law*, a writ by which persons are called into chancery, in cases where the common law has provided an ordinary remedy; and the name of it proceeds from the words therein, which charge the party called to appear at the day and place affirmed, "sub pœna centum librarum," &c.

SUBREPTITIOUS, or SURREPTITIOUS, a term applied to a letter, license, patent, or other act, fraudulently obtained of a superior, by concealing some truth which, had it been known, would have prevented the concession or grant.

SUBROGATION, or SURROGATION, in the civil law, the act of substituting a person in the place, and entitling him to the rights, of another. In its general sense, subrogation implies a succession of any kind, whether of a person to a person, or of a person to a thing.

SUBROY, a small town of Hindustan, province of Cutch, on the Gulf of Cutch, from which place it is distant twenty-three miles to the north. This town stands on a rising ground on the road from Luckput Bunder to Mundavie, and is defended by a castle. It is populous and flourishing, and the surrounding country is tolerably well cultivated.

SUBSTRACTION, or SUBTRACTION, in *Arithmetic*, the second rule, or rather operation, in arithmetic, whereby we deduct a less number from a greater, to learn their precise difference.

SUBTANGENT OF A CURVE, the line that determines the intersection of a tangent with the axis, or that determines the point wherein the tangent cuts the axis prolonged.

SUBTENSE, formed from *sub*, under, and *tendo*, I stretch, in *Geometry*, a right line which is opposite to an angle, and drawn between the two extremities of the arc which measures that angle.

SUBUNREEKA, a river of Hindustan, which has its source in the province of Bahar, district of Chuta Nagpoor, whence it flows in a south-easterly direction, and after a winding course of 250 miles falls into the Bay of Bengal. It is fordable except in the rainy season. It was the first river of Bengal into which Europeans were allowed to enter. The channel is now choked up with sand.

SUCCADANA, a town on the west coast of the island of Borneo. It is situated on the principal or southern outlet of a large river, which is navigable 150 miles for prows. It is celebrated for very large diamonds, and also for the best camphire; and is a considerable mart for opium, the sale of which is monopolized by the rajah and his family. It is the custom here, as at all the eastern ports, to give a present at the first audience, in proportion to the rank of the person visited; to the king about fifty dollars, to the rajah thirty, and the shahbunder and agent about twenty each. Gold dust, tin, and pepper, are also to be procured here. Lat. 1. 30. S.

SUCCULA, in *Mechanics*, an axis or cylinder with staves in it to move it round, but without any tympanum or peritrochium.

SUCKLING, SIR JOHN, an English poet and dramatist, was the son of Sir John Suckling, comptroller of the household to King Charles I. and was born in the year 1608–9. He is supposed to have been born at Twickenham, as it appears from the parish-register that he was baptized there on the 10th of February. He discovered an uncommon aptitude for the acquiring of languages, insomuch that he is reported to have spoken Latin at five years of age, and to have written it at nine. When he grew up, he travelled; but seems to have affected nothing more than the character of a courtier and fine gentleman; which he so far attained that he was allowed to have the peculiar happiness of making every thing he did become him. In his travels he made a campaign under the great Gustavus Adolphus; and his loyalty, if not his valour, appeared in the beginning of our civil wars; for, after his return to England, he raised a troop of horse for the king's service, entirely at his own charge, and mounted them so completely and richly that they are said to have cost him L.12,000. This troop, with Sir John at its head, behaved so ill in the engagement with the Scots, upon the English borders, in 1639, as to occasion a famous lampoon, composed by Sir John Mennis, which was set to a brisk tune, and much sung by the parliamentarians. This disastrous expedition, and the ridicule that attended it, were supposed to have hastened his death; but he survived till the 7th of May 1741. He was a sprightly wit and an easy versifier, but no great poet. His poems, plays, speeches, tracts, and letters, were collected into an octavo volume in the year 1709.

SUCKUT, a small town and district of Hindustan, province of Lahore, intersected by the Beyah river, belonging to the Sikhs. Long. 75. 45. E. Lat. 32. 41. N.

SUCTASGUR, a town and fortress of Hindustan, province of Allahabad. The fortifications were formerly more considerable, and defended the passes of the western hills. They are now neglected. It is the capital of a small district, which was included in the collectorship of Benares. It is fourteen miles south of the fortress of Chunar.

SUDASHYGUR, a fortress of Hindustan, on the western shore of the province of Canara. It is situated on a high point of land, and being remarkably white, is a conspicuous point from the sea. It commands the entrance of the Aliga river.

SUDATORY, a name given by the ancient Romans to their hot or sweating-rooms; sometimes also called *Laconica.*

SUDBURY, a town in the hundred of Babergh and county of Suffolk, fifty-six miles from London. It stands on the river Stour, which divides it from Essex, and is navigable to the sea by Manningtree. The town comprises three parishes, with each a church, and is tolerably well built. It was one of the earliest seats of the woollen manufacture, some share of which it still retains; and it has likewise some silk trade. It is a borough, governed by a mayor, six aldermen, and twenty-three common-council men, and returns two members to the House of Commons. It has a good market on Saturdays. The inhabitants in 1801 amounted to 3283, in 1811 to 3471, in 1821 to 3950, and in 1831 to 4677.

SUECA, a city of Spain, in the province of Valencia, and government of Alcira. It stands on the banks of the river Xucar, in a marshy soil, which, though not very favourable to health, is well adapted for the growth of rice, which is here cultivated to a great extent. In the town there is a church, with a monastery and a chapel; and it contains 700 dwellings, with 4800 inhabitants.

SUEN-HOA, a city of China, of the first rank, in the province of Pe-che-lee, situated among the mountains near the great wall. It is a populous place, well built, and distinguished by the beauty of its streets. The district includes a considerable number of forts destined to defend the great northern barrier of the empire. It is seventeen miles north-west of Pekin.

SUETONIUS TRANQUILLUS, Caius, a Latin historian, was the son of Suetonius Lenis, who became a military tribune in the reign of the emperor Otho. The son is supposed to have been born about the beginning of the reign of Vespasian. Having betaken himself to the practice of the law, he appears to have acquired reputation as a pleader. He lived on terms of intimacy with the younger Pliny, who recommended him to Trajan as a very learned and upright man, and obtained for him the "jus trium liberorum." Although he had a wife, he was without children; and a participation of this privilege was of some importance to him in the exercise of his profession. After the death of this emperor, he was appointed secretary to Hadrian; but he was dismissed from his office in consequence of his having manifested a want of due respect for the empress Sabina. After his retirement from public life, he had more leisure to devote himself to literary pursuits. Of that period of Roman history, his principal work, "Vitæ duodecim Cæsarum," contains the most curious and characteristic record which has been transmitted to our times. The picture which he exhibits is certainly a very foul one, but on that account is more likely to be true. His lives are not digested according to any order strictly chronological, but it is rather his plan to combine curious, interesting, and characteristic particulars, which serve to mark the progress of the different emperors, most of whom were a disgrace to human nature. Other two works of a slighter texture, "De illustribus Grammaticis liber," and "De claris Rhetoribus liber," bear the name of Suetonius. To him are likewise ascribed very brief lives of Terence, Horace, Lucan, Persius, Juvenal, and the elder Pliny.

Suetonius was twice printed at Rome during the same year, 1470, and several other editions appeared at an early period. We pass over these, and hasten to mention the valuable editions of Casaubon, printed at Geneva in quarto in the years 1595 and 1615. His commentary abounds with recondite learning. Another elaborate edition was published by Grævius, Hag. Com. 1672, 4to. It was reprinted at the same place in 1691, and at Utrecht in 1703. This learned editor was soon succeeded by Pitiscus, Traj. ad Ren. 1690, 2 tom. 8vo. Leovard. 1714, 2 tom. 4to. But an edition still more elaborate was produced by the indefatigable Burman, Amst. 1736, 2 tom. 4to. And after no long interval, he was followed by Oudendorp, Lugd. Bat. 1751, 2 tom. 8vo.

SUEVI, a common name of the people situated between the Elbe and the Vistula, distinguished otherwise by particular names.

SUEVUS, in *Ancient Geography*, a river of Germany, thought to be the same with the Viadrus or Oder, emptying itself at three mouths into the Baltic, the middlemost of which is called *Swine* or *Swene*, which last comes near the name *Suevus*.

SUEZ, a seaport situated at the northern extremity of the gulf of the same name. It is so incommodious that small boats can with difficulty land at the quay even at high water The town is in a ruinous state, walled on the west and south-west; but the wall is rapidly falling to decay. The population only consists of about a dozen agents, who receive goods from the ports of the Red Sea, and forward them to their correspondents at Cairo, together with some shopkeepers, who deal chiefly in provisions. Neither merchants nor artisans live in it. The pacha keeps a garrison here of about fifty horsemen, with an officer, who commands the town, the neighbouring Arabs, and the shipping in the harbour. Suez is one of the few harbours in the Red Sea where ships can be repaired. Although the port is now little frequented, the trade in coffee and India goods still passes this way to Cairo.

The isthmus of Suez is a low-lying land, composed of shell limestone rock, mixed with strata of siliceous limestone, and partly covered with sands or with saline marshes. In several places the solid strata are with difficulty perceived by their slight undulations; in the northern part in particular there is a vast plain, varied only by sand-hills. To the east, the south-east, and the south-west, the mountain-chains of Arabia Petræa and of Egypt skirt at a distance the table-land of the isthmus, which is terminated at the Red Sea. The lake Birket-el-Ballah adjoining Lake Menzaleh, Temsah or Crocodile Lake, and the almost dry basin of the Bitter Lakes, form from north to south a series of depressions, interrupted only by stripes of low land. The breadth of the isthmus, in a straight line from the mouth of Tineh on the Mediterranean to the northern point of the Gulf of Suez, is 378,844 feet, or nearly seventy-two miles.

The question whether or not the Isthmus of Suez has always existed, has given rise to much discussion among the learned; some maintaining that this neck of land was formerly covered by the sea, and that Africa was an island; others that it must formerly have been much narrower than it is now; and others that it has undergone little or no change. This latter hypothesis is defended by D'Anville, in opposition to the opinions of Gossellin and Rosière, whose arguments are in favour of the contraction of the gulf.

The surface of the isthmus generally declines from the shores of the Red Sea towards those of the Mediterranean; and the level of the latter is thirty feet lower than that of the Gulf of Suez. There is a similar descent towards the Delta and the bed of the river Nile; the level of the water of the Nile at Cairo, when at its lowest, being about nine feet lower than the surface of the gulf at low water. But the Nile rising sixteen cubits by the Nilometer, is nine feet higher than the Red Sea at high water, and fourteen higher than the same sea at low water. Besides these leading inclinations of the surface, there is a particular one in the middle of the isthmus. The deep basin called the Bitter Lakes is more than fifty-four feet lower than the level of the Red Sea, the waters of which would enter and fill it if they were not prevented by a little sandy isthmus about three feet above the level of the sea.

From this it follows that the Red Sea never could have occupied the basin of the Bitter Lakes in a constant manner, because its waters, if raised sufficiently high to form such a communication, would have found no barrier to the north of that basin: they would have flowed all the way to the Nile by the Ras-el-Ooadi, and to the Mediterranean by the Ras-el-Mayah. The two seas thus brought into contact would have reached a common level, and the strait would have become permanent.

But if a natural communication between the two seas has never existed within the periods of human record, the traces and remains of a canal have been ascertained with satisfactory precision. From Balbeis, on the old Pelusiac branch of the Nile, now the Canal of Menedji, this canal reaches to Ablaseh, the ancient Thou. There it enters the narrow valley of Arabes-Tommylat, the level of which is thirty-three feet lower than that of the Red Sea. It passes on to Abookesheyd, which is supposed to be the old Heroopolis. The basin of the Bitter Lakes might have been filled at pleasure from the waters of the Nile.

Beyond this basin the traces of the canal re-appear in the isthmus which separates the lakes from the Red Sea, and show that the canal was continued the whole way. According to Strabo, this canal was constructed by the Ptolemies; and the Arabian writers assert that it was opened

Su k. again by order of the Caliph Omar, and was used for navigation from the year 644 to 767; at which time another caliph caused it to be shut up, in order to deprive a rebel chief of his supplies of provisions. While the French army was in Egypt, some learned discussions were maintained on the practicability and advantages of its restitution. But however useful its re-establishment might be to the country through which it passes, it is very problematical if it could ever be rendered a medium of commercial communication on a large scale.

SUFFOLK, an English maritime county, on the borders of the German Ocean. It is bounded on the east by the sea; on the south by Essex, from which it is divided by the river Stour; on the west by Cambridgeshire; and on the north by Norfolk. Its medium length from east to west is forty-seven miles, and its breadth from north to south twenty-seven. The square contents are 1512 miles, or 967,680 statute acres. It consists of two grand divisions, one called the Liberty of Bury, the other the Guildable Land, each of which furnishes a distinct grand jury at the assizes. The next division is into twenty-one hundreds, and these are subdivided into five hundred and twenty-three parishes. The entire country forms a part of the diocese of Norwich.

Pop tion. The population of this county at the four decennial periods of enumeration was found to amount in 1801 to 210,431, in 1811 to 234,211, in 1821 to 270,542, and in 1831 to 296,000.

At the last period the occupiers of land employing labourers were 4,526

Occupiers not employing labourers	1,121
Labourers employed in agriculture	33,040
Labourers employed in manufactures	676
Labourers employed in retail trade or handicraft	18,167
Capitalists, bankers, &c	2,228
Labourers not agricultural	5,336
Other labourers under twenty years of age	4,940
Males at and above twenty years	71,376
Male servants	2,032
Female servants	11,483

In the same year the number of families chiefly employed in agriculture was found to be 31,491; those chiefly employed in trade, manufactures, and handicraft, were 18,116; and those comprised in neither of the preceding classes were 11,926. The number of inhabited houses was 50,139, occupied by 61,533 families; the uninhabited houses were 1141, and those building 259.

The annual value of the real property of the county, as assessed for the purposes of the property-tax in the year 1813, was L.1,127,404.

Tow The towns of this county containing more than 2000 inhabitants, with their population in 1831, were the following:

Ipswich	20,454
Bury St Edmund's	11,436
Woodbridge	4,769
Sudbury	4,677
Lowestoffe	4,238
Beccles	3,862
Bungay	3,734
Hadleigh	3,425
Mildenhall	3,267
Long Melford	2,514
Halesworth	2,473
Framlingham	2,445
Eye	2,313
Newmarket, but a part of this town, with 714, is in Cambridgeshire	2,134
Gorlestone, a suburb to Yarmouth in Norfolk, and by the reform bill a part of that borough	2,111
Lavenham	2,107
Brandon	2,065

Suffolk is generally a level tract of country, in which, as there are few elevations, there are scarcely any extensive prospects. It is, however, tolerably well clothed with trees, but wants running water; most of the streams being very sluggish in their course, and by no means copious. The soil is as various as in other districts of the same extent. On the sea-coast it is in general sandy, but rendered productive by the application of shell-marl, which is found in abundance. In the middle of the county, from north to south, called usually High Suffolk, which is the larger part, the soil is a tenacious, loamy clay, affording good pasturage for cows, whose butter is chiefly used to supply the London markets.

Suffolk.

Soil, agriculture, and productions.

The north-western division is a poor sandy soil, in many places covered with heath, and scarcely fit for any other purpose than that of feeding sheep or breeding rabbits, of which latter animals, it is said, the skins of more than 40,000 annually supply fur to the hatters. The corn furnished by the eastern division of the county, besides supplying its vicinity, is sent to London from the ports of Ipswich and Woodbridge. The cultivation is commonly conducted on the Norfolk system of turnips, barley, clover, and wheat; and the husbandry being well executed, the crops are generally very good. The beans are peculiarly productive. Turnips, and in some districts carrots, are extensively cultivated. Hemp is grown in the garden of almost every peasant, and spun into linen for their domestic uses. Some few hops are grown in the vicinity of Stowmarket.

Cattle. They have an excellent breed of draught-horses, well known by the name of Suffolk punches. The cows have been long celebrated for the abundance of their milk, which, in proportion to their size and the quantity of food they consume, exceeds the produce of any other race in the kingdom. They are all without horns. The sheep, of which large flocks are kept, are mostly of the Norfolk breed; but of late years they have been changed for those of the South Downs.

Manufactures. There are few manufactures in this county, though it was the first in which the Flemings introduced the clothing trade. Before the extension of machinery in the northern counties, the females found constant winter employment in spinning worsted, but that has ceased. A small portion of the manufacture of mixed silk and worsted stuffs is retained, in which 269 males above twenty years of age are employed at Sudbury, forty-two are so employed at Glemsford, and a few at Lavenham and at Hadleigh. At Brandon no less that sixty men are employed in making gun-flints. There is some coarse linen made from hemp at Haverhill, and a little bone-lace at Eye.

Fisheries and commerce. The branch of industry which, next to agriculture, gives employment to the greatest number of inhabitants, is the fishery. Many vessels are equipped at Lowestoffe and Southwold to take herrings, which are cured in houses appropriated for that purpose in these towns. The taking of mackerel is beneficial before the season when the shoals of herrings arrive on the coast. There is little other commerce in the county than that which arises from the transmission of the agricultural products to the metropolis.

Rivers and canals. The navigable rivers are the Sark, which passes by Thetford, and runs to the Ouse; the Deben, of short course, which runs by Woodbridge to the sea; the Orwell, a beautiful river, navigable to Ipswich; and the Blythe, navigable to Framlingham. To these may be added the Waveney, which forms the northern boundary of the county; and the Stour, which is its southern. The only navigable canal is one between Ipswich and Stowmarket; but the river Yare having been rendered navigable to Norwich, has a canal at its mouth at Lowestoffe in this county: the admission is by gates, which exhibit one of the most complete specimens of hydraulic architecture in the kingdom.

Landed property.

The landed property of the county is much divided. There are scarcely any estates so large as to create a decided political preponderance, and there is a larger number of proprietors occupying their own lands, of a value of from L.100 to L.400 per annum, than in any other county. Except in the heavy clay districts, the farms are generally large; and the tenants being possessed of ample capitals, the agricultural business is admirably conducted. There are neither mines nor mineral springs in this county. In the summer season sea-bathing attracts a considerable portion of company to the shore at Lowestoffe, Southwold, and some other spots, where every accommodation for such parties is provided.

Antiquities.

Among the antiquities stand first the remains of the ancient Roman castle at Burgh, on the banks of the Yare. It is said to have been the ancient Garianonum, erected by Publius Ostorius Scapula, in the reign of the emperor Claudius. The walls, which are still standing, enclose a space 642 feet in length and 320 in breadth; they are fourteen feet in height and nine in thickness. The whole ground plan, including the wall, is more than five acres, and is capable of containing a cohort and a half; having been built to keep in subjection the Sceni, a people inhabiting Suffolk, Norfolk, Huntingdonshire, and Cambridgeshire. The most remarkable of the Saxon antiquities are the monastery at Bury St Edmund's, that of Framlingham, and several ancient churches.

Titles and representation.

The following peers derive their titles from places in this county: Marquis Cornwallis; Earls of Suffolk, Orford, Euston, and Stradbrooke; and Barons Rendlesham and Worlingham. The county has been formed into two divisions, the eastern and western, for the purpose of electing members to parliament, each division returning two. The elections for the eastern part are held at Ipswich; and the other polling places are Needham, Woodbridge, Framlingham, Saxmundham, Beccles, and Halesworth. The elections for the western part are held at Bury St Edmund's; and the other polling places are Wickham Brook, Lavenham, Stowmarket, Botesdale, Mildenhall, and Hadleigh. By the reform act the boroughs of Dunwich, Alborough, and Orford, which had each returned two members, have been disfranchised; and Eye, which likewise returned two, now returns only one. Ipswich, Bury St Edmund's, and Sudbury return two members as before.

The most remarkable seats among a very great number belonging to noblemen and gentlemen in this county are, Euston Hall, Duke of Grafton; Broom Hall, Sir E. Kerrison; Ickworth, Marquis of Bristol; Henham, Lord Stradbrooke; Worlingham Hall, Lord Gosford; Boston Hall, Sir H. E. Banbury; Rendlesham, Lord Rendlesham; Benacre, Sir Thomas Gooch; Haveningham Hall, Lord Huntingfield; Sotterly Park, Miles Barm, Esq.; Flinton Hall, Alexander Adair, Esq.; Redgrove Hall, Admiral Wilson; Woolverston Park, Charles Berners, Esq.; Long Melford, Sir Hyde Parker; Shrubland Park, Sir William Middleton; and Tendring Hall, Sir Joseph Rowley.[1]

SUFFRAGAN, an appellation given to simple bishops with regard to archbishops, on whom they depend, and to whom appeals lie from the bishops' courts. The same name is likewise given to a bishop who is occasionally appointed to assist the diocesan.

SUFFRAGE denotes a vote given in an assembly where something is deliberated on, or where a person is elected to an office or benefice.

SUGAR, a solid sweet substance, obtained from the juice of the sugar-cane; or, according to chemists, an essential salt, capable of crystallization, of a sweet and agreeable flavour, and contained in a greater or less quantity in almost every species of vegetables, but most abundant in the sugar-cane.

As the sugar-cane is the principal production of the West Indies, and the great source of their riches; as it is so important in a commercial view, from the employment which it gives to seamen, and the wealth which it opens for merchants, and besides is now become a necessary of life; it may justly be esteemed one of the most valuable plants in the world. From the few remains of the Grecian and Roman authors which have survived the ravages of time, we can find no proofs that the juice of the sugar-cane was known at a very early period. There can however be no doubt, that in those countries where it was indigenous, its value was not long concealed. It is not improbable that it was known to the ancient Jews; for there is some reason to suppose, that the Hebrew word קנה, which frequently occurs in the Old Testament, and by our translators is rendered sometimes *calamus*, and sometimes *sweet cane*, does in fact mean the sugar-cane. The first passage in which we have observed it mentioned is Exodus, xxx. 23, where Moses is commanded to make an ointment with myrrh, cinnamon, kené, and cassia. Now the kené does not appear to have been a native of Egypt, nor of Judea; for in Jeremiah, vi. 20, it is mentioned as coming from a far country. "To what purpose cometh there to me incense from Sheba, and the sweet cane from a far country?" This is not true of the calamus aromaticus, which grows spontaneously in the Levant, as well as in many parts of Europe. If the cinnamon mentioned in the passage of Exodus quoted above was true cinnamon, it must have come from the East Indies, the only country in the world from which cinnamon is obtained. There is no difficulty therefore in supposing that the sugar-cane was exported from the same country. If any credit be due to etymology, it confirms the opinion that kené denotes the sugar-cane; for the Latin word *canna*, and the English word *cane*, are evidently derived from it. It is also a curious fact, that שכר, *sachar* or *sheker*, in Hebrew signifies *inebriation*, from which the Greek word *σάκχαρ* or *σακχάριον*, *sugar*, is undoubtedly to be traced.

The sugar-cane was first made known to the western parts of the world by the conquests of Alexander the Great. Strabo (lib. xv.) relates that Nearchus, his admiral, found it in the East Indies in the year 325 before Christ. It is evidently alluded to in a fragment of Theophrastus, preserved in Photius. Varro, who lived A. C. 68, describes it in a fragment quoted by Isidorus,[2] as a fluid pressed from reeds of a large size, which was sweeter than honey.[3] Dioscorides, about the year 35 before Christ, says "that there is a kind of honey called *saccharon*, which is found in India and Arabia Felix. It has the appearance of salt, and is brittle when chewed. If dissolved in water, it is beneficial to the bowels, and stomachic; is useful in diseases of the bladder and kidneys; and when sprinkled on the eye, removes those substances that obscure the sight." This is the first account we have of its medicinal qualities. Galen often prescribed it as a medicine. Lucan (lib. iii. v. 237) relates, that an oriental nation in alliance with Pompey used the juice of the cane as a common drink.

Quique bibunt tenera dulces ab arundine succos.

Pliny says it was produced in Arabia and India, but that the best came from the latter country. It is also mentioned by Arrian, in his Periplus of the Red Sea, by the name of *σάκχαρι* (*sacchari*), as an article of commerce from India to the Red Sea. Ælian,[4] Tertullian,[5] and Alexander Aphrodisæus,[1] mention it as a species of honey procured from canes.[2]

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[1] Kirby's Suffolk Traveller. Arthur Young's General View of the Agriculture of Suffolk. Views in Suffolk, by W. C. Brayley.

[2] Lib. xvii. cap. 3.

[3] Matthioli Dios. cap. lxxv.

[4] Nat. Hist.

[5] De Judicio Dei.

ative East

That the sugar-cane is an indigenous plant in some parts of the East Indies, we have the strongest reason to believe; for Thunberg found it in Japan, and has accordingly mentioned it as a native of that country in his *Flora Japonica*, published in 1784. Osbeck also found it in China in 1751. It may indeed have been transplanted from some other country; but as it does not appear from history that the inhabitants of Japan or China ever carried on any commerce with remote nations, it could only be conveyed from some neighbouring country. Marco Polo, a noble Venetian, who travelled into the east about the year 1250, found sugar in abundance in Bengal. Vasco de Gama, who doubled the Cape of Good Hope in 1497, relates that a considerable trade in sugar was then carried on in the kingdom of Calicut. On the authority of Dioscorides and Pliny, we should be disposed to admit that it is a native of Arabia, did we not find, on consulting Niebuhr's Travels, that this botanist has omitted it when enumerating the most valuable plants of that country. If it be a spontaneous production of Arabia, it must still flourish in its native soil. Mr Bruce found it in Upper Egypt. If we may believe the relation of Giovan Lioni, a considerable trade was carried on in sugar in Nubia in 1500. It abounded also at Thebes, on the Nile, and in the northern parts of Africa, about the same period.

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There is reason to believe that the sugar-cane was introduced into Europe during the crusades; expeditions which, however romantic in their plan, and unsuccessful in their execution, were certainly productive of many advantages to the nations of Europe. Albertus Aquensis, a monkish writer, observes that the Christian soldiers in the Holy Land frequently derived refreshment and support during a scarcity of provisions, by sucking the canes. This plant also flourished in the Morea, and in the islands of Rhodes and Malta, from which it was transported into Sicily. The date of this transaction it is not easy to ascertain; but we are sure that sugar was cultivated in that island previously to the year 1166; for Lafitau the Jesuit, who wrote a history of the Portuguese discoveries, mentions a donation made that year to the monastery of St Bennet, by William II., king of Sicily, of a mill for grinding sugar-canes, with all its rights, members, and appurtenances. From Sicily, where the sugar-cane still flourishes, on the sides of Mount Hybla, it was conveyed to Spain, Madeira, the Canary and Cape de Verd Islands, soon after they were discovered in the 15th century.[3]

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An opinion has prevailed that the sugar-cane is not a native of the western continent, or its adjacent islands the West Indies, but was conveyed thither by the Spaniards or Portuguese soon after the discovery of America by Columbus. From the testimony of Peter Martyr, in the third book of his first decade, composed during Columbus's second voyage, which commenced in 1493 and ended in 1495, it appears that the sugar-cane was known at that time in Hispaniola. It may be said that it was brought thither by Columbus, but for this assertion we have found no direct evidence; and though we had direct evidence, this would not prove that the sugar-cane was not an indigenous plant of the West Indies. There are authors of learning who, after investigating this subject with attention, do not hesitate to maintain that it is a native both of the islands and of the continent of America.

This opinion opposed by Labat,

Labat has supported this opinion with much appearance of truth;[4] and, in particular, he appeals to the testimony of Thomas Gage, an Englishman, who visited New Spain in 1625. Gage enumerates sugar-canes among the provisions with which the Charaibes of Guadaloupe supplied his ship. "Now," says Labat, "it is a fact that the Spaniards had never cultivated an inch of ground in the smaller Antilles. Their ships commonly touched at those islands, indeed, for wood and water; and they left swine in the view of supplying with fresh provisions such of their countrymen as might call there in future; but it would be absurd in the highest degree to suppose that they would plant sugar-canes, and at the same time put hogs ashore to destroy them. Neither had the Spaniards any motive for bestowing this plant on islands which they considered as of no kind of importance, except for the purpose that has been mentioned; and to suppose that the Charaibes might have cultivated, after their departure, a production of which they knew nothing, betrays a total ignorance of the Indian disposition and character.

from testimony.

"But," continues Labat, "we have surer testimony, and such as proves, beyond all contradiction, that the sugar-cane is the natural production of America. For, besides the evidence of Francis Ximenes, who, in a treatise on American Plants, printed at Mexico, asserts that the sugar-cane grows without cultivation, and to an extraordinary size, on the banks of the river Plata, we are assured by Jean de Lery, a Protestant minister, who was chaplain in 1556 to the Dutch garrison in the fort of Coligny, on the river Janeiro, that he himself found sugar-canes in great abundance in many places on the banks of that river, and in situations never visited by the Portuguese. Father Henepen and other voyagers bear testimony in like manner to the growth of the cane near the mouth of the Mississippi; and Jean de Laet to its spontaneous production in the island of St Vincent. It is not for the plant itself, thereore, but for the secret of making sugar from it, that the West Indies are indebted to the Spaniards and Portuguese; and these to the nations of the east." Such is the reasoning of Labat, which the learned Lafitau has pronounced incontrovertible; and it is greatly strengthened by recent discoveries, the sugar-cane having been found in many of the islands of the Pacific Ocean by our late illustrious navigator Captain Cook.

Description of the sugar-cane.

The sugar-cane, or saccharum officinarum of botanists, is a jointed reed, commonly measuring (the flag part not included) from three feet and a half to seven feet in height, but sometimes rising to twelve feet. When ripe it is of a fine straw colour inclining to yellow, producing leaves or blades, the edges of which are finely and sharply serrated, and terminating in an arrow decorated with a panicle. The joints in one stalk are from forty to sixty in number, and the stalks rising from one root are sometimes very numerous. The young shoot ascends from the earth like the point of an arrow; the shaft of which soon breaks, and the two first leaves, which had been enclosed within a quadruple sheath of seminal leaves, rise to a considerable height.[5]

Soil most favourable to its growth.

As the cane is a rank succulent plant, it must require a strong deep soil to bring it to perfection, perhaps indeed no soil can be too rich for this purpose. The soil which experience has found to be most favourable to the cultivation of it in the West Indies, is the dark-gray loam of St Christopher's, which is so light and porous as to be penetrable by the slightest application of the hoe. The under stratum is gravel from eight to twelve inches deep. Canes planted in particular spots in this island have been known to yield 8000 pounds of Muscovado sugar from a single acre. The average produce of the island for a series of years was 16,000 hogsheads of sixteen hundredweight, which is one half only of the whole cane-land, or 8500 acres. When annually cut, it gives nearly two hogsheads of sixteen hundredweight per acre for the whole of the land in ripe canes.

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[1] Lib. ii. prob. 79.

[2] For a more minute account of the history of sugar in the early and middle ages, the reader may consult a paper by Falconer, in the Manchester Transactions, vol. iv.

[3] D'Orville's Travels.

[4] Tom. iii. c. xv.

[5] "A field of canes, when standing, in the month of November, when it is in arrow or full blossom (says Mr Beckford in his Descriptive Account of the Island of Jamaica), is one of the most beautiful productions that the pen or pencil can possibly describe. It in common rises from three to eight feet or more in height; a difference of growth that very strongly marks the difference of soil or the varieties of culture. It is when ripe of a bright and golden yellow; and where obvious to the sun, is in many parts very beautifully streaked with red: the top is of a darkish green; but the more dry it becomes, from either an excess of ripeness or a continuance of drought, of a russet yellow, with long and narrow leaves depending; from the centre of which shoots up an arrow like a silver wand from two to six feet in height, and from the summit of which grows out a plume of white feathers, which are delicately fringed with lilac dye, and indeed is in its appearance not much unlike the tuft that adorns this particular and elegant tree."

Next to the ashy loam of St Christopher's is the soil which in Jamaica is called *brick-mould;* not as resembling a brick in colour, but as containing such a due mixture of clay and sand as is supposed to render it well adapted for the use of the kiln. It is a deep, warm, and mellow, hazel earth, easily worked; and though its surface soon grows dry after rain, the under stratum retains a considerable degree of moisture in the driest weather; with this advantage, too, that even in the wettest season it seldom requires trenching. Plant-canes, by which are meant canes of the first growth, have been known in very fine seasons to yield two tons and a half of sugar per acre. After this may be reckoned the black mould of several varieties. The best is the deep black earth of Barbadoes, Antigua, and some other of the windward islands; but there is a species of this mould in Jamaica that is but little, if any thing, inferior to it, which abounds with limestone and flint on a substratum of soapy marle.[1] Black mould on clay is more common; but as the mould is generally shallow, and the clay stiff and retentive of water, this last sort of land requires great labour, both in ploughing and trenching, to render it profitable. When manured and properly pulverized, it becomes very productive. It is unnecessary to attempt a minute description of all the other soils which are found in these islands. There is, however, a peculiar sort of land on the north side of Jamaica, chiefly in the parish of Trelawney, that cannot be passed over unnoticed, not only on account of its scarcity, but its value; few soils producing finer sugars, or such *as answer so well in the pan;* an expression signifying a greater return of refined sugar than common. The land alluded to is generally of a red colour; the shades of which, however, vary considerably from a deep chocolate to a rich scarlet; in some places it approaches to a bright yellow, but it is everywhere remarkable, when first turned up, for a glossy or shining surface, and if wetted stains the fingers like paint.

Proper season for planting it.

As in every climate there is a season more favourable for vegetation than others, it is of great importance that plants for seed be committed to the ground at the commencement of this season. As the cane requires a great deal of moisture to bring it to maturity, the properest season for planting it is in the months of September and October, when the autumnal rains commence, that it may be sufficiently luxuriant to shade the ground before the dry weather sets in. Thus the root is kept moist, and the crop is ripe for the mill in the beginning of the ensuing year. Canes planted in the month of November, or later in the season, lose the advantage of the autumnal rains; and it often happens that dry weather in the beginning of the ensuing year retards their vegetation until the vernal or May rains set in, when they sprout both at the roots and the joints; so that by the time they are cut the field is loaded with unripe suckers instead of sugar-canes. A January plant, however, commonly turns out well; but canes planted very late in the spring, though they have the benefit of the May rains, seldom answer expectation; for they generally come in unseasonably, and throw the ensuing crops out of regular rotation. They are therefore frequently cut before they are ripe; or, if the autumnal season sets in early, are cut in wet weather, which has probably occasioned them to spring afresh. In either case the effect is the same: the juice is unconcocted, and all the sap being in motion, the root is deprived of its natural nourishment, to the great injury of the ratoon. The chief objection to a fall plant is this, that the canes become rank and top-heavy at a period when violent rains and high winds are expected, and are therefore frequently lodged before they are fit to be cut.

The sugar-cane is propagated by the top-shoots, which are cut from the tops of the old canes. The usual method of planting in the West Indies is this. The quantity of land intended to be planted, being cleared of weeds and other encumbrances, is first divided into several plats of certain dimensions, commonly from fifteen to twenty acres each; the spaces between each plat or division are left wide enough for roads, for the conveniency of carting, and are called *intervals.* Each plat is then subdivided, by means of a line and wooden pegs, into small squares of about three feet and a half. Sometimes, indeed, the squares are a foot larger, but this circumstance makes but little difference. The negroes are then placed in a row in the first line, one to a square, and directed to dig out with their hoes the several squares, commonly to the depth of five or six inches. The mould which is dug up being formed into a bank at the lower side, the excavation or cane-hole seldom exceeds fifteen inches in width at the bottom, and two feet and a half at the top. The negroes then fall back to the next line, and proceed as before. Thus the several squares between each line are formed into a trench of much the same dimensions with that which is made by the plough. An able negro will dig from 100 to 120 of these holes for his day's work of ten hours; but if the land has been previously ploughed and lain fallow, the same negro will dig nearly double the number in the same time.

The cane-holes or trench being now completed, whether by the plough or by the hoe, and the cuttings selected for planting, which are commonly the tops of the canes that have been ground for sugar (each cutting containing five or six gems), two of them are sufficient for a cane-hole of the dimensions described. These, being placed longitudinally in the bottom of the hole, are covered with mould about two inches deep, the rest of the bank being intended for future use. In twelve or fourteen days the young sprouts begin to appear, and as soon as they rise a few inches above the ground, they are, or ought to be, carefully cleared of weeds, and furnished with an addition of mould from the banks. This is usually performed by the hand. At the end of four or five months the banks are wholly levelled, and the spaces between the rows carefully hoe-ploughed. Frequent cleanings, while the canes are young, are indeed so essentially necessary, that no other merit in an overseer can compensate for the want of attention in this particular. A carefal manager will remove at the same time all the lateral shoots or suckers that spring up after the canes begin to joint, as they seldom come to maturity, and draw nourishment from the original plants.

"In the cultivation of other lands, in Jamaica especially," says Mr Edwards, the elegant historian of the West Indies, whose superior excellence has induced us frequently to refer to him in the course of this article, "the plough has been introduced of late years, and in some few cases to great advantage; but it is not every soil or situation that will admit the use of the plough, some lands being much too stony, and others too steep; and I am sorry I have occasion to remark, that a practice commonly prevails in Jamaica, on properties where this auxiliary is used, which would exhaust the finest lands in the world. It is that of ploughing, then cross-ploughing, round-ridging, and harrowing the same lands from year to year, or at least every other year, without affording manure. Accordingly it is found that this method is utterly destructive of the ratoon or second growth, and altogether ruinous. It is indeed astonishing that any planter of common reading or observation should be passive under so pernicious a system. Some gentlemen, however, of late manage better; their practice is to break up stiff and clayey land, by one or two ploughings, early in the spring, and give it a summer's fallow. In the autumn following, being then mellow and more easily worked, it is holed and planted by manual labour after the old method, which has been already described. But, in truth, the only advantageous system of ploughing in the West Indies is to confine it to the simple operation of holing, which may certainly be performed with much greater facility and despatch by the plough than by the hoe; and the relief which, in the case of stiff and dry soils, is thus given to the negroes, exceeds all estimation, in the mind of a humane and provident owner. On this subject I speak from practical knowledge. At a plantation of my own, the greatest part of the land which is annually planted is neatly and sufficiently laid into cane-holes, by the labour of one able man, three boys, and eight oxen, with the common single-wheeled plough. The ploughshare indeed is somewhat wider than usual; but this is the only difference, and the method of ploughing is the simplest possible. By returning the plough back along the furrow, the turf is alternately thrown to the right and to the left, forming a trench seven inches deep, about two feet and a half wide at the top, and one foot wide at the bottom. A space of eighteen or twenty inches is left between each trench, on which the mould being thrown by the share, the banks are properly formed, and the holing is complete. Thus the land is not exhausted by being too much exposed to the sun; and in this manner a field of twenty acres is holed with one plough, and with great ease, in thirteen days. The plants are afterwards placed in the trench as in the common method where manual labour alone is employed."[1]

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[1] Edwards's History of the West Indies, vol. ii.

s d ac- ng to ge of roots.

In most parts of the West Indies it is usual to hole and plant a certain proportion of the cane-land, commonly one third, in annual rotation. Canes of the first year's growth are called *plant-canes*, as has been already observed. The sprouts that spring from the roots of the canes that have been previously cut for sugar are called *ratoons;* the first yearly returns from their roots are called *first ratoons*, the second year's growth *second ratoons*.

ures oyed.

Mr Edwards informs us, that the manure generally used is a compost, formed, 1st, of the vegetable ashes drawn from the fires of the boiling and still-houses; 2dly, feculencies discharged from the still-house, mixed up with rubbish of buildings, white-lime, &c.; 3dly, refuse, or field-trash, *i. e.* the decayed leaves and stems of the cane, so called in contradistinction to cane-trash, reserved for fuel; 4thly, dung, obtained from the horse and mule stables, and from moveable pens, or small enclosures made by posts and rails, occasionally shifted upon the lands intended to be planted, and into which the cattle are turned at night; 5thly, good mould, collected from gullies and other waste places, and thrown into the cattle-pens.

sugar- de- ed by keys,

The sugar-cane is liable to be destroyed by monkeys, rats, and insects. The upland plantations suffer greatly from monkeys. These creatures, which now abound in the mountainous parts of St Christopher's, were first brought thither by the French, when they possessed half that island. They come down from the rocks in silent parties by night, and having posted sentinels to give the alarm if any thing approaches, they destroy incredible quantities of the cane, by their gambols as well as their greediness. It is in vain to set traps for these creatures, however baited; and the only way to protect the plantation, and destroy them, is to set a numerous watch, well armed with fowling-pieces, and furnished with dogs. The negroes will perform this service cheerfully, for they are very fond of monkeys as food. Father Labat affirms they are very delicious, but the white inhabitants of St Christopher's never eat them.

rats,

The low-land plantations suffer as much by rats as those on the mountains do from monkeys; but the rats, no more than the monkeys, are natives of the place. They came with the shipping from Europe, and breed in the ground under loose rocks and bushes: the field negroes eat them greedily, and they are said to be publicly sold in the markets at Jamaica. To free the plantations from these vermin, the breed of wild cats should be encouraged, and snakes suffered to multiply unmolested: they may also be poisoned with arsenic, and the rasped root of the cassava made into pellets, and plentifully scattered over the grounds. This practice is however dangerous; for as the rats, when thus poisoned, become exceedingly thirsty, they run in droves to the neighbouring streams, which they poison as they drink, and the cattle grazing on the banks of these polluted waters have frequently perished by drinking after them. It is safer therefore to make the pellets of flour, kneaded with the juice of the nightshade, the scent of which will drive them away though they will not eat it. There is an East Indian animal called *mungoes*, which bears a natural antipathy to rats; and if this animal was introduced into our sugar islands, it would probably extirpate the whole race of these noxious vermin. The *formica omnivora* of Linnæus, the carnivorous ant, which is called in Jamaica the *raffle's ant*, would soon clear a sugar-plantation of rats.

and insects.

The sugar-cane is also subject to a disease which no foresight can obviate, and for which human wisdom has hitherto in vain attempted to find a remedy. This disease is called the *blast*, and is occasioned by a species of *aphis*. When this happens, the fine, broad, green blades become sickly, dry, and withered; they soon afterwards appear stained in spots; and if these spots are carefully examined, they will be found to contain innumerable eggs of an insect like a bug, which are soon quickened, and cover the plants with the vermin. The juice of the canes thus affected becomes sour, and no future shoot issues from the joints. Ants also concur with the bugs to spoil the plantation, and against these evils it is hard to find a remedy.

Time at which the crop ripens.

The crops of sugar-canes do not ripen precisely at the same period in all the colonies. In the Danish, Spanish, and Dutch settlements, they begin in January, and continue till October. This method does not imply any fixed season for the maturity of the sugar-cane. The plant, however, like others, must have its progress; and it has been justly observed to be in flower in the months of November and December. From the custom which these nations have adopted of continuing to gather their crops for ten months without intermission, it must necessarily follow that they cut some canes which are not ripe enough, and others which are too ripe, and then the fruit has not the requisite qualities. The time of gathering them should be at a fixed season, and probably the months of March and April are the fittest for it; because all the sweet fruits are ripe at that time, while the sour ones do not arrive at a state of maturity till the months of July and August.

The English cut their canes in March and April; but they are not induced to do this on account of their ripeness. The drought that prevails in their islands renders the rains which fall in September necessary to their planting; and as the canes are eighteen months in growing, this period always brings them to the precise point of maturity.[1] "The time of crop in the sugar islands," says Mr Edwards, "is the season of gladness and festivity to man and beast. So palatable, salutary, and nourishing, is the juice of the cane, that every individual of the animal creation, drinking freely of it, derives health and vigour from its use. The meagre and sickly among the negroes exhibit a surprising alteration in a few weeks after the mill is set in action. The labouring horses, oxen, and mules, though almost constantly at work during this season, yet, being indulged with plenty of the green tops of this noble plant, and some of the scummings from the boiling-house, improve more than at any other period of the year. Even the pigs and poultry fatten on the refuse. In short, on a well-regulated plantation, under a humane and benevolent director, there is such an appearance during crop-time of plenty and busy cheerfulness, as to soften, in a great measure, the hardships of slavery, and induce a spectator to hope, when the miseries of life are represented as insupportable, that they are sometimes exaggerated through the medium of fancy."

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[1] Edwards's History of the West Indies, vol. ii.

A season of festivity.

The canes when cut are sent to the mill.

The plants being cut, the branches at the top are given to the cattle for food; the top-shoot, which is full of eyes, is preserved for planting. The canes are cut into pieces about a yard long, tied up in bundles, and carried in carts to the mill, where they are bruised, and the juice is extracted from them. The mill consists principally of three upright iron-plated rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. Between these rollers, the canes, being previously cut short, and tied into bundles, are twice compressed; for, having passed through the first and second rollers, they are turned round the middle one by a circular piece of frame-work or screen, called in Jamaica the *dumb-returner*, and forced back through the second and third; an operation which squeezes them completely dry, and sometimes even reduces them to powder. The cane-juice is received in a leaden bed, and thence conveyed into a vessel called the *receiver*. The refuse, or macerated rind, of the cane, which is called *cane-trash*, in contradistinction to *field-trash*, serves for fuel to boil the liquor.

The juice extracted from them.

The juice as it flows from the mill, taken at a medium, contains eight parts of pure water, one part of sugar, and one part consisting of coarse oil and mucilaginous gum, with a portion of essential oil.

Vessels used for purifying it are,

As this juice has a strong disposition to fermentation, it must be boiled as soon as possible. There are some water-mills that will grind with great ease canes sufficient for thirty hogsheads of sugar in a week. It is necessary to have boiling vessels, or clarifiers, that will correspond in dimensions to the quantity of juice flowing from the receiver. These clarifiers are commonly three in number, and are sometimes capable of containing 1000 gallons each; but it is more usual to see them of 300 or 400 gallons each. Besides the clarifiers which are used for the first boiling, there are generally four coppers or boilers. The clarifiers are placed in the middle or at one end of the boiling-house. If at one end, the boiler called the *teache* is placed at the other, and several boilers, generally three, are ranged between them. The teache is ordinarily from seventy to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. Where the clarifiers are in the middle, there is usually a set of three boilers on each side, which constitute in effect a double boiling-house. On very large estates this arrangement is found useful and necessary. The objection to so great a number is the expense of fuel; to obviate which, in some degree, the three boilers on each side of the clarifiers are commonly hung to one fire.

The juice runs from the receiver along a wooden gutter lined with lead into the boiling-house, where it is received into one of the clarifiers. When the clarifier is filled, a fire is lighted, and a quantity of Bristol quicklime in powder, which is called *temper*, is poured into the vessel. The use of the lime is to unite with the superabundant acid, of which, for the success of the process, it is necessary to get rid. The quantity sufficient to separate the acid must vary according to the strength of the quicklime and the quality of the liquor. Some planters allow a pint of lime to every 100 gallons of liquor; but Mr Edwards thinks that little more than half the quantity is a better medium proportion, and, even then, that it ought to be dissolved in boiling water, that as little of it as possible may be precipitated. The heat is suffered gradually to increase till it approaches within a few degrees of the heat of boiling water, that the impurities may be thoroughly separated. But if the liquor were suffered to boil with violence, the impurities would again incorporate with it. It is known to be sufficiently heated when the scum begins to rise in blisters, which break into white froth, and appear generally in about forty minutes. The fire is then suddenly extinguished by means of a damper, which excludes the external air; and the liquor is allowed to remain about an hour undisturbed, during which period the impurities are collected in scum on the surface. The juice is then drained off either by a syphon or a cock; the scum, being of a tenacious gummy nature, does not flow out with the liquor, but remains behind in the clarifier. The liquid juice is conveyed from the clarifier by a gutter into the evaporating boiler, commonly termed the *grand copper*; and if it has been obtained from good canes it generally appears transparent.

In the evaporating boiler, which should be large enough to receive the contents of the clarifier, the liquor is allowed to boil; and as the scum rises it is taken off. The scumming and evaporation are continued till the liquor becomes finer and thicker, and so far diminished in bulk that it may be easily contained in the second copper. When put into the second copper, it is nearly of the colour of Madeira wine; the boiling and scumming are continued, and if the impurities be considerable, a quantity of lime-water is added. This process is carried on till the liquor be sufficiently diminished in quantity to be contained in the third copper. After being purified a third time, it is put into the fourth copper, which is called the *teache*, where it is boiled and evaporated till it is judged sufficiently pure to be removed from the fire. In judging of the purity of the liquor, many of the negroes, says Mr Edwards, guess solely by the eye (which by long habit they do with great accuracy), judging by the appearance of the grain on the back of the ladle: but the practice most in use is to judge by what is called the *touch*, *i. e.* taking up with the thumb a small portion of the hot liquor from the ladle, and, as the heat diminishes, drawing with the forefinger the liquid into a thread. This thread will suddenly break, and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. The proper boiling height for strong muscovado sugar is generally determined by a thread of a quarter of an inch long. It is evident that certainty in this experiment can be attained only by long habit, and that no verbal precepts will furnish any degree of skill in a matter depending wholly on constant practice.

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[1] The account given in the text concerning the time when the sugar-canes are collected, we have taken from the Abbé Raynal's History of the Trade and Settlements of the East and West Indies; but Mr Cazaud observes, that in February, March, and April, all the canes, whatever be their age, are as ripe as the nature of the soil ever allows them to be. (Philosophical Transactions, vol. lxix.)

being d it ed, ated, eed s es.

The juice being thus purified by passing through the clarifier and four coppers, it is poured into coolers, which are usually six in number. The removal from the teache to the cooler is called *striking*. The cooler is a shallow wooden vessel, seven feet long, from five to six wide, about eleven inches deep, and capable of containing a hogshead of sugar. As the liquor cools, the sugar grains, that is, collects into an irregular mass of imperfect crystals, separating itself from the molasses. It is then removed from the cooler and conveyed to the curing house, where the molasses drain from it. For receiving them there is a large cistern, the sloping sides of which are lined with boards. Directly above the cistern a frame of joist-work without boarding is placed, on which empty hogsheads without heads are ranged. The bottoms of these hogsheads are pierced with eight or ten holes, in each of which the stalk of a plantain leaf is fixed, so as to project six or eight inches below the joists, and rise a little above the top of the hogshead. The hogshead being filled with the contents of the cooler, consisting of sugar and molasses, the molasses being liquid, drain through the spongy stalk, and drop into the cistern. After the molasses are drained off, the sugar becomes pretty dry and fair, and is then called *muscovado* or *raw sugar*.

bod of ping by the h.

We have described the process for extracting sugar, which is generally adopted in the British West India islands, according to the latest improvements; and have been anxious to present it to our readers in the simplest and most perspicuous form, that it might be intelligible to every person; and have therefore avoided to mention the observations and proposed amendments of those who have written on this subject. Had we done so, we should have swelled the present article to too great a size, without accomplishing the purpose which we have in view; for our intention is not to instruct the planters, but to give a distinct account of the most approved methods which the planters have generally adopted. But though we judge it useless to trouble our readers with all the little varieties in the process which different persons employ, we flatter ourselves it will not be disagreeable to learn by what methods the French make their sugar purer and whiter than ours. A quantity of sugar from the cooler is put into conical pans or earthen pots, called by the French *formes*, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of the sugar-loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay moistened with water. This water filters through the mass, carrying with it the syrup which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called *fine syrup*. Care is taken to moisten and keep the clay to a proper degree of softness as it becomes dry. The sugar-loaves are afterwards taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed, and exported to Europe, where they are still further purified. The reason assigned why this process is not universally adopted in the British sugar islands is this, that the water which dilutes and carries away the molasses dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. The French planters probably thought otherwise, upwards of 400 of the plantations of St Domingo having had the necessary apparatus for claying and actually carrying on the system.

The art of refining sugar introduced by a Venetian.

The art of refining sugar was first made known to the Europeans by a Venetian, who is said to have received 100,000 crowns for the invention. This discovery was made before the new world was explored; but whether it was an invention of the person who first communicated it, or whether it was conveyed from China, where it had been known for a considerable time before, cannot now perhaps be accurately ascertained. We find no mention made of the refining of sugar in Britain till the year 1659, though it probably was practised several years before; for in the Portuguese island of St Thomas in 1642 there were seventy-four sugar ingenios, each having upwards of two hundred slaves.

In refining, it is mixed with lime-water and bullock's blood, and exposed to heat.

The sugar which undergoes the operation of refining in Europe is either raw sugar, sometimes called *muscovado*, or *cassonado*, which is raw sugar in a purer state. The raw sugar generally contains a certain quantity of molasses as well as earthy and feculent substances. The cassonado, by the operation of earthing, is freed from its molasses. As the intention of refining these sugars is to give them a higher degree of whiteness and solidity, it is necessary for them to undergo other processes. The first of these is called *clarification*. It consists in dissolving the sugar in a certain proportion of lime-water, adding a proper quantity of bullock's blood, and exposing it to heat in order to remove the impurities which still remain. The heat is increased very gradually till it approach that of boiling water. By the assistance of the heat, the animal matter which was thrown in coagulates, at the same time that it attracts all the solid feculent and earthy matter, and raises it to the surface in the appearance of a thick foam of a brownish colour. As the feculencies are never entirely removed by a first process, a second is necessary. The solution is therefore cooled to a certain degree by adding some water; then a fresh quantity of blood, but less considerable than at first, is poured in. The fire is renewed, and care is taken to increase the heat gently as before. The animal substance seizes on the impurities which remain, collects them on the surface, and they are then skimmed off. The same operation is repeated a third and even a fourth time, but no addition, except water, is made to the liquor. If the different processes have been properly conducted, the solution will be freed from every impurity, and appear transparent. It is then conveyed by a gutter into an oblong basket about sixteen inches deep, lined with a woollen cloth; and after filtering through this cloth, it is received in a cistern or copper which is placed below.

Then freed from its remaining impurities by evaporation.

The solution being thus clarified, it undergoes a second general operation, called *evaporation*. Fire is applied to the copper into which the solution was received, and the liquid is boiled till it has acquired the proper degree of consistency. A judgment is formed of this by taking up a small portion of the liquid and drawing it into a thread. When, after this trial, it is found sufficiently viscous, the fire is extinguished, and the liquid is poured into coolers. It is then stirred violently by an instrument called an *oar*, from the resemblance it bears to the oar of a boat. This is done in order to diminish the viscosity, and promote what is called the *granulation*, that is, the forming of it into grains or imperfect crystals. When the liquid is properly mixed and cooled, it is then poured into moulds of the form of a sugar-loaf. These moulds are ranged in rows. The small ends, which are lowest, are placed in pots; and they have each of them apertures stopped up with linen for filtering the syrup, which runs from the moulds into the pots. The liquor is then taken out slowly in ladlefuls from the coolers, and poured into the moulds. When the moulds are filled, and the contents still in a fluid state, it is necessary to stir them, that no part may adhere to the moulds, and that the small crystals which are just formed may be equally diffused through the whole mass. When sugar is completely crystallized, the linen is taken away from the apertures in the

Afterwards poured into moulds, where the syrup is drained from it.

Lastly exposed to a certain degree of heat.

moulds, and the syrup, or that part which did not crystallize, descends into the pots in which the moulds are placed. After this purgation the moulds are removed and fixed in other pots, and a stratum of fine white clay diluted with water is laid on the upper part of the loaf. The water descending through the sugar by its own weight, mixes with the syrup which still remains in the body of the loaf, and washes it away. When the clay dries, it is taken off, and another covering of moist clay put in its place; and if it be not then sufficiently washed, a third covering of clay is applied. After the loaves have stood some days in the moulds, and have acquired a considerable degree of firmness and solidity, they are taken out and carried to a stove, where they are gradually heated to the 50° of Reaumur (64° of Fahrenheit), in order to dissipate any moisture which may be still confined in them. After remaining in the stove eight days, they are taken out; and after cutting off all discolouring specks, and the head if still wet, they are wrapped in blue paper, and are ready for sale. The several syrups collected during the different parts of the process, treated in the same manner which we have just described, afford sugars of inferior quality; and the last portion, which no longer affords any sugar, is sold by the name of *molasses*.

In what the beauty of sugar consists; how farther refined.

The beauty of refined sugar, when formed into loaves, consists in whiteness, joined to a smallness of grain; in being dry, hard, and somewhat transparent. The process which we have described above refers to sugar once refined; but some more labour is necessary to produce double-refined sugar. The principal difference in the operation is this; the latter is clarified by white of eggs instead of blood, and fresh water in place of lime-water.

How sugar-candy is made.

Sugar-candy is the true essence of the cane formed into large crystals by a slow process. When the syrup is well clarified, it is boiled a little, but not so much as is done in the process for making common sugar. It is then placed in old moulds, having their lower ends stopped with linen, and crossed at little distances with small twigs to retain the sugar as it crystallizes. The moulds are then laid in a cool place. In proportion as the syrup cools, crystals are formed. In about nine or ten days the moulds are carried to the stove, and placed in a pot; but the linen is not removed entirely, so that the syrup falls down slowly in drops. When the syrup has dropped away, and the crystals of the sugar-candy are become dry, the moulds are taken from the stove, and broken in pieces to disengage the sugar, which adheres strongly to the sides of the mould. If the syrup has been coloured with cochineal, the crystals take a slight taint of red; if indigo has been mixed, they assume a bluish colour. If it be desired to have the candy perfumed, the essence of flowers or amber may be dropped into the moulds along with the syrup.

The average quantity of sugar imported into Great Britain and Ireland during the last twenty years ending with 1837 is 4,486,014 cwts.; the quantity imported in 1837 was 4,482,578 cwts., which is somewhat under the average of the preceding nineteen years, while the population may be assumed to have increased at least twenty per cent. during the same period. From these facts we may fairly assume, that if the duty on sugar were reduced so as to bring the price within the reach of the poorer classes, the demand would greatly increase.

Sugar was imported into England in the fourteenth century, but in small quantities. The demand, however, increased very rapidly, and the consumption of this important necessary of life is now about twenty times greater than it was in the beginning of last century.

In 1700 it was 22,000,000 lbs.
... 1754 .... 119,320,000 ...
... 1790 .... 181,500,000 ...
... 1807 .... 255,098,450 ...
... 1837 .... 432,938,608 ...

Taking the aggregate population of the united kingdom in 1837 at twenty four millions and a half, this gives to each individual just sixteen pounds per annum; a proportion very far below what might be expected were the price reduced.

An Account of the Quantity of Sugar imported into the United Kingdom, distinguishing Great Britain from Ireland, and specifying the Countries whence the Imports were received; together with a Statement of the Quantities and Descriptions cleared from the Warehouses and retained for Consumption, the Rates of Duty and Drawback, the Gross Amount of Duty, the Sum paid for Drawback, &c., and the Net Amount of Revenue, with the Gazette Average Prices, at the end of each Quarter of the Year 1837.

Places whence imported.	Quantities imported into		
	Great Britain.	Ireland.	United Kingdom.
British Colonies and Plantations in America, viz.—	Cwts. qrs. lbs.	Cwts. qrs. lbs.	Cwts. qrs. lbs.
Antigua........	56,360 0 2	5,810 1 2	62,170 1 4
Barbadoes.......	413,287 2 21	32,425 1 23	445,713 0 16
Dominica	33,723 2 10	...	33,723 2 10
Grenada.........	161,921 2 20	...	161,921 2 10
Jamaica.........	901,078 2 15	3,221 0 3	904,299 2 18
Montserrat.....	5,694 3 24	...	5,694 3 24
Nevis...........	24,269 0 0	...	24,269 0 0
St Christopher.	72,266 2 16	1,003 0 2	73,269 2 18
St Lucia........	31,235 3 9	20,194 2 0	51,430 1 9
St Vincent......	201,191 1 21	...	201,191 1 21
Tobago..........	90,803 0 25	...	90,803 0 25
Tortola..........	13,534 0 5	...	13,534 0 5
Trinidad........	224,873 1 2	70,493 3 1	295,367 0 3
Demerara.......	705,637 3 18	87,214 0 4	792,851 3 22
Berbice..........	148,836 0 5	1,699 3 14	150,535 3 19
Honduras.... ..	0 3 21	...	0 3 21
British North American Colonies..........	2,364 0 17	1 1 18	2,365 2 7
West Coast of Africa...........	1 3 11	...	1 3 11
Mauritius.......	537,454 3 17	...	537,454 3 17
British Possessions in the East Indies, viz.—			
East India Company's Territories, exclusive of Singapore.....	297,923 3 10	...	297,923 3 10
Singapore.......	5,019 0 26	...	5,019 0 26
Ceylon..........	2 0 0	...	2 0 0
Siam.............	18,805 3 6	...	18,805 3 6
Java.............	2,877 3 13	...	2,877 3 13
Philippine Islands........	49,118 1 12	...	49,118 1 12
China............	0 0 2	...	0 0 2
New South Wales	1,042 2 5	...	1,042 2 5
Foreign Colonies in the West Indies, viz.—			
Cuba............	125,985 0 26	...	125,985 0 26
St Thomas......	308 3 0	...	308 3 0
United States of America.......	1,667 0 12	...	1,667 0 12
Mexico..........	0 0 4	...	0 0 4
Columbia........	533 1 5	...	533 1 5
Brazil...........	110,216 1 26	...	110,216 1 26
States of the Rio de la Plata	0 0 11	...	0 0 11
Chili.............	0 0 10	...	0 0 10
Peru..............	7,993 0 24	...	7,993 0 24
Europe...........	14,485 0 21	...	14,485 0 21
Total......	4,260,514 3 24	222,063 1 11	4,482,578 1 7
Total in 1836 ..	4,411,527 0 8	237,633 3 27	4,649,161 0 7

Quantity cleared for consumption in the united kingdom.

	Cwts.	qrs.	lbs.
Of the British plantations	3,562,778	3	19
Of Mauritius	522,360	3	23
Of the East Indies	270,078	0	10
Of the foreign plantations	35	2	7
Total	4,355,253	2	3
Quantity retained for consumption in the united kingdom	3,954,809	3	3
Gross amount of duty.			
Great Britain	L.4,874,162	4	3
Ireland	395,973	7	6
United kingdom	L.5,270,135	11	9
Drawback paid on exportation.			
Great Britain	L 497,419	3	4
Ireland	113	10	5
United kingdom	L.497,532	13	9
Repayments on over-entries, &c.			
Great Britain	L.11,936	0	11
Ireland	102	5	6
United kingdom	L.12,038	6	5
Net amount of revenue.			
Great Britain	L.4,364,807	0	0
Ireland	395,757	11	7
United kingdom	L.4,760,564	11	7
Rates of duty per cwt.			
British plantations and Mauritius	L.1	4	0
Any British possessions in the East Indies into which the importation of foreign sugar is prohibited	1	4	0
Of other British possessions in the East Indies	1	12	0
Foreign	3	3	0
Average price per cwt. according to the London Gazette.			
March 1837	L.1	18	$0\frac{1}{4}$
June	2	1	$6\frac{1}{2}$
September	2	3	$7\frac{1}{4}$
December	1	15	$5\frac{3}{4}$

SUGAT, a town of Asia Minor, in the pachalic of Bursa, supposed to be on the site of the ancient Tottarium. The houses are generally built of mud and wood, two stories high, with projecting verandahs, and roofed with common red tile. It is remarkable for the tomb of Ali Osman, held in high respect by the natives.

SUGGOWLY, a town of Hindustan, in the province of Bahar, district of Bettiah. It is situated on the Boora Gunduck river, and it carries on a considerable trade in timber, floated down from the northern hills. Long. 85. 5. E. Lat. 26. 43. N.

SUIATOI NOS, or HOLY CAPE, a cape of Asiatic Russia, in the province of Irkoutsk, between the rivers Yana and Indigirka, on the coast of the Frozen Ocean. Long. 39. 30. E. Lat. 68. 30. N.

SUICIDE, the crime of self-murder, or the person who commits it. We have often wished to see a history of crimes drawn up by a man of ability and research. In this history we would propose that the author should describe the crimes peculiar to different nations in the different stages of society, and the changes which they undergo in the progress of civilization. After having arranged the historical facts, he might, by comparing them with the religion and the knowledge of the people, deduce some important general conclusions, which would lead to a discovery of the cause of crimes, and of the remedy most proper to be applied. Some crimes are peculiar to certain stages of society, some to certain nations. Suicide is one of those crimes which we are led to believe not common among savage nations. The first instances recorded of it in the Jewish history are those of Saul and Ahitophel; for we do not think the death of Samson a proper example. We have not reason to suppose that it became common among the Jews till their wars with the Romans, when multitudes slaughtered themselves that they might not fall alive into the hands of their enemies. But at this period the Jews were a most desperate and abandoned race of men, had corrupted the religion of their fathers, and rejected that pure system which their promised Messiah came to announce.

When this crime became remarkable among the Greeks, we have not been able to discover; but it was forbidden by Pythagoras, as we learn from Athenæus, by Socrates and Aristotle, and by the Theban and Athenian laws. In the earliest ages of the Roman republic it was seldom committed; but when luxury and the Epicurean and Stoical philosophy had corrupted the simplicity and virtue of the Roman character, they then began to seek shelter in suicide, from their misfortunes or the effects of their own vices.

The religious principles of the Brahmins of India led them to admire suicide on particular occasions as honourable. Accustomed to abstinence, mortification, and the contempt of death, they considered it as a mark of weakness of mind to submit to the infirmities of old age. We are informed that the modern Gentoos, who still in most things conform to the customs of their ancestors, are frequently, when old and infirm, brought to the banks of rivers, particularly to those of the Ganges, that they may die in its sacred streams, which they believe can wash away the guilt of their sins. But the maxims of the Brahmins, which have encouraged this practice, we are assured by Mr Holwell, are a corruption of the doctrines of the Shaster, which positively forbid suicide under the severest punishment. The practice which religion or affection has established among the Gentoos, for women at the death of their husbands to burn themselves alive on the funeral pile, we do not think ought to be considered as suicide, as we are not anxious to extend the meaning of the word; for were we to extend it thus far, it would be as proper to apply it to those who choose rather to die in battle than make their escape at the expense of their honour. Thus we should condemn as suicides the brave Spartans who died at Thermopylæ in defence of their country. According to the Gentoo laws, "it is proper for a woman after her husband's death to burn herself in the fire with his corpse. Every woman who thus burns shall remain in paradise with her husband three crore and fifty lacs of years. If she cannot, she must in that case preserve an inviolable chastity. If she remain chaste, she goes to paradise; and if she do not preserve her chastity, she goes to hell."

A custom similar to this prevailed among many nations on the continent of America. When a chief died, a certain number of his wives, of his favourites, and of his slaves, were put to death, and interred together with him, that he might appear with the same dignity in his future station, and be waited upon by the same attendants. This persuasion was so deeply rooted, that many of their retainers offered themselves as victims; and the same custom prevails in many of the negro nations in Africa.

If we may rely on the historians of Japan, voluntary death is common in that empire. The devotees of the idol Amida drown themselves in his presence, attended by their relations and friends, and several of the priests, who all consider the devoted person as a saint, who is gone to everlasting happiness. Such being the supposed honours appropriated to a voluntary death, it is not surprising that the Japanese anxiously cherish a contempt of life. Accordingly it is a part of the education of their children "to repeat poems in which the virtues of their ancestors are celebrated, an utter contempt of life is inculcated, and suicide is set up as the most heroic of actions."

A notion seems also to have prevailed among the ancient Scythian tribes, that it was pusillanimous and ignoble for a man whose strength was wasted with disease or infirmity, so as to be useless to the community, to continue to live. It was reckoned an heroic action voluntarily to seek that death which he had not the good fortune to meet in the field of battle. Perversion of moral feeling does not spring up, we hope, spontaneously in any nation, but is produced by some peculiarities of situation. A wandering people like the Scythians, who roamed about from place to place, might often find it impossible to attend the sick, or to supply from their precarious store the wants of the aged and infirm. The aged and infirm themselves, no longer able to support the character of warriors, would find themselves unhappy. In this way the practice of putting to death such persons as were useless to the community might originate, and afterwards be inculcated as honourable; but he who put an end to his infirmities by his own hand obtained a character still more illustrious.

The tribes of Scandinavia, which worshipped Odin, the "father of slaughter," were taught, that dying in the field of battle was the most glorious event that could befall them. This was a maxim suited to a warlike nation. In order to establish it more firmly in the mind, all were excluded from Odin's feast of heroes who died a natural death. In Asgardia stood the hall of Odin, where, seated on a throne, he received the souls of his departed heroes. This place was called *Valhalla*, signifying "the hall of those who died by violence." Natural death being thus deemed inglorious, and punished with exclusion from Valhalla, the paradise of Odin, he who could not enjoy death in the field of battle was led to seek it by his own hands when sickness or old age began to assail him. In such a nation suicide must have been very common.

As suicide prevailed much in the decline of the Roman empire, when luxury, licentiousness, profligacy, and false philosophy, pervaded the world, so it continued to prevail even after Christianity was established. The Romans, when they became converts to Christianity, did not renounce their ancient prejudices and false opinions, but blended them with the new religion which they embraced. The Gothic nations, also, who subverted the Roman empire, while they received the Christian religion, adhered to many of their former opinions and manners. Among other criminal practices which were retained by the Romans and their conquerors, that of suicide was one; but the principles from which it proceeded were explained so as to appear more agreeable to the new system which they had espoused. It was committed either to secure from the danger of apostasy, to procure the honour of martyrdom, or to preserve the crown of virginity.

When we descend to modern times, we lament to find so many instances of suicide among the most polished nations, who have the best opportunities of knowing the atrocity of that unnatural crime. The English have long been reproached by foreigners for the frequent commission of it; and the "gloomy month of November" has been stigmatized as the season when it is most common. But this disgraceful imputation, we think, may be justly attributed, not to the greater frequency of the crime in England than in other countries, but to the custom of publishing in the newspapers every instance of suicide which is known.

It might lead to some interesting conclusions to compare together, not only the number of suicides in different countries, but also the rank and principles, the sex and age, of those unhappy persons by whom it has been committed. Mercier says, that at Paris it was the lower ranks who were most commonly guilty of it; that it was mostly committed in garrets or hired lodgings; and that it proceeded from poverty and oppression. A great many, he says, wrote letters to the magistrates before their death. Mr Moore's correspondent from Geneva informed him, that from the year 1777 to 1787 more than 100 suicides were committed in Geneva; that two thirds of these unfortunate persons were men; that few of the clerical order have been known to commit it; and that it is not so much the end of an immoral, irreligious, dissipated life, as the effect of melancholy and poverty.[1]

Humanity would in most cases dispose us to conclude that suicide is the effect of insanity, were there not so many instances of cool deliberate self-murder. That suicide is an unnatural crime, which none but a madman would commit, compassion indeed may suppose; but the murder of a wife, a father, or a child, are also unnatural; yet compassion does not teach us in all cases to ascribe such a crime to madness. Passion may often arise to such a height of outrage as to be scarcely distinguishable from madness in its symptoms and its effects; yet we always make a distinction between that madness which arises from disease and that which is owing to a violent perturbation of mind. If a person be capable of managing his worldly affairs, of making a will, and of disposing of his property, immediately before his death, or after he formed the resolution of dying by his own hands, such a man is not to be considered as insane.

But though a regard for truth prevents us from ascribing suicide in all cases to insanity, we must ascribe it either to insanity or to vicious passion. These two divisions, we imagine, will comprehend every species of it, whether arising from melancholy, *tædium vitæ* or *ennui*, disappointment in schemes of ambition or love, pride, gaming, or a desire to avoid the shame of a public execution; passions which are often increased by false views of God, of man, and of a future state, arising from deism and infidelity. If these be the causes of suicide in modern times, what a disgraceful contrast do they form to those principles which actuated many of the ancient philosophers, the Gentoos, the Japanese, and the worshippers of Odin? When they committed suicide, they committed it from principle, from a belief of its lawfulness, and the hope of being rewarded for what they judged an honourable sacrifice. But in modern times, we are sorry to say, when it is not the effect of madness, it is the effect of vice: and when it is the effect of vice, it proves that the vicious passions are then indulged to the highest degree; for there is no crime which a man can commit that is so strong a symptom of the violence of particular passions. It is from not attending to this circumstance that it has been found so difficult to refute the arguments in favour of suicide. If the criminality of suicide be confined merely to the violent action, many apologies may be made for it; but if it be considered solely as the effect of vice, as the strongest symptom of ungoverned passion, he who undertakes its defence must undertake the defence of what all men will loudly condemn.

As suicide was deemed a crime by the most illustrious and virtuous of the Greek and Roman philosophers, it was considered as a crime by the laws, and treated with ignominy. By the law of Thebes suicides were to have no honours paid to their memory. The Athenian law ordained the hand which committed the deed to be cut off, and burnt apart from the rest of the body. The body was not buried with the usual solemnities, but was ignominiously thrown into some pit. In Cea and Massilia (the ancient *Marseille*), it was considered as a crime against the state; and it was therefore necessary for those who wished to destroy themselves to obtain permission from the magistrates. Plutarch acquaints us, that an unaccountable passion for suicide seized the Milesian virgins; from indulging which they could not be prevented by the tears and entreaties of parents and friends: but what persuasion and entreaty could not effect was accomplished by very different means. A decree was issued, "that the body of every young woman who hanged herself should be dragged naked through the streets by the same rope with which she had committed the deed." This wise edict put a complete stop to the extraordinary phrensy, and suicide was no longer committed by the virgins of Miletus.

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[1] Moore's Enquiry into the subject of Suicide. Lond. 1790, 2 vols. 4to.

In the early part of the Roman history there seems to have been seldom occasion for framing any laws against suicide. The only instance recorded occurs in the reign of Tarquinius Priscus. The soldiers who were appointed to make drains and common sewers, thinking themselves disgraced by such servile offices, put themselves to death in great numbers. The king ordered the bodies of all the self-murderers to be exposed on crosses, and this put an effectual stop to the practice. It is doubtful whether there was any standing law against suicide during the existence of the republic; but during the reign of the emperors it was thought proper to lay it under certain regulations, though not absolutely to condemn it as a crime. In Justinian's Pandects there is a law, by which it was enacted, "that if persons accused, or who had been found guilty, of any crime, should make away with themselves, their effects should be confiscated." But this punishment only took place when confiscation of goods happened to be the penalty appointed by the law for the crime of which the self-murderer was accused or found guilty, and was not inflicted for suicide committed in any other circumstances.

When the Christian church had extended its jurisdiction in the Roman empire, it was decreed in the sixth century, that no commemoration should be made in the eucharist for such as destroyed themselves; neither should their bodies be carried out to burial with psalms, nor have the usual service said over them. This ecclesiastical law continued till the reformation, when it was admitted into the statute law of England. As an additional punishment, however, confiscation of land and goods seems to have been adopted from the Danes, as we learn from Bracton.[1] At present the punishment consists in confiscating all the personal property of a *felo de se* for the use of the crown, and in excluding his body from interment in consecrated ground.

SUIDAS, a Greek lexicographer, is supposed by Fabricius to have lived during the latter part of the eleventh century; but other writers are disposed to believe that he must have belonged to a more recent period. His country and his personal history are alike unknown. From authors of various denominations he compiled an ample dictionary, which, with all its imperfections, has been found a most valuable repository of ancient erudition; and no scholar, intimately acquainted with the Greek language and literature, is unacquainted with the Lexicon of Suidas. The first edition, which is very elegantly printed, was published by Demetrius Chalcondylus, Mediol. 1499, fol. He had access to several manuscripts. The text of Aldus has some appearance of being derived from a different source, Venet. 1514, fol. A third edition, with various interpolations, followed after a longer interval, Basil. 1544, fol. It was succeeded by the Latin version of Wolfius, Basil. 1564, fol. Basil. 1581, fol. An edition of the Greek text, accompanied with a Latin version, was published by Æmilius Portus, Colon. Allobrog. 1619, 2 tom. fol. A splendid and valuable edition was at length produced by Küster, Cantab. 1705, 3 tom. fol. Here the version of Portus has received innumerable corrections; and from the collation of manuscripts, as well as by the aid of his own critical sagacity, he effected a great reformation of the text. He was a man of superior talents, and of profound erudition; but it is admitted that he ought to have devoted a greater portion of time to so formidable an undertaking. His edition was assailed by J. Gronovius in three different publications; and to this virulent critic Küster replied in a *Diatribe Anti-Gronoviana*, of which a second edition was printed at Amsterdam, 1712, 8vo. The text of Suidas was afterwards illustrated by many other writers, nor must we fail to mention the elaborate work of Toup, *Emendationes in Suidam*, Lond. 1760–6, 3 tom. 8vo. Oxon. 1790, 4 tom. 8vo. The labours of these learned men prepared the way for a most valuable edition, recently published under the following title: "Suidæ Lexicon post Ludolphum Kusterum ad codices manuscriptos recensuit Thomas Gaisford, S.T.P. Ædis Christi Decanus, necnon Græcæ Linguæ Professor Regius." Oxon. 1834, 3 tom. fol. The third volume is very thin, and merely includes three Indices. By his edition of Suidas, Dr Gaisford has made a great accession to his former reputation in a department of learning in which he has no living rival in Great Britain.

SUIT, in *Law*, the same with action. The Romans, at an early period, introduced set forms for actions into their law, after the example of the Greeks; and made it a rule, that each injury should be redressed by its proper remedy only. "Actiones (say the Pandects) compositæ sunt, quibus inter se homines disceptarent, quas actiones ne populus prout vellet institueret, certas solemnesque esse voluerunt." The forms of these actions were originally preserved in the books of the pontifical college, as choice and inestimable secrets, till one Cneius Flavius, the secretary of Appius Claudius, stole a copy and published them to the people. The concealment was ridiculous: but the establishment of some standard was undoubtedly necessary to fix the true state of a question of right, lest, in a long and arbitrary proceeding, it might be shifted continually, and be at length no longer discernible; or, as Cicero expresses it, "sunt jura, sunt formulæ, de omnibus rebus constitutæ, ne quis aut in genere injuriæ, aut in ratione actionis, errare possit. Expressæ enim sunt ex uniuscujusque damno, dolore, incommodo, calamitate, injuria, publicæ a pretore formulæ, ad quas privata lis accommodatur." And in the same manner Bracton, speaking of the original writs upon which English actions are founded, declares them to be fixed and immutable, unless by authority of parliament. And all the modern legislators of Europe have found it expedient, from the same reasons, to fall into the same or a similar method.

SUKANA, or SUKNA, a village of the Syrian desert, near which is a warm sulphureous spring, 140 miles south-south-east of Aleppo.

SUK EL HARF, a town of Yemen, in Arabia, twenty-eight miles south-south-east of Saade.

SUKI, a town of Anatolia, in Asiatic Turkey, governed by an aga. It is twelve miles north-north-east of Milets.

SULIAGO, or SURIAGO, a chain of small islands in the Pacific Ocean, extending about ninety miles in length by twelve in breadth. Long. 125. 27. to 128. 30. E. Lat. 9. 24. to 10. 32. N. The largest, from which the others derive their name, is twenty miles in circumference, and is twenty miles north-north-east from the coast of Mindanao. Long. 126. 27. E. Lat. 9. 27. N. There is a town of the same name on the north coast of the island of Mindanao. Long. 125. 31. E. Lat. 9. 45. N.

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[1] Bracton de Legibus et Consuetudinibus Angliæ, lib. iii. tract. 11.

SULLY, Maximilien de Bethune, Duke of, was born at Rosny on the 13th of December 1560, and died at Villebon on the 22d of December 1640. His name is so conspicuous in the public annals of France, that a mere outline of his personal history would require an ample allotment of space. He participated in the fortunes of Henry IV. and rendered him the most important services in the cabinet as well as the field. He was grand master of the artillery, and superintendent of the finances. Rigidly attentive to the interest of the king, he had no disposition to neglect his own; and in the course of a long life he accumulated an immense fortune, of which he laid the foundation by his marriage with Anne de Courtenay, a rich heiress. He was remarkable for his decision of character and bluntness of manners; and in spite of all the allurements presented to him, he steadily adhered to the protestant faith. The Memoirs of Sully furnish some of the most curious and valuable materials for the history of that eventful era.

SULPHUR Island, an island in the North Pacific Ocean, discovered by Captain Gore in 1779, about five miles long. Long. 141. 12. E. Lat. 24. 48. N.

SULPICIA, a Roman poetess, who lived under the reign of Domitian, and has been so much admired as to be termed the Roman Sappho. We have nothing, however, left of her writings but a satire, or rather the fragment of one, against Domitian, who published a decree for the banishment of philosophers from Rome. This satire is to be found in Scaliger's *Appendix Virgiliana*, and in other collections. It was separately published, with elaborate annotations by C. G. Schwartz. Altorf. 1721, 8vo. Hamb. 1819, 4to. She is mentioned by Martial and Sidonius Apollinaris; and is said to have addressed a poem on conjugal love to her husband Calenus, a Roman knight.

SULPITIUS Severus, an ecclesiastical writer, was born in Aquitania about the year 363. His father was a man of superior rank. Having received a suitable education, the son applied himself to the practice of the law, and distinguished himself by his learning and eloquence. He married a rich wife, and was thus placed in a state of greater independence. He chiefly resided at Toulouse, and at *Eluso* or *Elusio*, near Carcassonne. The death of his beloved wife weaned his affections from the world, and he is supposed to have devoted himself to an ecclesiastical, if not a monastic life. He had recourse to the instructions of Martin bishop of Tours, whose life he has written; and he likewise contracted a friendship with Paulinus bishop of Nola. The invasion of the Vandals impelled him to seek a place of refuge at Marseille, where he entered a monastery, and is supposed to have died about the year 410. His principal work is his *Historia Sacra*, deduced from the creation of the world to his own time, and written in a style superior to the standard of that declining age of Latinity. The first edition was published by Flacius Illyricus. Basil. [1556] 8vo. Various editions of his works subsequently appeared; some of which were illustrated by the notes of Sigonius, Vorstius, Horn, and Le Clerc. A more elaborate edition was undertaken by De Prato, Veronæ, 1741–54, 2 tom. 4to. He promised a third volume, which however did not make its appearance.

SULTAN, or Soldan, a title or appellation given to the emperor of the Turks.

SULTANHISSAR, a village of Anatolia, in Asiatic Turkey, situated near the remains of the ancient Greek city of Tralles, and twenty-three miles east of Scalanova. On the top of an adjacent hill are found traces of some ancient buildings, particularly a temple and a theatre, with fifty rows of seats. Some remains of a magnificent portico are also seen, with two rows of pillars.

SULTANPORE, a town of Hindustan, province of Lahore, belonging to the Sikhs. Long. 74. 45. E. Lat. 31. 18. N. 2. A town in the province of Oude, pleasantly situated on the eastern bank of the Goompty river, seventy-eight miles south-east from Lucknow. Long. 82. 3. E. Lat. 26. 18. N. 3. A town in the Afghan territories, province of Mooltan, twenty miles east from the city of Mooltan. Long. 71. 40. E. Lat. 30. 38. N. 4. A town in the Mahratta territories, province of Khandesh, on the north side of the Tuptee river, ninety miles east by north from Surat. Long. 74. 22. E. Lat. 21. 35. N.

SULZER, John George, a philosophical writer of distinction, was born at Winterthur, in the canton of Zürich, on the 16th of October 1720. He was the youngest of twenty-five children. At the age of sixteen, when he went to the university of Zürich, he had not the smallest notion of the sciences or of elegant literature, and consequently no taste for study. The first incident that developed a hidden germ of philosophical genius, was his meeting with Wolf's Metaphysics. This was the birth of his taste for science; but he wanted a guide. The clergyman with whom he lodged was an ignorant man; and the academical prelections were, as yet, above the reach of his comprehension. On the other hand, a sedentary life was not suitable to his taste; and a sociable turn of mind often led him into company, where he lost much time in frivolous amusements, yet without corrupting his morals. Who, that observed him at this period, says Mr Formey in his Eloge, would have thought that Sulzer would one day be numbered among the most knowing and wise men of his time? John Gessner, who became an eminent naturalist, was the instrument of Providence that rendered Sulzer's inclination to study triumphant over his passion for amusement and company. Animated by the counsels and example of this fellow-student, he applied himself to philosophy and mathematics with great ardour, and resumed the pursuit of Greek literature and the oriental languages. He was settled as a pastor in a rural district. In 1741 he published Moral Contemplations on the Works of Nature; and in the following year an Account of a Journey through the Alps, which showed at the same time his knowledge of natural history, and the taste and sensibility with which he surveyed the beauties of nature, and the grandeur and goodness of its Author. He afterwards became private tutor to a young gentleman at Magdeburg. This procured him the acquaintance of Euler, Maupertuis, and Sack, which opened to his merit the path of preferment, and advanced him successively to the place of mathematical professor in the Gymnasium of Berlin in 1747, and to that of member of the Royal Academy in 1750. In this last quality he distinguished himself in a very eminent manner, enriched the class of speculative philosophy with a great number of excellent memoirs, and was justly considered as one of the first-rate metaphysicians in Germany. But his genius was not confined to this branch of science. His universal Theory of the Fine Arts is a valuable production. A profound knowledge of the arts and sciences, and a perfect acquaintance with true taste, are eminently displayed in this work, and will secure to its author a permanent and distinguished rank in the republic of letters. The first volume of this excellent work was published in 1771, and the second in 1774. His Remarks on the Philosophical Essays of Hume is a work of real merit, which does justice to the acuteness, while it often detects the sophistry, of the Scotish philosopher. The moral character of Sulzer was amiable and virtuous: sociability and beneficence were its characteristical lines; and his virtues were animated by that sacred philosophy which forms the Christian, ennobles man, and is the only source of that heart-felt serenity and sedate fortitude which support humanity, when every other object of confidence fails. He died at Berlin on the 27th of February 1779.

SUMATRA, a large island in the Eastern Seas, the most western of that great chain of islands which extends in the eastern ocean from the coasts of New Holland and New Guinea to the coast of China on the east, and westward to the Malayan peninsula. The equator divides it into two parts almost equal. It may be estimated at 1050 miles in length by 165 miles in average breadth, and its general direction is north-west and south-east: the one extremity is in 5° 56′ N. and the other in 5° 56′ S. This island lies exposed on the south-west to the great Indian Ocean; the north point stretches into the Bay of Bengal, to the north-east it is divided from the peninsula of Malaya by the Straits of Malacca, to the east by the Straits of Banca from the island of that name, to the south-east by the commencement of the Chinese Seas, and on the south it is separated from the island of Java by the Straits of Sunda. The origin of the name is unknown. In the east it is generally known by the name of Pulo Purichu and Indalas. It is one of the largest islands in the world, and is broadest at its southern extremity, narrowing gradually towards the north. It is of a very unequal surface. A chain of mountains runs through its whole extent: the ranges are from 3000 to 5000 feet high, and in some places much higher, being in many parts double and treble; and they run nearer to the western than the eastern shore, being seldom more than twenty miles from the sea. These mountains, though high, do not rise above the level of perpetual snow. Mount Ophir, situated immediately under the equinoctial line, is 13,800 feet above the level of the sea. Between these ridges of mountains are extensive plains, considerably elevated above the surface of the maritime lands, where the air is cool, and they are esteemed in consequence the most eligible portion of the country; and being cleared from woods, which in all other parts cover both the hills and valleys in Sumatra with an eternal shade, they are the best inhabited parts of the country. The most satisfactory account of the country is derived from the journeys into the interior by Sir Stamford Raffles, who was appointed governor of the British settlements at Sumatra, and arrived in Bencoolen in 1818; and who made excursions inland and along the coast, and also crossed the island from Bencoolen to Palembang. He afterwards proceeded from Padang, on the south coast, and, traversing the first range of mountains, penetrated to the ulterior plains; and he describes the country as populous, well cultivated, and fertile. The hills which he passed rose to the height of 5200 feet, as estimated by the barometer, and the slopes were covered with plantations of coffee, indigo, maize, sugar-cane, and all the oil-giving plants, and the lower plains were almost exclusively occupied with rice. The rice-fields are managed in the same manner as those of Java, and were equal in fertility. After arriving at the summit of the steep ascent, he observes, "our view opened on one of the finest countries we ever beheld;" "as we descended," he continues, "the scene improved; we found ourselves in an immense amphitheatre, surrounded by mountains 10,000 and 12,000 feet high; the soil on which we stood rich beyond description, and vegetation luxuriant and brilliant in every direction; the people superior to those on the coast, in general about six feet high, and proportionably stout, with clear and clean skins, and an open ingenuous countenance. They seemed to have abundance of every thing; rice, the staple food of the country, being five times as cheap as at Bencoolen, and every other article of produce in proportion. The children were decorated with a profusion of silver ornaments, and particularly with strings of dollars and other coins hanging round their neck, to the value sometimes of 100 dollars. A fine breed of cattle," he continues, "which seems peculiar, abounds here, and throughout the Menangcabow country; oxen seem to be used in agriculture in preference to buffaloes; they are generally about three feet four inches high, beautifully made, and mostly of a light-brown colour, with black eyes and lashes, and are sold at from three to four dollars a head."[1] Here are also found many large and beautiful lakes, which extend at intervals through the interior of the country, and tend to facilitate the intercourse between its different districts. But little is known respecting the interior of this large and fertile island, or the dimensions, direction, and situation of the lakes. The most remarkable is one of great extent in the Batta country. There is a second in the country of Menangcabow, which is used by the inhabitants for transporting goods to and from Palembang; there is another in the Corinchia country; one in the Lampoon country, extending to Passumah, which is very large, and in which there are boats of a large size, which carry sails, and require a day and a night to cross it. This lake is stated by Mr Anderson, who visited the east coast of Sumatra in 1822, under the orders of the East India Company, to be very large, the shore not being visible from the opposite side. The borders of the lake are reported to be in a high state of cultivation, containing numerous villages, and a dense population. The lake has an island in the centre, where edible bird-nests, so highly prized as a luxury in China, are procured. Those who navigate this lake are mostly pirates, who plunder each other, and carry off their children, selling them for slaves.[2] The lake of Sincara, in one of the interior valleys of the island, is described by Sir Stamford Raffles as a beautiful sheet of water, about fourteen miles long by seven broad, surrounded by mountains and hills, except on one side, where it is bounded by a plain of its own width. On the margin of this lake for two or three miles are rice-fields, plantations, and villages, rising successively above each other, and advancing up the hill nearly to the summit of the first ridge, where the forest has been cleared, and cultivation extended. On the banks of this lake are situated seven principal towns, with their numerous villages and hamlets; which being shaded by trees, form so many groves, the dark foliage of which pleasingly contrasts with the bright tints of the rice-plantations in the middle of which they are placed. At each of these towns a weekly market is held, to which the traders from the other towns and adjacent countries repair by water. There are numerous canals, and each town has one or two large boats capable of carrying six tons with one hundred men. Sir Stamford sounded at a short distance from the shore, and found bottom at 68 fathoms; but in the centre no bottom was found at 180 fathoms. The lake abounds in fish.

From the direction of the mountains, which, as has been mentioned, approach near to the western coast, being only twenty miles from the sea, while on the eastern side there is an intervening country not less than 150 miles in breadth, all the largest rivers are found on that coast. The rivers on the western coast are numerous, but they are in general too small and rapid for the purpose of navigation. And it is the vicinity of the mountains on this side that occasions the profusion of springs, as well as their rapidity and diminutive size. They have not space to accumulate in so limited a range; while the extended declivity of the eastern coast not only presents a larger surface for the formation of rivers, by the reception of rain, and by the union of subsidiary streams, but gives them a more steady and uniform current, than where the torrent rolls immediately from the mountains. Those rivers on the eastern shore are the Siak, Indragiri, Jambi, and Palembang. They convey a large body of water into the ocean. They labour however under this inconvenience, that, owing to the continual action of the heavy surf from the great Indian Ocean, which is more powerful than the ordinary force of the stream, a bank of sand is thrown up at their mouths, which diverts their course to a direction parallel with the shore, till the accumulated waters at length force their way wherever there is least resistance. In the dry season, which is that of the southerly monsoon, the parallel course of the rivers is of the greatest extent; but during the rainy season, being in flood, they, by the greater force of their current, break through all obstructions, and recover their natural channel. The rivers on the western shores are Kataun, Indrapura, Tabuyong, and Sinkel, which, though not so large as those on the eastern shore, are still considerable streams.

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[1] Memoir of the Life and Public Services of Sir Thomas Stamford Raffles, p. 349.

[2] Mission to the East Coast of Sumatra, by J. Anderson, Esq., p. 252.

Climate.

The diversified surface of Sumatra gives rise to a considerable variety of climate; but it is remarkable, that on the sea-level near the shore the heats are more moderate than in other countries within the tropics. At the most sultry hour in the afternoon the thermometer fluctuates between 82 and 85 degrees: Marsden, whose work contains the fullest information concerning this island, mentions that he never saw it higher than 86 in the shade, and at sun-rise it is usually as low as 70. Inland, as the country ascends, the heat decreases rapidly, so that beyond the first range of hills the inhabitants find it expedient to light fires in the morning, and to continue them till the day advances. Frost, snow, and hail are unknown to the inhabitants in any quarter. The hill-country is liable to a fog, which is dense to a surprising degree; it is observed to rise every morning among the distant hills; the extremities of it when near at hand are perfectly defined; and it is seldom observed to disperse till about three hours after sun-set. The island is subject to the monsoons. Southward of the equinoctial, the south-east monsoon, or dry season, begins about May, and abates in September; the north-west monsoon begins about November, and the hard rains cease about March. For one half of the year the island is deluged with almost constant rains. Besides the monsoons, which vary every six months, there is a daily variation in the winds, which blow from the sea to the land during so many hours of each day, and during the night in the opposite direction, from the land to the sea, excepting only when the monsoon rages with remarkable violence; and even, says Marsden, "at such times the wind rarely fails to incline a few points, in compliance with the subordinate cause, which has not power, in these circumstances, to produce an entire change." On the west coast of Sumatra, the period of the setting in of the sea-breeze is about ten in the morning, after an hour or two of calm; and it continues till near six in the evening. The commencement of the land-breeze is about seven in the evening, when it prevails during the night, and dies away about eight in the morning. The land-wind in Sumatra is cold, chilly, and damp; an exposure to it is consequently dangerous to health, and sleeping in it is almost certain death. Thunder and lightning prevail in Sumatra in all their terrific grandeur, especially during the north-west monsoon, when the explosions are extremely violent: the forked lightning is seen in all directions, and the sky seems on fire, while the ground appears to tremble. The island is unfortunately subject to earthquakes, which often prove most destructive. Sir Stamford Raffles mentions, that a day previous to his arrival, a violent earthquake had occurred, which had nearly destroyed every building in the place. The shocks were experienced at intervals for several weeks. But the most violent of them happened on the 18th March 1818, during the night, and was truly awful. Every building in the town of Bencoolen suffered more or less; some were laid in ruins, and others so shattered that it was found scarcely worth while to repair them. The house which was occupied by Sir Stamford he describes as being rent from top to bottom, the cornices broken, and every thing unhinged. These earthquakes are said to occur every five or six years. An earthquake occurred in 1797, which continued for three minutes with vibratory shocks. At Padang the houses were almost entirely destroyed; about 300 lives were lost; some were crushed under the ruins of falling houses, some were swallowed up by the earth opening and closing over them, and others were drowned by the sudden irruption of the waters of the ocean.[1]

Soil, produce.

The soil has been celebrated for its fertility; but, according to Marsden,[2] it is rather sterile than rich. It is generally a stiff, reddish clay, covered with a stratum or layer of black mould, of no considerable depth, and burned to the state of a brick where it is exposed to the influence of the sun. From this there springs a strong and perpetual verdure of rank grass, brushwood, or timber trees, according as the country has remained for a longer or shorter period uncultivated; and this forest or jungle, as there is but a scanty population, affords abundant cover for wild beasts of the most ferocious kind, by which the country is infested. "There is nothing," says Sir S. Raffles, "more striking than the grandeur of the vegetation; the magnitude of the flowers, creepers, and trees, contrast strikingly with the stinted, and I had almost said pigmy, vegetation in England. Compared with the forest-trees of these tropical regions, your largest oak is a mere dwarf. Here we have creepers and vines entwining larger trees, and hanging suspended for more than 100 feet, in girth not less than a man's body, and many much thicker; the trees seldom under 100, and generally approaching 160 to 200 feet in height. One tree that we measured was, in circumference, nine yards, and this is nothing to one I measured in Java."[3] The most important article of cultivation is rice, of which there are many different species, which may be ranged under two kinds, namely, the upland rice, which grows on the high and dry grounds, and the lowland or marshy rice, which grows in the low and marshy grounds. The cocoa-nut tree may also be esteemed an important object of cultivation; it serves as an article of food, and is in universal consumption, being an ingredient in most of the dishes, and the oil being employed as an article for anointing the hair, and for burning in lamps. There are also large plantations of the betel-nut tree and the bamboo. The latter, growing thick into an impenetrable mass, is used in the fortification of villages. The sago tree also flourishes, and there is a great variety of palms. The sugar-cane is cultivated, but such is the indolence or ignorance of the inhabitants, that all the sugar which they require is imported from Java; all the use they make of the sugar-cane is to chew it. Maize, Chili pepper, turmeric, ginger, coriander and cummin seed, are raised in the gardens of the natives. Pepper is an important article of cultivation. The plant appears to flourish in any of the different soils that are found in this island, and it is a great article of commerce. The pepper plants, which are in even rows, running parallel and at right angles with each other, present a fine contrast to the wild scenes of nature which surround them. The camphire tree, which grows in the northern parts of the island, is valued for its juice, which is an article of trade, and sells at a high price. The benzoin is produced from a tree which grows in the northern parts of the island. Cassia and cotton are also produced, and form articles of export. Various other shrubs and plants are cultivated, and are converted by the natives to many useful purposes. Hemp is extensively cultivated, not however for the useful purpose of making ropes, but to procure an intoxicating liquor called *bang*, which they smoke in pipes along with tobacco. Plantations of the latter plant are met with in almost every district; and there is a variety of other creeping plants, which are manufactured into twine, thread, and other articles of the same nature.

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[1] Memoir of the Life and Public Services of Sir Stamford Raffles, p. 294.

[2] Marsden's History of Sumatra, p. 68.

[3] Memoir of the Life and Public Services of Sir Stamford Raffles, p. 317.

No country in the world is more distinguished than Sumatra for the variety of fine fruits with which it abounds, and which are the spontaneous produce of the earth; for the natives bestow no more care on this than on any other production. The most remarkable are the mangustin, which is produced in abundance, and which for delicacy and flavour holds pre-eminence over all the Indian fruits; the pine-apple, which, though not indigenous, grows in great plenty with ordinary culture; the orange, which is in great perfection and variety; the shadock of the West Indies, which is here very fine, and is distinguished into the white and the red. Limes and lemons abound; as also the bread-fruit; the jack-fruit; the mango, a rich high-flavoured fruit of the plum kind; the papaw, a fruit substantial and wholesome, like a smooth sort of melon, but not very highly flavoured; the pomegranate, the tamarind, nuts and almonds of different kinds, besides various other fruits of which the names are scarcely known in Europe. Owing to the equable temperature that prevails throughout the year, there is a perpetual succession of shrubs and flowers, which diffuse a pleasant fragrance, and are many of them used in medicine, or in affording useful dyes. The castor-oil plant is found in abundance, especially near the sea-shore; also the caoutchouc or Indian rubber plant; the indigo plant; a red wood called ubar, resembling logwood in its properties; and the uphas, or poison-tree, whose deleterious qualities have been so much exaggerated.

The zoology of Sumatra is distinguished by some of the most remarkable animals in nature. The shelter afforded by its vast forests or tracts of jungle is most favourable to the breed of wild animals, which abound throughout the island. Numerous herds of elephants range over the forests, and are pursued and killed for their teeth; they are extremely destructive to the plantations of the natives, which they trample down by merely walking through the grounds, and thus obliterating all traces of cultivation. The rhinoceros, both the single and the double horned, is also a native of the woods. Of the ferocious animals, the tiger is the most remarkable. Here he grows to an enormous size, and his strength is so prodigious that he is enabled to drag into the woods the largest prey, and by a stroke of the fore-paw will break the leg of a horse or buffalo. Whole villages are sometimes depopulated by these animals, and great numbers of inhabitants lose their lives. Sir Stamford Raffles, who fixed his residence in the interior, east of Bencoolen, among the hills, states, among its conveniences, that the temperature was six degrees lower than on the coast; and that the only inconvenience he could suffer would be from tigers and elephants abounding in the vicinity. One of the villagers mentioned to him, that both his father and grandfather had been carried off by these animals; and he adds, that there is scarcely a family that has not lost some of its members by them, and that on the banks of one of the rivers upwards of a hundred persons had been carried off by tigers the year before; yet the inhabitants are so superstitious that they will not use any means for their extirpation. When a tiger enters a village, these ignorant people prepare rice and fruits as an offering to the animal, conceiving that he will be pleased with these hospitable attentions, and pass on without doing them any harm. They are occasionally caught in traps, which are ingeniously contrived in the form of a cage with falling doors, into which the beast is enticed, and is then enclosed; or a large beam of timber is so placed as to fall on his back and crush him. Another expedient is to entice him to ascend a plank, which being nearly balanced, is weighed down by him when he is past the centre, and he falls upon sharp stakes prepared below. The natives sometimes contrive to poison tigers. The bear is common: he is small and black, and climbs the cocoa-trees, feeding upon the tender part or cabbage. The deer abounds in every variety of species; and the monkey tribes are innumerable. Here are also sloths, squirrels, teleggos or stinkards, civet-cats, tiger-cats, porcupines, hedgehogs, armadillos, bats of all kinds, alligators in the rivers, which are also haunted by the hippopotamus, guanos, cameleons, flying lizards, tortoises, and turtle. The alligators are very voracious, frequently destroying the people as they bathe in the river, according to their invariable custom, from which no dangers deter them. The house-lizards are four inches in length, and are the largest reptiles that can walk in an inverted position. Among the animals which are domesticated is the buffalo, which, however, exists in a wild state, and is a remarkably strong and active animal, keeping pace with the swiftest horse; and is even said by Marsden to fight an equal battle with the tiger, the females and weaker sort only being his sure prey. This animal supplies the inhabitants with milk, butter, and beef. The cow is a stranger to the country, and does not appear to be naturalized. The breed of horses is small, but they are well made and hardy. The sheep are also a small breed; the other animals are the goat and the hog, both domestic and wild; the otter, the cat, the rat, and the dog.

Reptiles. Frogs, toads, and reptiles of every kind, abound in the swamps; and the noise which they make on the approach of rain is tremendous. They fall a prey to the snakes, which are common in this island, and are of all sizes, some thirty feet in length, though Marsden states, that the largest he ever saw was only twelve feet long, which was killed in a hen-house, where it was devouring the poultry. He also mentions his opinion, that the bite of very few of these serpents is mortal, as he never saw a well-authenticated instance of a person suffering from them. Among the poisonous serpents is the viper; and the hooded snake is sometimes found in the country. The boa constrictor is the largest, and sometimes grows to the length of thirty feet, and is of proportionate bulk and strength.

Fish. The surrounding seas abound in fish. Among these are the dnyong, a large sea-animal of the mammalia order, with two strong pectoral fins serving for the purpose of feet; the grampus-whale, a fish which derives its name from the peculiarity of its dorsal fin resembling a sail. There are, besides, sharks, skates, the muræna gymnotus, rock cod, pomfret, mullet, the flying fish, and many others.

Birds. Of birds there is a much greater variety than of other animals; and so numerous are the curious species, that Marsden cannot even give a list of them. They consist of peacocks, eagles, vultures, kites, and crows, jackdaws, kingfishers; the rhinoceros bird, remarkable for its horn; the stork, the snipe, coot, plover, pigeons, quails, starlings, swallows, minas, parrots and parroquets, geese, ducks, teal, &c. The Sumatran pheasant is a bird of great magnificence and beauty; the plumage being perhaps the most rich, without any degree of gaudiness, of all the feathered race.

Insects. The island may be said literally to swarm with insects, which are extremely annoying and destructive. These consist of cochroaches, crickets, bees, flies of all sorts, mosquitoes, scorpions, centipedes, and water and land leeches. These leeches are extremely annoying to those who travel in the woods; and Sir Stamford Raffles mentions, that in his journeys through the woods they got into the boots and shoes of the travellers, which were filled with blood. Ants exist in immense numbers and varieties. The white ant, well known for its mischievous properties for destroying papers, furniture, &c. is found in great numbers; also the great red ant, about three fourths of an inch long, which bites severely, and usually, like the bee, leaves its sting in the wound. There are also the common red ant, the minute red ant, the large black ant, which is equal in size to the large red ant; the fire-fly, which is larger than the common fire-fly, and emits so vivid a light that words may be read by it.

Minerals.

Sumatra abounds in minerals. Gold is chiefly found in the mountainous districts in the interior of the island. No gold has been found, at least very frequently, to the southward of Limon, a branch of the Jambee river, or to the northward of Nalaboo, whence Acheen is principally supplied. Menangcabow has always been famed since the earliest periods of history for the riches of its gold mines, its iron ores, and its mineral productions in general; on which account it was that the Dutch were induced to establish their head factory in its neighbourhood. Its jurisdiction in ancient times extended over the whole of Sumatra; and it is situated about eighty miles inland from Padang, and nearly in the centre of the island. The Malays are attracted to all the districts where gold is found. They are the only persons who collect it, or dig for it; the original inhabitants confining their attention to the raising of provisions, with which they supply the Malays who search for the metal. It is found in earth taken up from the beds of rivers. and washed till the pure grains are separated and cleansed from the particles of mud and stone. The gold is found in a pure metallic state; and they simply beat or wash it, and sell it in the lumps or dust in which they find it. Some pieces have been found pure that weigh six or seven ounces; and they are sometimes joined with an equal bulk of marble, which does not detract from their value, being sold as mineralogical specimens. In some of the specimens the gold may be said rather to enclose the rock, than the latter to contain the gold. No accurate account can be obtained of the quantity of gold exported. From the west coast Marsden estimates that 10,000 ounces may be annually exported. But he has no data to calculate the exports from the eastern coast. It has been conjectured that the whole may amount to 15,000 ounces. It was sold at the settlements for L.3. 5s. per ounce, but afterwards rose to L.3. 18s., which would yield no profit on its exportation to Europe. The gold-dust is cleansed from impurities by a very dexterous process. A skilful person called a Pundi is employed, who by the sharpness of his eye can distinguish the dross from the ore with surprising nicety. He spreads out the dust on a kind of wooden platter; and the bare particles are touched and put aside with a piece of linen cloth rolled up to a point. There are no silver mines; but there are copper mines, of which the ore is very rich, and which resembles the Japan copper in the appearance which it presents of a mixture of gold. In the country of Menangcabow, which is nearly in the centre of the island, iron ore is collected, smelted, and formed into metal. The colour of the soil indicates its existence in many parts of the island, especially on the sea-coast, where the sand is of a strong shining black, and is attracted by loadstone. The steel which is here manufactured is of a peculiar temper, and has a degree of hardness that has never been imitated in Europe. There is, however, no industry in the island to profit by these products, and the consumption of the natives is chiefly supplied by English and Swedish bar-iron. Tin is one of the great mineral products of the island. It chiefly abounds in the neighbourhood of Palembang, on the east coast; but in many other parts its existence is indicated, and particularly in the neighbourhood of Bencoolen. Sulphur is gathered in any quantity near the volcanoes, which abound in the island; yellow arsenic is also found, and is an article of traffic; and saltpetre is procured chiefly in extensive caves, the haunt of certain species of birds, of whose dung the soil is formed. Coal exists in various parts, and is washed down to the coast in floods: it is not esteemed good, being found near the surface of the earth. The veins are observed to run, not exactly in a horizontal direction, but to dip downwards; and till the pits have a certain depth no good coal is to be found. Mineral and hot springs are discovered in many districts, the waters resembling those of Harrowgate, and being nauseous to the palate. In the caves where the saltpetre is formed are found the edible bird-nests which are so highly prized in China as a luxury of the table, and to that country they are exported as an article of traffic. Some of the company's servants advanced into one of these caves 740 feet, when his lights were extinguished by the damp vapour; and into another 600 feet, through a narrow passage three feet wide and five feet high, which led into a spacious place forty feet high. Bees' wax is a commodity of great importance in all the eastern islands, and is exported to China, Bengal, and other parts of the continent, though no trouble is taken with the bees, which are left to settle where they list, and are never collected in hives. The honey is of a poor quality. Gum-lac, which, though found adhering to the branches of trees, is known to be the work of insects, as wax is of the bee, is procured in small quantities from the country near Bencoolen, and at Padang is a considerable article of trade. It is chiefly valuable for the animal part, which is soluble in water, and yields a fine purple dye. Ivory is an article of export; and elephants also are sent to the Coromandel coast, vessels being built expressly for their transport. The following are the general articles of import, as enumerated by Marsden in his comprehensive account of this island. From the coast of Coromandel, salt, blue and white cloths, chintz, and a variety of other cotton goods; from Bengal, opium and taffetas; from China, coarse porcelain, tobacco, and a number of miscellaneous commodities; from the eastern islands, a striped cotton manufacture, guns, krises, and other weapons, salt and rice; from Europe, silver, iron, lead, cutlery and other hard ware, brass wire, and scarlet cloth.

Manuf tures.

The Sumatrans are a rude people, and have made no great progress in manufacturing industry, yet there are some particular manufactures in which they excel. Many of those who have visited this country entertain an opinion that in former times it was the seat of a great Malay empire, of which Menangcabow was the capital, where arts and industry flourished; and the monuments that have been discovered by Sir Stamford Raffles afford evidence of a higher state of refinement than at present prevails. In the histories of former times, it is mentioned that great founderies of cannon were established at Acheen; and that manufactories of fire-arms and knives were carried on at Menangcabow. If this were the case, the arts have degenerated since that period, as there are now no manufactories of iron, except of nails, and various kinds of tools, such as adzes, axes, hoes, &c. They are equally ignorant of the art of the carpenter; they do not even know how to use a saw, excepting where they have been instructed by the British, by whom this instrument has been introduced. They fell trees by means of a hatchet; and when they wish to split the wood into stems, they must choose those kinds of wood of which the direction of the grain admits of its being easily split asunder. They have woods of certain qualities, which, by the help of wedges, they are enabled to split into boards. Their chief cement is made of buffalo milk, which in a hot and damp climate proves a much stronger cement than glue. They make ink by mixing lamp-black with the white of an egg. They are however very curious and ingenious in carving, both in wood and ivory, though they show no taste in their designs, which are grotesque and out of nature. The handles of their knives are the chief subjects of this art; and these are in general curiously ornamented with the head and beak of a bird, or with the folded arms of a human being. In the interior, according to the observation of Sir Stamford Raffles, manufactures are more advanced. Menangcabow has always been famed for the manufacture of its kris blades. In its vicinity iron has been worked from time immemorial; and an extensive manufactory of coarse pottery, near the banks of the lake, supplies not only Padang, but Bencoolen, with that useful article. The Sumatrans are entire strangers to the art of painting and drawing. In cane and basket work they are particularly neat and expert, as well as in mats; of which some kinds are much prized for their extreme fineness, and for the beauty and taste of the borders with which they are ornamented. They excel also in the manufacture of silk and cotton cloths of varied colours, chiefly for domestic use. These are worn in all parts of the country by the natives, and especially by the women. Some of their work is very fine, and the patterns prettily fancied. Their apparatus for weaving is, however, of the rudest description, and renders their progress tedious. The women are expert at embroidery, the gold and silver thread for which is procured from China, as well as their needles. Gunpowder is manufactured in various parts of the island, chiefly among the people of Menangcabow, the Battas, and Achenese, among whom, as they are frequently at war, it is an article in great request. It is not, however, well made, being imperfectly granulated, and often hastily prepared for immediate use. Different kinds of earthenware are manufactured in the island. The manufacture of filagree is here carried to the greatest perfection. There is no manufacture in any part of the world that has been more justly admired and celebrated than the fine gold and silver filagree of Sumatra; but this is not the work of the Sumatran artisan; it is a manufacture of the Malays, the original and ancient inhabitants, to whose superior taste and industry many of the monuments of art which remain are ascribed. This manufacture is in universal use in the country; and its fineness and beauty form a singular contrast to the coarseness of the tools which are employed in the workmanship, and which are rudely and inartificially formed by the goldsmith from any old iron that he can pick up. A piece of iron hoop as a wire-drawing instrument, an old hammer-head stuck in a block as an anvil, and two old nails tied together as a pair of compasses, are the chief instruments. They have no bellows, but blow the fire with their mouths through a reed. They are very inexpert at polishing the plain parts, but in other respects nothing can exceed the extraordinary delicacy of the Malay work. They are extremely expert in manufacturing fishing-nets, and springes for catching birds.[1]

Sc es. The proficiency of the Sumatrans in science is very limited. Their numeration table does not extend beyond tens of thousands. Their utmost attainment in arithmetic is to multiply and divide several places of figures. Of geography they have no idea whatever. They know not that the country they inhabit is an island, nor have they any general name for it. Habit renders them expert in travelling through woods, where they perform journeys of weeks or months without seeing a dwelling. In the pathless woods they make marks on the trees for the future guidance of themselves and others. They have no notion of astronomy; and the Malays, as well as the Arabs and other Mahommedans, fix the length of the year at 354 days, or twelve lunar months of twenty-nine and a half days. They mark the time of the day by the position of the sun in the heavens; which is sufficiently exact for all practical purposes so near the equator, where the sun ascends and descends almost perpendicularly, and rises and sets at all seasons of the year within a few minutes of six o'clock. They are entirely destitute of either history or chronology, the memory of all past events being only preserved by tradition. Their literary compositions, says Sir Stamford Raffles, seldom go farther back than the introduction of Mahommedanism, except to give some romantic tale, from which little or nothing can be gathered. But he adds, "it was my good fortune to discover in Java the vestiges of a former high state of literature and the arts, in poems, in the ruins of temples, in sculptured images, in ancient inscriptions." This active and philosophical inquirer into the ancient state of these eastern countries discovered also monuments in Sumatra, inscribed with characters which corroborated all his views concerning their ancient civilization. The people are fond of music, and have many instruments, which are mostly borrowed from the Chinese and other eastern nations. Their musical instruments are chiefly of the noisy kind; and they have no science, though they have a few simple tunes. In Sumatra the art of medicine is at an equally low ebb with the sciences. It consists in the application of a few simples, and chiefly in certain charms. Every old man or woman is a physician; and they are rewarded in proportion to their success, though they generally contrive to procure payment in advance for the charms which they dispose of to their patients. They either administer juices inwardly, or they apply outwardly the juices of certain trees, or, chopping their leaves small, they apply them as poultices. They have no knowledge of anatomy, nor do they practise phlebotomy. The inhabitants are assailed with leprosy under various forms. It is sometimes a disease of the skin; but there is another form of the disease, under which the flesh mortifies and falls off the bones; and the disorder being deemed infectious, the patient is driven into the woods, where victuals are left for him from time to time by his relatives. The small-pox makes terrible ravages in the island, and the inhabitants have a great dread of this loathsome and fatal disease. Among the other great benefits, the enlightened Sir Stamford Raffles introduced among them the vaccine inoculation, which they expressed the utmost willingness to receive. Insanity they imagine to be a possession by the evil spirit; and their mode of exorcism is to enclose the unfortunate victim in a hut, to which they set fire about his ears, suffering him to make his escape through the flames in the best manner he can. This, along with other barbarous practices, marks the little progress which they have made in knowledge or moral improvement.

Language. The Malay language, which is understood to be the original language in the peninsula of Malacca, has extended itself through all these Asiatic islands, and has become the common tongue in this part of the globe, being spoken everywhere along the coasts of Sumatra. It also prevails in the inland country of Menangcabow, and is understood in almost every part of the island. From the smoothness and sweetness of its sound, it has been called the Italian of the east. Their writing is in the Arabic character, very little corrupted; owing to which, and the adoption of the Mahommedan religion, a great number of Arabic words are incorporated with the Malay. Various other languages are spoken in Sumatra besides the Malay, which all, however, bear a manifest affinity to each other, and spring from the same root; and this common language is spread over all the islands in the Eastern Seas, more or less corrupted in different places, but still retaining the same stock of radical words. Marsden has remarked, that in the most distant places, "as the Philippines and Madagascar, the deviation of the words is scarcely more than is observed in the dialects of neighbouring provinces in the same kingdom."[1]

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[1] Marsden's Sumatra, p. 41, &c.

Political divisions.

It is conjectured that in former times Sumatra was the seat of an extensive Malay empire, and of arts and commerce. All traces of this empire are now obliterated, and it is only from the monuments of ancient architecture that such historical inferences are drawn. The modern divisions of the island are chiefly the empire of Menangcabow and the Malays, the Achenese, the Battas, the Rejangs, and the people of Lampong.

Government, manners, character.

The government among them seems chiefly aristocratical. It is the rule of chief men, and in some parts the despotic assumption of power by some aspiring chief. Their government, however, seems to be founded in opinion; their submission is voluntary. Almost all the governments throughout the island partake of the patriarchal and the feudal. Where the people by conquest have been compelled to submit to a foreign yoke, feudal manners are followed; where, on the other hand, the natives have been long undisturbed by revolutions, the patriarchal sway prevails. The Malay and the native Sumatran differ in mind fully as much as in features and person. The Malay inhabitants have an appearance of degeneracy from those ancient virtues which laid the foundation of an extensive empire. Their portrait, as drawn by various travellers, has many dark traits. Marsden describes them as proud, yet without that pride which restrains them from meanness and fraud. They can practise low cunning and the most plausible duplicity, dissembling under an outward calmness the strongest passions and most inveterate antipathy, until the moment of gratification is found. Veracity, gratitude, and integrity, are not among their qualities. They seem to make no distinction between honour and infamy; and their courage is the result of some momentary and vindictive impulse, which hurries them on to deeds of desperation, not that calm and steady valour which distinguishes the European in the day of battle. These harsher traits of the Malay character are greatly softened in the portrait drawn by Sir Stamford Raffles. Their piracies he traces to their warlike disposition, which, he observes, only requires to be directed into a better course; and their vindictive spirit, to high notions of honour. The attacking his enemy with the kris by the Malay is the counterpart of duelling among the European nations. He proudly defends his property, his life, and character in this manner, which is not secured to him by law; and he seldom draws his kris except in defence of his honour, or in some warlike enterprise. This practice, however reprobated, has produced a habitual good breeding among the Malays.[2] The original Sumatran has many of the Malay vices, and some virtues belonging to himself, which are however of the negative kind. He is mild, peaceable, and forbearing, but when roused to resentment he is implacable. He is temperate and sober, abstemious both in meat and drink. His diet consists of vegetables, and water is his only beverage; yet his hospitality is extreme, and bounded only by his ability. The Sumatrans are continent in respect to women, modest and courteous in their behaviour, grave in deportment, seldom excited to laughter, and habitually patient. On the other hand, they are litigious, indolent, and addicted to gaming. They gamble with dice or with shells, and have various games on chequered boards and other delineations. They are addicted to cock-fighting in an extraordinary degree; and when in affluent circumstances, their propensity to it is so great that it resembles rather a serious occupation. Quarrels, attended with dreadful consequences, have often arisen on these occasions.

Laws, customs.

The Sumatrans have no written code of laws and their various disputes are settled by custom and precedent. There is no class of persons invested with legislative powers. The chiefs of districts judge in cases both civil and criminal. In pronouncing their decision, they do not say such is the law, but such is the custom; and their decision is generally submitted to. The want of written laws was supposed by the East India Company's servants likely to occasion endless disputes; and in the year 1779 a code was promulgated for the benefit of those under their jurisdiction. It may be greatly doubted, however, how far such a system, constructed by Europeans, would suit the wants of an uncivilized people, in preference to their own tried and well-known modes, however rude and inartificial. Legal disputes chiefly originate among them in the intricacy of marriage-contracts. Their laws of marriage are very coarse and rude; a wife being obtained by purchase, and becoming to all intents and purposes the property and slave of her husband, who may dispose of her, only making the first offer to her relations. When a man dies, his effects are equally distributed among his children; but if one possesses remarkable abilities above the rest, he receives a larger portion; a contrivance, apparently, for producing division and strife. Land is so plentiful among them, that they rarely consider it a subject of right; another proof of the low state of civilization. They have few capital punishments, and, according to Marsden, corporal punishment is rare; murder being compensated by money, and adultery being punishable by fine. But recent discoveries by Mr Marsden himself, and by Sir Stamford Raffles, as well as by others who have lately visited the island, have laid open among the Battas and other interior tribes such horrid and ferocious practices, as would not be believed unless authenticated by evidence above all dispute. The Battas are an extensive and populous nation, occupying the whole of that part of the island lying between Acheen and Menangcabow, reaching to both shores. The coast is but thinly inhabited; but the people are said to be as thick as the leaves of the forest, and to amount to between one and two millions. Their laws are remarkably severe; and for adultery, midnight robbery, for intermarrying in the same tribe, or for a treacherous attack on a house, village, or person, the criminals are condemned to be eaten alive, which shocking sentence is actually carried into execution by these savages. They also eat the prisoners taken in war. The mode of proceeding is thus described. "The victim is tied to a stake with his arms extended; the party collect in a circle around him, and the chief gives the order to commence eating. The chief enemy, when it is a prisoner, or the chief party injured in other cases, has the first selection; and after he has cut off his slice (the victim being alive), others cut off pieces according to their taste and fancy, until all the flesh is devoured. It is either eaten raw or grilled, and generally dipt in sambul, a preparation of Chili pepper and salt, which is always in readiness. Rajah Bandaharru, a Batta, and one of the chiefs of Tappanooly, asserted that he was present at a festival of this kind about eight years ago, at the village of Subluan, not nine miles distant, where the heads may be still seen. When the party is a prisoner taken in war, he is eaten immediately, and on the spot. Whether dead or alive, he is equally eaten; and it is usual even to drag the bodies from the graves, and, after disinterring them, to eat the flesh." Sir Stamford relates another example of this practice, too horrid to be detailed, at which the British resident was invited to attend; and after a great part of his flesh was eaten while he was still alive, one man approached and stabbed him to the heart; which, he adds, "was rather out of compliment to the foreign visitors, as it is by no means the custom to give the

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[1] Marsden's Sumatra, p. 163.

[2] Memoir of the Life and Services of Sir Stamford Raffles, p. 256.

coup de grace."[1] Such details present a shocking picture of the ferocious habits of these worse than savages; and few will, after this, be inclined to listen to Sir Stamford's praise, that "they are honest and honourable, and possess many more virtues." It seems an abuse of the name of virtue to couple it with such brutalities.

Till about 150 years ago, the southern coast of Sumatra was dependent on the king of Bantam, whose deputy collected the tribute of pepper, and filled up any vacancies in the magistracy, by nominating new functionaries, or confirming those already chosen. Soon after this time the English established a settlement at Bencoolen, and the deputy of the king of Bantam informed the chiefs that he should visit them no more; and raising two chief men to the supreme power, he gave into their hands the government of the country, and withdrew his master's claim. The interior of the country is ruled by princes or chiefs. Near the sea-coast it is much influenced by the Europeans, who are virtually the rulers; but the influence of the East India Company's residents never extended to any distance in the interior, which was indeed not known until it was explored in 1818 by Sir Stamford Raffles. In the districts adjacent to the coast the power of the resident was exerted for the benefit of the people. He has always been considered their protector from the injustice and oppression of their chiefs. By fraud and legal chicanery, though not by open acts of violence, they take advantage of the ignorant and necessitous, and contrive to strip them of their property, their family, and their liberty. To prevent these iniquitous practices, the perversion of justice in consequence of bribes, the subornation of witnesses, and such like practices, the resident's authority has always been useful; and when it is accidentally relaxed, oppression and disorders ensue.

The British settlement at Bencoolen has however been the scene of great disorders, arising from the mal-administration of the residents sent thither by the Company. Although it was one of the first establishments formed by the Company in the east, it had benefited less than any other part of the country under their control. The establishment formed was solely for the purpose of procuring pepper, in a country deficient in population, and in a new and unappropriated soil, which could only be rendered productive by capital and industry. The expenses of the establishment amounted to L.100,000 per annum, the returns were only a few tons of pepper. On the first formation of their settlements on the coast of Sumatra, the Company held the native chiefs bound to compel their subjects each to cultivate a certain number of pepper vines, the produce to be delivered exclusively to the Company's agents, at a price far below the value of the labour employed in the cultivation. For a certain time, while the influence of the chiefs continued, the stipulated quantity of pepper was delivered to the agents; but the oppression soon began to be heavily felt; the cultivators withheld their labour, and the chiefs, destitute of the power to force it, left to the Company's agents the cruel task of driving the people to their unprofitable toil. Prior to 1801, the establishment maintained at Fort Marlborough was considerable; and the private trade of Bencoolen, carried on by the governor and council, and the servants of the Company, was extensive, and contributed to the improvement of the settlement. The trade consisted in the importation of articles from Western India, which were principally exported to the Java market. From the restrictive policy of the Dutch government, and the corruption of its servants, a contraband trade had arisen, which was carried on, particularly that portion of it which consisted in opium and piece-goods, through the medium of Bencoolen. In 1801 the original establishment of Fort Marlborough was reduced, and it became a dependency of Bengal; and a strictly economical and purer system of administration being introduced by Mr Parr, the resident, great reductions took place in all the public establishments, by which numbers of people were suddenly thrown out of employment, and many reduced to starvation. At the same time, contracts were entered into for a certain quantity of labour, to be employed in the cultivation of pepper, and the pepper plantations were farmed out to the Company's servants; and, that the resident might have an interest in forcing the people to cultivate pepper, he was allowed one dollar per cwt. on the quantity delivered to government. Along with pepper, Mr Parr endeavoured to enforce the cultivation of coffee; and a long series of measures, offensive to the natives, was also carried into effect. Insults were offered to the principal chiefs, which produced a deep feeling on men of violent and vindictive tempers; and the attempt to compel the cultivation of coffee brought matters to a crisis. A deep-laid plot was formed for vengeance; the measures of the government were fully discussed; secret oaths were administered, and the revolt soon after broke out. The government-house was surrounded, the guards were overpowered, and the resident, blind to his danger, was murdered. The measures that followed were dictated by the spirit of revenge. It was thought unsafe to touch the chiefs; but several of the people were blown from the mouths of guns. Every village within a certain distance was consigned to the flames, and the country was laid waste, as if it were intended to surround the settlement with a desert. For its protection, the fruit-trees, venerable from age, and considered as the tutelary deities of the place, and their destruction an act of sacrilege, were cut down; every thing that could afford shelter was levelled with the ground, and the inhabitants were turned loose upon the country, forbidden to appear with krises, and degraded by every stigma that jealousy could devise. Of 1000 head of cattle possessed by one village, only 300 remained in 1820, the rest being either stolen, shot, or dispersed.

In 1818, when Sir Stamford Raffles landed at Bencoolen as lieutenant-governor, he beheld nothing but dilapidation and ruin; the roads impassable, the highways overrun with rank grass, the government-house a den of ravenous dogs and polecats. As the chief revenue of the government was derived from gaming and cock-fighting farms, these immoral practices were publicly patronized by it. The consequence was, that there was no security either for person or property; murders and robberies were daily committed, and never detected; and the grossest profligacy was seen in every direction. The new governor, with that rare union of wisdom and benevolence which so eminently qualified him for a legislator, immediately commenced measures of reform. The African slaves who were employed in the hard work of the colony, and who were dissolute and depraved, and their children in a state of vice and wretchedness, were declared free before an assembly of native chiefs; the forced cultivation of pepper was abolished; the people were allowed as formerly to wear krises and other weapons, according to immemorial usage. The gaming and cock-fighting farms, so destructive of every principle of good government, social order, or morals, were abolished; and various reforms of other evils equally mischievous were carried into effect. Under the wise, beneficent, and enlightened rule of Sir Stamford Raffles, it is scarcely necessary to add, that the country, the revenue, the trade, and the morals of the people, began to improve. He was a rare example of true disinterestedness and patriotism. The object of his life was the happiness of the people under his sway; his wisdom suggested the means; and the eminent success of his plans, both in Sumatra and in other places, attest the judgment with which they were formed. During his short administration the cultivation of rice was extended, the spice plantations were established, the population increased, and the people were conciliated; so that this wise and beneficent ruler had good reason to boast that he was making a country and a garden out of a wilderness, and laying the foundation of the future civilization of Sumatra. We have no data for estimating the population of this island. Sir Stamford reckoned the inhabitants of the Batta country, the valley beyond the first range of mountains, to be between one and two millions. But this is merely a conjecture, and there are many districts still unexplored. The British establishment at Bencoolen was withdrawn in 1824, when Sumatra was relinquished to the Dutch. (F.)

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[1] Memoir of the Life and Services of Sir Stamford Raffles, p. 426.

SUMAUN, a town of Hindustan, province of Agra. It is twenty-eight miles north-north-east from the town of Etaweh. Long. 79. 5. E. Lat. 27. 6. N.

SUMBAWA, a large island in the Eastern Seas, about 180 miles in length by forty in average breadth. It is situated between the eighth and ninth degrees of south latitude, and is separated from Lombhook by the Straits of Allass. It is almost divided into two equal parts by a deep bay, which indents it in the middle. This island is divided into the different states of Beema, Dompoo, Tambora, Sangur, Pekat, and Sumbawa, all governed by their respective chiefs, who were formerly either allies or under the protection of the Dutch East India Company, and were all sufficiently obedient, with the exception of the chief of Sumbawa, who rebelled. Near the north-east end of the island, on a fine bay which stretches seven or eight leagues south, is situated the town of Beema, remarkable for its excellent harbour, the sides of which are bold and high, and the approach safe; but the passage through is sometimes dangerous, from the strong current which generally prevails, and the great depth of water, as 100 fathoms of line, though close in shore, will hardly reach the bottom. The channel in some places is only 150 or 200 yards across; but the depth is so great that a ship of the line may sail on either side within thirty yards of the rocky mountains. These give a grand and picturesque appearance to the channel, which terminates in a safe and commodious basin, presenting one of the finest harbours in the world. On the east side of the bay stands the town of Beema, which comprehends under its jurisdiction the Straits of Sapy, the whole of Manzeray, and the island of Gonong Api. The island produces sappan wood, rice, horses, saltpetre, sulphur, wax, birds' nests, tobacco, &c., though there is but little trade carried on at this place. The number of horses exported under the appellation of Beema horses is very considerable. There are two volcanic mountains in the island, Gonong Api and another, which are looked upon with superstitious veneration by the inhabitants. Gold-dust is found in Sumbawa, particularly in the district of Dompoo, which also supplies teak-timber. Pearls are fished for in the large bay to the westward of Beema Bay, as also at Pekat.

SUMBHULPORE, a district of Hindustan, in the province of Gundwana, situated between the twenty-first and twenty-second degrees of north latitude. It is of an unwholesome atmosphere, especially to foreigners, owing to the mountainous and woody nature of the country, to the sudden vicissitudes of heat and cold, and to the quantity of jungle which it contains. The soil in the valleys is a rich loam, which produces sugar, cotton, and all kinds of grain; and in the mountains gold and diamonds are found. This district constituted the ancient kingdom of Gurrah, and was overrun by the armies of Aurungzebe. On the decline of the Mogul empire it became independent; and in the war between the British and the Mahrattas in 1803 several of the pergunnahs or parishes were taken possession of by the former. The capital, which is of the same name, is situated on the east side of the Mahanuddy river. Long. 83. 47. E. Lat. 21. 33. N.

SUMBOONHAUT, a town and temple in the Ghoorkha country, in Nepaul. It is celebrated for a temple containing from time immemorial the sacred fire, and is annually resorted to by innumerable pilgrims from Bootan and Thibet, and is a source of considerable revenue to the Nepaul government. Long. 85. 38. E. Lat. 27. 33. N.

SUMBUL, a town of Hindustan, province of Delhi, and district of Bareilly, situated on the Yarvufadur river. It is fifty-two miles west-north-west from Bareilly.

SUMISHORE, a town of Hindustan, in the province of Bahar. It is forty-six miles west-north-west from Bettiah. Long. 84. 15. E. Lat. 27. 15. N.

SUMMER, the name of one of the seasons of the year, being one of the quarters when the year is divided into four quarters, or one half when the year is divided only into two, summer and winter. In the former case, summer is the quarter during which, in northern climates, the sun is passing through the three signs Cancer, Leo, Virgo, or from the time of the greatest declination, till the sun again comes to the equinoctial, or has no declination; which is from about the 21st of June till about the 22d of September. In the latter case, summer contains the six warmer months, while the sun is on one side of the equinoctial; and winter the other six months, when the sun is on the other side.

SUMNUM, a small town of Persia, in the province of Khorassan. It is the capital of a rich district containing fifty villages, and bounded on the north by Mount Elburz, and on the south by the Great Salt Desert.

SUMY, a city of Russia, the capital of a circle of the same name, in the province Slobod-Ukraine, 911 miles from St Petersburg. It stands on the river Psiol, where the Sumy falls into it. It is surrounded with walls and ditches, contains two stone and eight wooden churches, 1230 houses, with 13,600 inhabitants, who distil much brandy, and are celebrated for the horses which they breed. Long. 28. 1. E. Lat. 50. 50. N.

SUMPTUARY Laws (*Leges Sumptuariæ*), are laws made to restrain luxury. Most ages and nations have had some such laws. Political writers have been much divided in opinion with respect to their utility. Montesquieu observes that luxury is necessary in monarchies, as in France, but ruinous to democracies, as in Holland. With regard to England, whose government is compounded of both species, it may still be a dubious question, says Blackstone, how far private luxury is a public evil, and as such cognizable by public laws.

SUN, Sol, ⊙, in *Astronomy*, the great luminary which enlightens the world, and by its presence constitutes day.

SUNBURY, a town of the county of Middlesex, in the hundred of Spelthorne, eighteen miles from London. It is finely situated on the left bank of the Thames, between Hampton Court and Shepperton, and is much resorted to by the lovers of angling in the summer season. The population amounted in 1811 to 1655, in 1821 to 1777, and in 1831 to 1863.

SUNDA, Straits of. The arm of the sea which separates the large islands of Sumatra and Java is so called by the Europeans, and by the Malays Sunda Kalapa. The length of this channel, taken from the flat point to Varkens or Hog Point, is about seventy miles; and on the opposite coast, from Java Head to Bantam Point, about ninety. The passage, though wide, is occasionally dangerous, from the currents. There are two passages formed by Prince's Island, which lies in the mouth of the straits; one between it and Java, which is generally made use of during the south-west monsoon, in order that they may approach as close as possible to the shore, so as to anchor to escape the danger of being driven to sea by the currents which set strongly out of the straits to the westward. The other passage, called the Great Channel, is sometimes resorted to during the south-east monsoon; but it is navigated with the greatest difficulty, in consequence of the opposition from the south-easterly gales. In the narrowest part of the straits is an island, which, from its situation, is called Thwart the Way, or Middle Isle; on both sides of which a strong current runs during the whole year, setting with the prevailing easterly or westerly winds either to the north-east or south-west. The other chief islands in the straits are Prince's Isle, Krakatau, and Pulo Baby. The rest are small and insignificant, mostly level, founded on beds of coral, and covered with trees.

SUNDAY, or the LORD'S DAY, a solemn festival observed by Christians on the first day of every week, in memory of our Saviour's resurrection. In the Breviary and other offices, we meet with Sundays of the first and second class. Those of the first class are, Palm, Easter, Advent, and Whitsunday, those of *Quasimodo* and *Quadragesima*. Those of the second class are the common Sundays. Anciently each Sunday in the year had its particular name, which was taken from the introit of the day; which custom has only been continued to some few in lent; as *Reminiscere, Oculi, Lætare, Judica*. Some are of opinion that the Lord's Day mentioned in the Apocalypse is our Sunday, which they believe was so early instituted by the apostles. Be this as it may, it is certain a regard was paid to this day even in the earliest ages of the church; as appears from the first Apology of Justin Martyr, where he describes the exercise of the day as not much unlike to ours. But it was Constantine the Great who first made a law for the proper observance of Sunday; and who, according to Eusebius, appointed it should be regularly celebrated throughout the Roman empire. Before him, and even in his time, they observed the Jewish Sabbath as well as Sunday; both to satisfy the law of Moses, and to imitate the apostles, who used to meet together on the first day. By Constantine's law, promulgated in 321, it was decreed, that for the future the Sunday should be kept as a day of rest in all cities and towns; but he allowed the country people to follow their work. In 538, the council of Orleans prohibited country labour; but because there were still many Jews in Gaul, and the people fell into many superstitious uses in the celebration of the new Sabbath, like those of the Jews in that of the old, the council declares, that to hold it unlawful to travel with horses, cattle, and carriages, to prepare food, or to do any thing necessary to the cleanliness and decency of houses or persons, savours more of Judaism than of Christianity.

SUNDAY ISLAND, a small island on the east coast of New Holland, discovered by Captain Bligh in 1788. Lat. 11. 58. S.

SUNDEEP ISLE, an island of Bengal, in the district of Chittagong, about twenty miles in length by ten in breadth. It is the seat of a salt manufacture by the government, subordinate to the Bulwa and Chittagong agency. The soil is fertile and affords excellent pasture for cattle, and might be easily rendered of much more value than it is at present; but its station for the manufacture of salt supersedes every other use. Ships may safely approach it on all sides except the north. The entrance of the river is safe, and it possesses good anchorage, where ships may remain safe during the adverse monsoon; but the climate is dangerous to Europeans. The town is situated about a mile from the western shore, on the north bank of a creek called Sittal. Towards the end of the sixteenth century a number of Portuguese had settled on the coasts of Arracan and Chittagong; and, having recommended themselves by their bravery and maritime skill, had risen to considerable commands in the service of the native princes. But in consequence of their turbulent conduct, they were expelled by the rajah of Arracan from his dominions, and many of them put to death. A remnant however joining together, elected Sebastian Gonzales for their chief, who took possession of this island, and having collected about 3000 men, extended his conquests. He was at last subdued by the rajah of Arracan, who retained possession of the island till 1666, when it was conquered by the Mogul armies, and came into the possession of the British along with the province of Bengal. Long. of the town 91. 36. E. Lat. 22. 25. N.

SUNDELLA, a town of Hindustan, in the nabob of Oude's territories. It is thirty miles north-west from Lucknow. Long. 80. 30. E. Lat. 27. 5. N.

SUNDERBUNDS, an extensive and woody district of Bengal, situated at the mouth of the eastern or great branch of the river Ganges. It is a dreary region, consisting of a labyrinth of rivers and creeks, all of salt, except those that communicate immediately with the principal arm of the Ganges, these numerous natural canals being so disposed as to form a complete inland navigation. Bishop Heber describes the prospect on the banks of the river as a dismal unbroken line of black wood and thicket, apparently impenetrable and interminable, which, he adds, "one might easily imagine to be the habitation of every thing monstrous, disgusting, and dangerous, from the tiger and the cobra de capello down to the scorpion and mosquito. The seamen," he continues, "spoke of the shore with horror, as the grave of all who were so unfortunate as to remain many days in its neighbourhood." On a nearer approach, the appearance of the Sunderbunds improved; the woods assumed a greater variety of green and shade; several round-topped trees and some low palms were seen among them, and a fresh vegetable fragrance was wafted from the shore.

In tracing the coast of this delta, eight openings are found, each of which appears to be the principal mouth of the Ganges. The navigation through the Sunderbunds is effected chiefly by means of the tides, there being two distinct passages; the one named the Southern or Sunderland Passage, and the other the Balliaghaut Passage. The first is the longer of the two, and opens into the river about sixty-five miles below Calcutta. The latter opens into a lake on the east side of Calcutta; the navigation is intricate, extending more than 200 miles through a forest, divided into numberless islands by various channels, and the prospects are romantic. At one time the masts of vessels are entangled among the branches of trees, and at other times they sail on a broadly-expanded river skirted with beautiful woods. The water is everywhere salt; and the whole tract is uninhabited except by tigers, and wild deer, their natural prey. During the dry season, the lower shores of these rivers are visited by salt-makers and wood-cutters, who supply Calcutta with wood for fuel from these desolate tracts, and many of whom every year are devoured by tigers; these animals growing here to an enormous size, and so ferocious that they have been sometimes known to swim off and attack boats. In addition to these, the waters swarm with alligators. Some attempts have been made to bring parts of the Sunderbunds into cultivation, but with little success, as the want of fresh water must always prove a great obstacle to improvement; nor is it desirable to settle such an unhealthy tract while so many healthy stations remain unoccupied. The Sunderbunds are deemed of importance as a political barrier to Bengal on the south.

SUNDERLAND, a large and important seaport town on the east coast of England, in the county of Durham, 268 miles from London by way of Stockton. The municipal boundary includes the townships of Monkwearmouth, Bishopwearmouth, and Southwick, which form an area of 5095 acres. The river Wear, after running through the centre of the borough, falls into the sea. Sunderland proper is situated on the south or right side of the river, and is a

Sunderland.

place of considerable antiquity. At the latter end of the twelfth century it received a charter from Bishop Pudsey, which gave it equal privileges with those enjoyed by Newcastle, and from that time it has risen into importance. The town consists of one long street, under the names of Sunderland High Street and Bishopwearmouth High Street, and the two together extend to nearly a mile in length. This continued street is broad, well built, having many respectable shops, and in it are the principal buildings. With this exception, Sunderland presents the appearance of one mass of small houses, of considerable age, crowded together, with interstices of narrow streets and lanes; and here the population is extremely dense. To this crowded state of the population, together with the want of cleanliness, may be traced the fearful ravages of the cholera in 1832, which first broke out in England at this port. On the outskirts of the town there are some good streets, which are rapidly extending, with excellent houses, and in them the higher class of the inhabitants reside. There are various well frequented literary institutions in the town, to most of which libraries are attached. It contains numerous charitable institutions, which are liberally supported. The great object of interest is the magnificent iron bridge which crosses the Wear, and connects Sunderland with Monkwearmouth. It consists of a single arch of 236 feet in span, formed by small segments of iron, having a height of upwards of 100 feet from the centre of the arch to the surface of the river at low water, which enables vessels of above 300 tons burden to pass under by merely lowering their top-gallants. The projector of the bridge was Rowland Burdon, Esq. of this neighbourhood, who subscribed L.23,000 out of the L.27,000 which it cost. The harbour is constructed at the mouth of the river, by means of two piers of more than 200 yards in length, which form a beautiful promenade. It is defended by a battery, near to which are extensive brick barracks, capable of holding 2000 men. At the end of the north pier there is a lighthouse. The water in the harbour is too shallow to admit large vessels, and they are loaded and discharged by means of large boats locally called keels. Great advantages have been gained by the formation of a railway, running through the eastern part of the town, in the direction of the low quay; by which means the coals and other products of the interior are more easily and expeditiously shipped than higher up the river, where great inconvenience was frequently experienced from its crowded state above the existing staiths where the coals are kept. The trade, which is principally in the building of vessels and shipment of coals, is on the increase. Of the former, a hundred can be laid on the stocks at the same time; and when it is mentioned that there are upwards of thirty yards for building ships, five for small craft, and four dry and floating docks, besides a large basin or dock, which is constructed on the left bank, near the mouth of the river, the shipping interest of the port must appear to be of great value. In the year 1836 the number of ships which left the port was 994, with a tonnage of 153,415; and in 1837 they had increased to 1338, with a tonnage of 193,133. The coal-trade employs many vessels and hands. It is calculated that upwards of 2000 seamen belonging to the town are occupied in the trade, besides those employed in the keels. The quantity of coals shipped for home consumption in 1836 was 971,190 tons; for foreign consumption, 170,367 tons. In 1837 the quantity for home use was 931,944 tons; for foreign, 242,252 tons. In addition to those important branches of industry, there are several extensive manufactories for chain-cables, ropes, sail-cloths, salt, glass, and pottery. Lime also forms a considerable part of the trade, upwards of 40,000 tons being annually shipped. The value of the custom-duty received at this port for the year 1836, after deducting all expenses, amounted to L.71,637, and for the year 1837 L.80,072. The municipal government of the borough is vested in a mayor, fourteen aldermen, and forty-one councillors, and it is divided into seven wards. The borough returns two members to parliament. In 1821 the population of Sunderland alone amounted to 14,725, and in 1831 to 17,060. In 1821 the conjoined population amounted to 31,891, and in 1831 to 40,735.

Sundr
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Super
tive.

SUNDRABORN, a small state and town on the island of Celebes.

SUNERAMPORE, a town of Bengal, district of Daçca, situated on the Megna river. Long. 91. E. Lat. 24. 5. N.

SUNGEI TENANG, a country in the interior of Sumatra, between the second and third degrees of south latitude. It is mountainous, and the access to it is extremely difficult, from high ranges of mountains, and thick forests which intervene.

SUNNINGHILL, a parish in Berkshire, in the hundred of Cookham, twenty-two miles from London, and five miles from Staines. It is finely situated in the most delightful part of Windsor forest. It chiefly consists of elegant villas, and was once much visited on account of some mineral springs, which had great reputation in removing paralytic complaints. Besides the hill, the parish contains the liberty of Early, and the townships of Sandford and Woodley. The whole population amounted in 1811 to 1534, in 1821 to 1648, and in 1831 to 1701. A small portion of this parish is on the opposite side of the Thames, and in the county of Oxford.

SUPEREROGATION, in *Theology*, what a man does beyond his duty, or more than he is commanded to do. The Romanists strenuously contend for works of supererogation, and maintain that a stock of merit is accumulated, of which the church has the disposal, and which she distributes in indulgences according to her own pleasure. This absurd doctrine was first invented towards the close of the twelfth century, and modified and embellished by St Thomas in the thirteenth. Men were then taught to believe that there actually existed an immense treasure of merit, composed of the pious deeds and virtuous actions which the saints had performed beyond what was necessary for their own salvation, and which were therefore applicable to the benefit of others; and the guardian and dispenser of this precious treasure was the Roman pontiff; and that of consequence he was empowered to assign to such as he thought proper a portion of this inexhaustible source of merit, suitable to their respective guilt, and sufficient to deliver them from the punishment due to their crimes. The reformed churches do not allow of any work of supererogation; but hold, with the apostles, that when we have done our best, we are but unprofitable servants.

SUPERFICIES, or SURFACE, in *Geometry*, the outside or exterior face of any body. This is considered as having the two dimensions of length and breadth only, but no thickness; and therefore it makes no part of the substance, or solid content, or matter, of the body. The terms, or bounds, or extremities, of a superficies, are lines; and superficies may be considered as generated by the motions of lines. Superficies are either rectilinear, curvilinear, plane, concave, or convex. A rectilinear superficies is that which is bounded by right lines; curvilinear superficies is bounded by curve lines; plane superficies is that which has no inequality in it, or risings, or sinkings, but lies evenly and straight throughout, so that a right line may wholly coincide with it in all parts and directions; convex superficies is that which is curved and rises outwards; concave superficies is curved and sinks inwards.

SUPERFLUOUS INTERVAL. See MUSIC.

SUPERINTENDENT, which is equivalent to bishop, denotes an ecclesiastical superior in several reformed churches, particularly among the Lutherans of Germany.

SUPERLATIVE, in *Grammar*, one of the degrees of rpar- r Pro- tion ‖ ersti- on.

comparison, being that inflection of adjective nouns that serves to augment and heighten their signification, and shows the quality of the thing denoted to be in the highest degree.

SUPERPARTICULAR Proportion, or *Ratio*, is that in which the greater term exceeds the less by unit or 1: as the ratio of 1 to 2, or 2 to 3, or 3 to 4.

SUPERPARTIENT Proportion, or *Ratio*, is when the greater term contains the less term once, and leaves some number greater than 1 remaining: as the ratio of 3 to 5, which is equal to that of 1 to 1$\frac{2}{3}$; of 7 to 10, which is equal to that of 1 to 1$\frac{3}{7}$.

SUPERSTITION, a word that has been used so indefinitely that it is difficult to determine its precise meaning. From its resemblance in sound to the Latin word *superstes*, a survivor, it is evidently derived from it, and different attempts have been made to trace their connection in signification. In the dialogue of Cicero "De Natura Deorum," Balbus says that they who prayed and sacrificed whole days that their children might *survive* them, were called superstitious. Lactantius censures this etymology, and avers that they were not called superstitious who wished that their children might survive them (for this we all wish), but because they who survived their parents worshipped their images. Others again affirm that superstition is derived from *superstes*, because it consisted in considering the dead as if they were alive. But these etymologies are solely conjectural, and we consider conjectures as absurd in philology as we do in science; they may mislead, but are seldom of any benefit. The usual meaning affixed to the word superstition, both in the Latin and English languages, is so different from *superstes*, that its change of meaning must be owing to some accident after which it is in vain to inquire. If we had not known that the word *paganus*, a pagan, was derived from *pagus*, a village, because the heathens in a certain period of the Christian history lived in villages, the whims and fancies of etymologists would not have thrown much light on the subject.

Without labouring, from the aid of etymology, to define superstition, which is a word of a very extensive signification, we shall consider to what objects it is applied; and then, by observing what is common to them all, we shall be enabled to fix with some degree of precision the meaning of the term. We apply it to the idolatry of the heathens; we apply it also to the Jews, who made the will of God of no effect by their traditions, and substituted ceremonies in place of the religion of their fathers. We say also that Christians are guilty of superstition; the Romanists, who believe in transubstantiation and in the efficacy of prayers to saints; and those Protestants who esteem baptism and the Lord's Supper, and the punctual performance of other ceremonies, without regard to morality, as sufficient to ensure salvation. Those persons are also reckoned superstitious who believe, without any evidence, that prophecies are still uttered by divine inspiration, and that miracles are still performed. The word is also extended to those who believe in witchcraft, magic, and apparitions, or that the divine will is declared by omens or augury; that the fortune of individuals can be affected by things indifferent, by things deemed lucky or unlucky, or that diseases can be cured by words, charms, and incantations.

Through all the particulars which we have enumerated, there runs one general idea, the belief of what is false and contrary to reason. From this, however, we must not suppose that whatever is false and contrary to reason may be denominated superstition. Superstition has always a reference to God, to religion, or to beings superior to man. We do not however distinguish all false and irrational opinions in religion by the name of superstition. We do not, for instance, apply this name to the opinions which some of the ancients entertained, that God is the soul of the world, and that men are only portions of him separated for a time; or that the soul after death lives successively in different bodies. If we examine the subject with more attention, we shall discover that the foundation of superstition is ignorance of the moral attributes of God; for we never say a man is superstitious for entertaining erroneous opinions of the natural attributes of God. Some of the Socinians have denied the prescience of God; and a French philosopher has not only rejected the belief that he is a spirit, but has presumed to say that he is composed of a species of crystals. The first of these opinions discovers very imperfect ideas of God, and the second is the height of impiety and absurdity; yet the Socinians have not been accused of superstition, nor can this French philosopher be suspected of it. We do not call every false opinion concerning the unity or moral attributes of God by the name of superstition, as, for instance, the opinion which some sceptics have supported, that God is not good; for, as was mentioned before, superstition always involves the idea of credulity. It does not consist in falsely denying that God possesses any particular moral attributes, but in believing more than what is true concerning them; in forming mean, unworthy ideas of them; in supposing that he is guided by blind passion like mankind, and enjoins upon his creatures commandments which are irrational and absurd.

Superstition.

As superstition arises from ignorance and credulity in the understanding, so it has also a seat in the passions. Fear has been commonly considered as a passion of the human mind, from which it chiefly derives its origin; and there is no doubt that more superstition has arisen from fear united with ignorance and credulity, than from any other passion; yet it would certainly be improper to exclude all other passions. We cannot account for the superstition of the Egyptians, without supposing that much of it arose from gratitude. They worshipped the Nile, because it distributed fertility and abundance over the land of Egypt; and they worshipped some animals, merely because they prevented the increase of other animals which were noxious. Thus they adored the ibis, because it destroyed the eggs of the crocodile.

Having thus endeavoured to analyse the ideas comprehended under the word superstition, we may sum them up in a few words. It respects God and beings superior to man, and extends to our religious opinions, worship, and practices; and may be defined absurd opinions and actions arising from mean and defective ideas of the moral attributes of God. Let us apply this definition to the different species of superstition already mentioned.

But before entering upon this application, it may be proper to observe, that superstition involves the idea of a blameable inattention to reason, or a credulity arising from an indolence of understanding. We generally make a distinction between the imperfect opinions which a savage, from the necessary effects of his situation, forms of the attributes of God, and those which civilized nations entertain. We say the savage is ignorant, and we ascribe his ignorance to his situation; but we call the Roman Catholic superstitious, and we blame him for not having those just ideas of God which he might have obtained by opening his Bible, or by the exercise of his understanding in the favourable situation in which he is placed. Superstition, then, does not originate so much from the natural weakness of the human understanding, as from a misapplication or a neglect of it.

We cannot therefore with any propriety apply the name *superstition* to polytheism in general; for what all the ancient philosophers, after much study and reflection, concluded to be true, could never proceed from credulity and inattention, but from their situation. We speak very properly, however, when we call idolatry by the name of superstition; because there is no man so devoid of understanding as not to be capable of discovering that a piece of metal, or wood, or stone, can neither hear nor answer petitions. Superstition was a name which the ancient philosophers gave to those who entertained mean opinions of the gods, or did foolish things to obtain their favour. According to Theophrastus, the superstitious man is one who, having washed his hands, and sprinkled himself all round, leaves the temple with a laurel leaf in his mouth, with which he walks about the whole day. Or, if a weasel should cross his path, he will not advance a step till he has thrown three stones over the road. If he find a serpent in his house, he rears a place of devotion on the spot. He often purifies his house, will not sit upon a grave, or touch a dead person. He is anxious about the interpretation of his dreams, will not offer a sacrifice unless his wife go along with him, or, if she is engaged, he takes the nurse and the little children. He purifies himself with onions; and when he sees a mad or an epileptic person, he spits in his bosom. Such was the character of superstition in the days of Theophrastus. All these whimsical ceremonies were performed in order to prevent mischief, and to avert the wrath of the gods; and therefore perfectly correspond with the definition given above.

It is only necessary to consider a little the superstitious opinions and practices among Jews and Christians, to be sensible that they have all arisen from mean and absurd ideas of the moral attributes of God; for they have generally entertained noble opinions of his natural attributes. The Jews considered God as a partial being, who had a predilection for their nation in preference to all others, and preferred external homage and ceremony to moral purity. If the Romanists think consistently, they must esteem God as a being who can be prevailed upon by the importunity of one dead man to assist another, or as a being whose patience would be fatigued with hearing prayers constantly. Hence their practice of praying to saints. They in effect believe, however they may deceive themselves, that God is unjust, or they could not believe transubstantiation; for it supposes that God can give commands directly contrary to those principles of belief with which he has endued the human mind. They consider a strict adherence to a variety of ceremonies, to forms, pomp, and show, as essential to the worship of God; and thus they evidently betray most inadequate conceptions of the creator and governor of the universe. They thought it their duty to extirpate heretics: this was supposing God a cruel and revengeful being. Even among Protestants, we are sorry to say, a great deal of superstition remains: we have not yet learned to consider God as a spirit, who is to be worshipped in spirit and in truth, as a pure, moral, benevolent being; and hence arise all the superstitious practices which prevail in some Protestant churches.

Besides those superstitious opinions and practices which entirely respect our duty to God, there are others which may be termed vulgar superstitions. These also arise from imperfect and mean ideas of the moral attributes of God. To believe vulgar prophecies, which are always the effusions of madness or knavery, is to suppose that God, who has drawn a veil over futurity, and only delivers prophecies to accomplish some great moral purpose, sometimes gives them for no purpose at all, or to gratify idle curiosity, or to disclose such a knowledge of what is to happen as is inconsistent with the free agency of man and the moral administration of the world. Nor is it less superstitious to believe in vulgar miracles. To believe in them, is to believe that God suspends the laws of nature for the most trivial purposes, or to countenance fraud and worldly ambition: it is to receive the most extraordinary facts upon the most unsatisfactory evidence. The belief of witchcraft, of apparitions, and the second sight, may be resolved into the same principle. To suppose that God would communicate the power of doing mischief, and of controlling his laws, to creatures, merely for gratifying their own passions, is unworthy of God. The belief of apparitions is equally inconsistent with the goodness of God. The same objection rises against the second sight as against the belief of vulgar prophecies, and may also be extended to omens, to astrology, to things lucky and unlucky, and to fortune-telling. As to the different devices and charms for preventing and curing disorders, they resemble in every respect false miracles.

A judicious history of superstition would be a curious and entertaining work, and would exhibit the human character in a remarkable point of view. Superstition is most prevalent among men of weak and uncultivated minds; it is more frequent in the female sex than among men, and abounds more in the rude than in the refined stages of society. The general features of it have been the same in all ages; but it assumes certain peculiarities, according to the diversity of character in different nations. It gained admission into the science of medicine at an early period. He who was endowed with superior genius and knowledge was reckoned a magician. Dr Bartolo was seized by the inquisition at Rome in the seventeenth century, because he unexpectedly cured a nobleman of the gout. Diseases were imputed to fascination, and hundreds of poor wretches were dragged to the stake for being accessory to them. Mercatus, physician to Philip II. of Spain, a writer of uncommon accuracy and information, appears strongly inclined to deny the existence of fascinatory diseases; but he is constrained to acknowledge them for two reasons; 1st, because the inquisition had decided in favour of their reality; 2dly, because he had seen a very beautiful woman break a steel-mirror to pieces, and blast some trees by a single glance of her eyes.

As the opinions concerning the cause of diseases were superstitious, those concerning the method of curing them were not less so. In the Odyssey we read of a cure performed by a song. Josephus relates, that he saw a certain Jew, named Eleazar, draw the devil out of an old woman's nostrils by the application of Solomon's seal to her nose, in presence of the Emperor Vespasian. Many different kinds of applications were used for expelling the devil. Flagellation sometimes succeeded admirably; purgatives and antispasmodics were other modes of discharging him. Dr Mynsight cured several bewitched persons with a plaster of assafœtida. How the assafœtida was so efficacious, was much disputed. Some thought the devil might consider so vile an application as an insult, and run off in a passion; but others very sagely observed, that as devils are supposed to have eyes and ears, they might likewise have noses.

Nor was it only in medicine that these superstitious opinions were entertained, they also prevailed in natural philosophy. The pernicious effects in mines, which we now know are occasioned by noxious air, were confidently imputed to the demons of the mine. Even Van Helmont, Bodin, Strozza, and Luther, attributed thunder and meteors to the devil. Chemists were employed for centuries in search of the philosopher's stone, with which they were to perform miracles. It was a common question among philosophers in the seventeenth century, whether the imagination could move external objects; a question generally decided in the affirmative.

Though superstition be generally the mark of a weak mind, such is the infirmity of human nature, that we find many instances of it among men of the most sublime genius and most enlightened minds. Socrates believed that he was guided by a demon. Lord Bacon believed in witchcraft; and relates that he was cured of warts by rubbing them with a piece of lard with the skin on, and then nailing it with the fat towards the sun on the post of a chamber window facing the sun. Henry IV., one of the most illustrious of monarchs, was very uneasy before his assassination, on account of some prophecies. Sully declares, that one of the considerations that kept him faithful to his master in the most unpromising state of his affairs, was a prediction of La Brosse, that Henry would make his fortune. The astrologer Morin directed Cardinal de Richelieu's motions in some of his journeys. The enlightened Cudworth defended prophecies in general, and called those who opposed the belief of witchcraft by the name of atheists; and the predictions of Rice Evans were supported in the eighteenth century by the celebrated names of Warburton and Jortin. Dr Hoffmann, the father of the modern theory and practice of medicine, in a dissertation published in the large edition of his works in 1747, says, that the devil can raise storms, produce insects, and act upon the animal spirits and imagination; and, in fine, that he is an excellent optician and natural philosopher, on account of his long experience. Dr Johnson is supposed to have believed in the second sight.

With respect to the effects of superstition on the human mind, they are indeed deplorable. It chains down the understanding, and sinks it into the most abject and sordid state, and keeps it under the dominion of fear, and sometimes of cruelty. Where once it takes possession, it has a tendency to become extreme, and generally becomes so intolerable, that men of reflection and learning conspire its destruction. The Christian religion gave a violent shock to the heathen superstition; the reformation in a great measure demolished the superstition of the church of Rome; and the superstition which remained among Protestants after their separation from that church has been gradually yielding to the influence of enlightened reason, or to the bold and daring attacks of infidelity and deism. We behold the prospect of its ruins with pleasure, and thank the deists for their zeal; but it is from the firm hope that the religion of Jesus will arise in all its beauty and simple majesty, and be admired and respected as it deserves; for, mean and contemptible as superstition certainly is, we would rather see men do what they reckon their duty from superstitious principles, than see anarchy and vice prevail, even though attended with all the knowledge and liberality of sentiment which deism and infidelity can inspire.

SUPINE, in Latin grammar, part of the conjugation of a verb, being a verbal substantive of the singular number and the fourth declension. There are two kinds of supines; one, called the *first supine*, ending in *um* of the accusative case, which is always of an active signification, and follows a verb of motion, as *abiit deambulatum;* the other, called the *last supine*, and ending in *u* of the ablative case, is of a passive signification, and is governed by substantives or adjectives, as *facile dictu*.

SUPPER, the evening repast. Suppers that are heavy should be avoided, because the stomach is more oppressed with the same quantity of food in a horizontal posture than in an erect one, and because digestion proceeds more slowly when we sleep than when we are awake. They should be eaten long enough before bed-time, that they may be nearly digested before going to sleep, and then a draught of pure water will dilute that which remains in the stomach.

SUPPER *of the Lord*, otherwise called the *Eucharist*, is a sacrament ordained by Christ in his church, of which the outward part is bread and wine, and the inward part or thing signified the body and blood of Christ, which the majority of Christians believe to be in some sense or other taken and received by the faithful communicants.

There is no ordinance of the gospel which has been the subject of more violent controversies between different churches, and even between different divines of the same church, than this sacrament; and though all confess that one purpose of its institution was to be a bond of love and union among Christians, it has, by the perverseness of mankind, been too often converted into an occasion of hatred. The outward and visible sign, and the inward and spiritual grace, have equally afforded matter of disputation to angry controversialists. Many members of the church of Rome condemn the Greek church and the Protestants for using leavened bread in the Lord's Supper, contrary to the example set them by our Saviour; while the Greek church in general, and some Protestant societies in particular, unite with the church of Rome in censuring all churches which mix not the wine with water, as deviating improperly from primitive practice.

That it was unleavened bread which our Lord blessed and brake and gave to his disciples as his body, cannot be questioned; for at the time of the passover, when this ordinance was instituted, there was no leavened bread to be found in Jerusalem.[1] For the mixed cup, the evidence is not so decisive. It is indeed true, that the primitive Christians used wine diluted with water; and if we may believe Maimonides,[2] it was the general custom of the Jews, as well at the passover as at their ordinary meals, to add a little water to their wine, on account of its great strength; but that this was always done, or that it was done by our Saviour in particular, there is no clear evidence. Origen indeed affirms,[3] that our Lord administered wine unmixed; and he was not a man to hazard such an affirmation, had there been in his days any certain tradition, or so much as a general opinion, to the contrary. On this account we have often heard with wonder the necessity of the mixed cup insisted on by those who without hesitation make use of leavened bread; for if it be essential to the sacrament that the very same elements be employed by us that were employed by our Saviour, the necessity of unleavened bread is certainly equal to that of wine diluted with water.

But the mixed cup is said to be emblematical of the blood and water which flowed from the side of our Lord when pierced by the spear of the Roman soldier, while the absence of leaven is emblematical of no particular circumstance in his passion. This argument for the mixture is as old as the era of St Cyprian, and has since been frequently urged with triumph by those who surely perceived not its weakness. The flowing of the blood and water from our Saviour's side was the consequence either of the spear's having pierced the *pericardium*, or more probably of an *ascites* or *hydrothorax*, occasioned by his cruel and lingering death. But whatever was the cause of it, how can the mixing of wine with water in the sacrament be emblematical of the flowing of blood and water separately? Such a mixture surely bears a more striking resemblance to the reunion of the *serum* and *crassamentum*, after they had been separated, by whatever cause. We urge not these objections to the mixed cup from any dislike that we have to the practice. It is unquestionably harmless and primitive; and we wish that greater regard were paid to primitive practices than the generality of Christians seem to think they can claim: but let the advocates for antiquity be consistent; let them either restore, together with the mixed cup, the use of unleavened bread, or acknowledge that neither the one nor the other is essential to the sacrament. This last acknowledgement must indeed be made, if they would not involve themselves in difficulties from which they cannot be extricated. If either the mixed cup or unleavened bread be absolutely necessary to the validity of the sacrament, why not wine made from the grapes of Judæa? why not that particular kind of wine which was used by our Saviour? and where is that wine to be found?

Frivolous.

About the thing signified.

But the controversies respecting the outward part or sign of the Lord's Supper are of little importance when compared with those which have been agitated respecting the inward part or thing signified; and of these we hasten to give as comprehensive a view as the limits prescribed to such articles will admit.

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[1] Exod. xii. 15, 19.

[2] In Mishnam.

[3] Hom. xii. in Hieremiam.

Our blessed Lord, in the same night that he was betrayed, "took bread, and blessed it, and brake it, and gave it to the disciples, and said, Take, eat; this is my body. And he took the cup, and gave thanks, and gave it to them, saying, Drink ye all of it; for this is my blood of the new testament, which is shed for many for the remission of sins." Such was the institution of the Lord's Supper as it is recorded in the gospel by St Matthew; and we have the same account of it, in almost the very same words, by other three inspired writers, St Paul, St Mark, and St Luke. That it was the bread which Christ blessed and brake that is here called his body, and the wine over which he gave thanks that he styles his blood of the new testament, will admit of no reasonable doubt; but in what sense they became so, has been the subject of many controversies.

Doctrine of the church of Rome.

The church of Rome, which holds, that after consecration, Jesus Christ, God and man, is really, truly, and substantially, contained under the outward appearances of the bread and wine, informs us, that about the middle of the mass, when the priest, taking into his hand, first the bread and then the wine, pronounces over each separately the sacred words of consecration, the substance of these elements is immediately changed by the almighty power of God into the body and blood of Christ; but that all the outward appearances of the bread and wine, and all their sensible qualities, remain. This more than miraculous change is called transubstantiation, and is founded on the philosophy of Aristotle, which resolves all bodies into *matter* and *form;* for it is only the *matter* or imperceptible substance which supports the *forms* or sensible qualities of bread and wine, that is changed into the *substance* or matter of the body and blood of Christ; so that this divine matter, coming into the place of the former earthy matter, supports the same identical *forms* which it supported. Hence we are told, "that Jesus Christ, now present instead of the bread and wine, exhibits himself to us under those very same outward *forms* or appearances which the bread and wine had before the change." Could this doctrine be true, it would be abundantly mysterious; but, to add to the mystery, we are further informed, that under each kind is contained Jesus Christ whole and entire, his body and blood, his soul and divinity; so that when a man eats what has the appearance of a wafer, he really and truly eats the body and blood, the soul and divinity, of Jesus Christ; and when he afterwards drinks what has the appearance of wine, he drinks the very same body and blood, soul and divinity, which not a minute perhaps before he had wholly and entirely eaten! The ingenious author from whose work we have taken this account of the Romish doctrine concerning the real presence, may perhaps reject our inference, that the orthodox members of his church must believe the *soul* and *divinity* of Christ to be *eaten* and *drunk* in the Lord's Supper; but he cannot deny that, according to his statement of the Romish faith, the soul and divinity are both received whole and entire into the stomach of each communicant. He says, indeed, that "communion consists in receiving Jesus Christ whole and entire, his sacred body, his precious blood, his blessed soul, and his adorable divinity, into our *souls;*" but that which was formerly bread and wine unquestionably goes into the *stomachs* of the communicants; and since, according to him, it is now the body and blood of Christ, the soul and divinity must go thither with it, for these four cannot be separated. This our author himself grants. "The Scripture," says he, "positively declares, that Christ rising again from the dead, dieth no more; death shall no more have dominion over him (Rom. vi. 9). Consequently his body, his blood, and his soul, shall never more be separated from one another; and as the union of his divine and human natures can never more be broken, so neither can these, his two natures, united in his divine person, be ever separated. From this it necessarily follows, that wherever the body of Christ is, there also his blood, his soul, and his divinity, must of necessity be in like manner."

Now, whether we suppose, with this author, that the soul and divinity of Christ directly carry his body and blood with them into the human soul, or, trusting in some degree to the evidence of sense, believe that the body and blood carry his soul and divinity with them directly into the stomach of each communicant; is it credible, is it possible, that the high and lofty One, who inhabiteth eternity, and whom the oracles of truth assure us that even the heaven of heavens cannot contain, should be *substantially* received *whole* and *entire* into a finite spirit like the human soul, or into a body so limited as the human stomach? Our author says it is; declaring that, "by the blessed *presence* of Jesus Christ, *whole and entire within us,* are communicated to our souls all the heavenly graces which are the effects of the holy communion: such as the sanctification of the soul by an increase of justifying grace; the rendering of it more pure, more holy, more beautiful, more agreeable, in the eyes of God; the cleansing of the soul from all those venial sins and imperfections of which we repent, and preserving us from falling into mortal sins; the uniting of us in a most intimate manner with Jesus Christ, who comes to us in this holy sacrament on purpose to dwell in our souls and abide with us; and the giving us a pledge and earnest of a glorious immortality, to the enjoyment of which it brings us at last, if we persevere to the end in the grace of God."

The consequence of the doctrine of transubstantiation is the *sacrifice of the mass,* by which, it is said, God's acceptance of Christ's sacrifice on the cross is obtained for the actual benefit of those persons in particular for whom the mass is offered. In the work so often quoted, we are told that "Jesus Christ our redeemer, who is both our high priest and our victim, who, in order to perfect the work of our redemption, and reconcile man with his offended Creator, offered himself once in a bloody manner upon the cross, in order to communicate and apply to the souls of individuals those graces which, by his death, he merited for mankind in general, continues to offer himself daily upon the altar in an unbloody manner, by the ministry of his priests, in the *mass.* The sacrifice of the cross and that of the mass are both one and the same sacrifice, because in both the victim is the same and the high priest the same, viz. Jesus Christ. The only difference is in the *manner* of offering. On the cross he offered himself in a bloody manner, and actually died; whereas on the altar he is offered up to God in an unbloody manner, not *actually* dead, but under the *appearance* of death;" so that the communicants not only eat the man Jesus Christ, but even eat him alive![1]

It is known to all our readers that this doctrine of transubstantiation was one cause of the breach between the church of Rome and those various societies which call themselves reformed churches. The real and substantial change of the bread and wine into the body and blood of our Lord is rejected by every reformer, as a change contradictory and impossible, and fraught with the most impious consequences; and volumes have been written to expose the weakness of those arguments which have so often been vainly urged in its support. It has been shown to imply numberless absurdities, such as, that the same thing can be in a million of different places, *whole* and *entire*, at the same instant of time; that it is above 1800 years old, and yet may be not more than one minute; that *forms* or sensible qualities are real things, independent of their subject and the sentient beings who perceive them; that the infinite and eternal God, who created and sustains the universe, is himself wholly and substantially comprehended by the human soul; and that the half, or fourth, or tenth part of the body of Christ, is equal to the whole of that body. That these are necessary consequences of transubstantiation, has been so completely proved in various works to which every reader may have access, that it is needless for us to repeat arguments so hackneyed; but there are two objections to that doctrine, which, as we do not remember to have met with them elsewhere, and as they appear to us absolutely conclusive, it may be worth while to state in this place.

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[1] This whole account of the Romish doctrine respecting the sacrament of the Lord's Supper is taken from a work in two small volumes, called "The sincere Christian instructed in the Faith of Christ, from the written Word." Its author is a man of learning, and great personal worth; and as he fills a high station in the church of Rome, we cannot doubt but that he has given a fair view of the doctrine of that church respecting this and every other article of which he treats.

The advocates for the real presence in the Lord's Supper contend, that every word relating to that ordinance is to be taken in the strictest and most literal sense; and they affect to triumph over the Protestants, because their notions of the sacrament cannot be supported without having recourse to figure and metaphor. This however is a very vain triumph; for we hesitate not to affirm, that supposing transubstantiation possible, and even capable of proof, there is not in the whole New Testament a single word or a single phrase which, if interpreted *literally*, gives the slightest countenance to that wonderful doctrine. The reader will remember that transubstantiation, as we have stated it from a dignitary of the Romish church, and as it is in fact stated by the council of Trent, consists in a change of the matter, imperceptible substance, or *substratum*, of the bread and wine, into the matter, imperceptible substance, or *substratum*, of Christ's body and blood; for all parties agree that the sensible qualities of the bread and wine remain, and, according to the Romanist, are, after the consecration, either supported by the *matter* of Christ's body and blood, or hung upon nothing. But the phrase τοῦτό ἐστι τὸ σῶμά μου, if taken in the literal sense, cannot possibly denote the consequence of such a change as this; for every person at all acquainted with the Greek language, especially the language of the Peripatetic school, knows that τὸ σῶμά μου signifies, not the *matter* or *substratum* of my body divested of its sensible qualities, but the body of me in its natural state, consisting of matter and qualities, or matter and form united. Unless therefore the *sensible qualities*, as well as the *matter* of the bread and wine, give place to the sensible *qualities* as well as the *matter* of our Saviour's body and blood, and unless he appear glorified on the altar as he appeared on the mount at his transfiguration, the words τὸ σῶμά μου must be interpreted figuratively. Had the apostles understood their Master's words in the sense in which they are understood by the church of Rome, they would have rendered them into Greek, not τοῦτό ἐστι τὸ σῶμά μου, "this is my *body*," but τοῦτό ἐστι ἡ ὕλη τοῦ σώματός μου, "this is the *matter* of my body." In like manner, when St John relates[1] that Jesus said, "Whoso eateth my flesh and drinketh my blood, hath eternal life, and I will raise him up at the last day," had he understood his adorable Master to speak of his flesh and blood in the Eucharist in the sense in which they are taught to be there by the church of Rome, he would have represented him as saying, not Ὁ τρώγων μου τὴν σάρκα, καὶ πίνων μου τὸ αἷμα, but Ὁ τρώγων τὴν ὕλην τῆς σαρκός μου, καὶ πίνων τὴν ὕλην τοῦ αἵματός μου, "whoso eateth the *matter* of my flesh, and drinketh the *matter* of my blood, hath eternal life, and I will raise him up at the last day."

But further, supposing this singular conversion possible in itself, it cannot be rendered credible, however stated in any language that ever was or ever will be spoken by man. At first sight it may appear paradoxical to affirm that a possible fact cannot be so related as to obtain credit; but that transubstantiation, if possible, is such a fact, will be apparent on the slightest consideration.

The relation which subsists between things and words is arbitrary; so that what is termed *body* in English, is σῶμα in Greek, and *corpus* in Latin; and the same thing might with equal propriety (had the authors of these languages so pleased) have been expressed in the first by *soul*, in the second by νοῦς, and in the third by *anima*. The consequences of this are, that there is no universal language spoken, that the natives of one country understand not the speech of those of another, and that different men speaking the same language are perpetually liable to mistake each other's meaning. Between the *substrata* of bodies and their *sensible qualities* there is a relation founded in nature, so that the sensible qualities which indicate the substance to which they belong, to be *gold*, for instance, in one country, indicate the same thing in every other country, and have done so from the beginning of time. The sensible appearances of bodies therefore are a universal language, the language of the Author of Nature, by which he declares to his creature man, that though the ὕλη πρώτη, or primary matter of all bodies, may be the same kind of substance, yet the ὕλη προσεχὴς of one body, or the internal combination of its primary parts, differs from that of another; that gold, for instance, has a different *substratum* or *basis* from iron, lead, or silver; that the internal organization or structure of the body of an ox is different from that of a horse; and that the *internal substance* or *substratum* which exhibits the appearances of bread and wine is different from that which supports the sensible qualities of flesh and blood. Supposing therefore the doctrine of transubstantiation to be possible and even true, it would still be impossible, by any statement in human language, or by any argument urged in its support, to render that doctrine an object of rational belief; for if it be said that the words τοῦτό ἐστι τὸ σῶμά μου were spoken by a divine person, who could neither be deceived himself nor intend to deceive us, it may be replied, that the sensible appearances of bread and wine, which are confessed to remain, are likewise the language of a divine person, even of the Creator and Governor of heaven and earth; that this language addressed to the sight, the taste, the touch, and the smell, is equally intelligible to all nations; that since the creation of the world its meaning has never been mistaken by the scholar or the clown, the sage or the savage, except in this single instance of our Lord's flesh and blood exhibiting the sensible appearances of bread and wine; and that it is therefore infinitely more probable that the members of the church of Rome should mistake the meaning of the words τοῦτό ἐστι τὸ σῶμά μου, which, though spoken by Christ, are part of the language of men, and liable to all its ambiguities, than that all mankind should mistake the language of God himself, which is liable to no ambiguities, and which was never in any other instance misunderstood by a single individual. Should transubstantiation therefore be really true, its truth can never be proved or rendered probable, but by an immediate operation of the Spirit of God on the mind of man; and he who is conscious of no such operation on his own mind, may rest assured that the Father of mercies, who knows whereof he is made, will never bring upon him, for his incredulity in this instance, any of the anathemas denounced by the church of Rome upon those who place implicit confidence in the universal language of Him who created them, in opposition to her figurative and contradictory interpretations of the written word. Of the transubstantiation of the elements a visible miracle would afford no proof. Had the water been changed into wine at the marriage in Cana of Galilee for the express purpose of bearing testimony to this singular conversion, what must have been the consequence on the minds of those who witnessed that miracle? Nothing, we think, but scepticism or distrust of their own faculties; for they would have had the very same evidence that *no* substantial change was wrought on the elements, as that the water was *actually* turned into wine.

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[1] Chap. vi. 54.

Though the reformed churches unanimously reject the doctrine of transubstantiation, and of course the sacrifice of the mass, its inseparable consequence, they are far from being agreed among themselves respecting the nature of the Lord's Supper; and the notions of this ordinance entertained by some of them appear to us as untenable as any part of the doctrine of the church of Rome. The Lutherans believe that the body and blood of Christ are really and substantially present with the bread and wine; that the body is really and truly eaten, and the blood really and truly drunk, by the communicants; and that whatever motion or action the bread has, the body has the same.[1] According to them, therefore, the same sensible appearances are exhibited by two substances united in some inexplicable manner, which is neither a personal union, nor incorporation, nor the enclosure of the body within the bread; nor does it last longer than while the sacrament is celebrating. This union is generally called *consubstantiation;* but they reject the term, contenting themselves with asserting the real presence, without presuming to define the mode by which the body and blood of Christ are united to the sacramental elements.

Doctrine of the Lutherans incredible.

It would be superfluous to waste time in replying to this doctrine. Every reader sees that it implies the possibility of the same thing's being whole and entire in a million of places at one and the same instant of time, which has been so often urged as an unanswerable objection to the Romish doctrine; and it is fraught with this additional absurdity peculiar to itself, that two bodily substances may at once occupy the same place, which is directly contrary to our notions of solidity. It may likewise be observed, that whatever be the real sense of our Saviour's words, he says expressly, "This is my body;" this thing which I give you, and which you see and feel: whereas, had he meant what Luther and his followers teach, he would surely have said, "*With* this bread receive my body, *with* this cup receive my blood."

Of the early Calvinists,

The notions of some of the early Calvinists respecting the Lord's Supper are very mysterious, and expressed in language of which we are not sure that we understand the meaning. In the year 1561 an attempt was made in France to bring the Catholics and Protestants to an uniformity of doctrine on this great topic of controversy; and deputies were appointed by both parties to meet at Poissy, and debate the question in a friendly manner. The principal managers on the side of the Catholics were the cardinals of Lorraine and Tournon; those on the side of the Protestants were Beza and Peter Martyr. After several meetings, disputes, and violent separations, the Protestant deputies declared their faith in the following words: "We confess, that Jesus Christ, in the Supper, does truly give and exhibit to us the substance of his body and blood by the efficacy of his Holy Spirit; and that we do receive and eat spiritually, and by faith, that very body which was offered and immolated for us, so as to be bone of his bone and flesh of his flesh, to the end that we may be enlivened thereby, and receive what is conducive to our salvation. And because faith, supported by the word of God, makes those things present which it apprehends, and by that faith we do in deed and reality receive the true natural body and blood of Christ, by the power of the Holy Spirit; by this means we confess and acknowledge the presence of his body and blood in the Supper." One of the Romish delegates expressing his dislike of this last clause, the Protestant ministers gave the following explanation of their sentiments. "No distance of place can hinder us from communicating of the body and blood of Christ, for the Lord's Supper is a heavenly thing; and though on earth we receive with our mouths bread and wine, which are the true signs of his body and blood, yet by faith, and the efficacy of the Holy Ghost, our minds, which are fed with this food, are rapt up into heaven, and enjoy the presence of the body and blood; and that by this means it may be said that the body is truly joined to the bread, and the blood to the wine; but after the manner of a sacrament, and not at all according to place or natural position."[2]

unintelligible.

If the reader can discover the precise meaning of these passages, his sagacity exceeds ours. That the Protestant deputies believed, or professed to believe, that the natural body and blood of Christ are by the faithful received in the Lord's Supper, is indeed evident; but their notions respecting the manner of this reception are very unintelligible, if not contradictory. In the former quotation, they confess that Christ's body and blood are really present in the sacrament; that they are made present by faith (we suppose the faith of the communicants); and that the very body which was offered and immolated for us is eaten spiritually and by faith. In the latter quotation, they seem to say that Christ's body and blood are in heaven, at a great distance from the true signs of them; that on earth the communicants receive only these signs, which are bread and wine; but that, by faith and the efficacy of the Holy Spirit, their minds, during actual communion, are rapt up into heaven, where they enjoy the presence of the body and blood; and that by this means the body and blood are truly joined to the bread and wine through the medium of the mind of the communicant, which is at once present both to the sign and to the thing signified. To this mysterious doctrine it is needless to urge objections. Every man who is accustomed to think, and to use words with some determinate meaning, will at once perceive that the authors of this declaration must have had very confused notions of the subject, and have pleased themselves with sound instead of sense, satisfied that they could not be wrong if they did not symbolize with the Lutherans or the council of Trent.

Of the churche Britain

The churches of England and Scotland, in their established doctrines respecting the Lord's Supper, appear to be Calvinistical; but the compilers of the Thirty-nine Articles and of the Confession of Faith must have been much more rational divines than Beza and Peter Martyr. They agree in condemning the doctrine of transubstantiation, as contrary to common sense, and not founded in the word of God; they teach, that to such as rightly, worthily, and with faith, receive the sacrament, the bread which we break is a partaking of the body of Christ, and the cup of blessing a partaking of the blood of Christ; and they add, that the body and blood of Christ are eaten and drunk, not corporally or carnally, but only after a heavenly and spiritual manner, by which the communicants are made partakers of all the benefits of his death.[3] In one important circumstance these two churches seem to differ. The Confession of Faith, as we understand it,[4] affirms that in the Lord's Supper there is no sacrifice. The thirty-first article of the Church of England likewise condemns the Popish sacrifice of the mass, as a *blasphemous fable* and *dangerous deceit;* but in *the order for the administration of the Lord's Supper or Holy*

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[1] Luther. Cogit. MS. 400. Gerhard. in Loc. Theol. de Sacra Cœna.

[2] Thuanus, lib. xxviii. See also Johnson's Unbloody Sacrifice, vol. i.

[3] Articles of the Church of England, art. xxviii.; and Confession of Faith, chap. xxix.

[4] Chap. xxix. § 3.

Communion, the celebrator "beseeches God most mercifully to accept the alms and *oblations* of the congregation," and again "to accept *their sacrifice of praise* and thanksgiving:" from which petitions many have inferred that, in the Lord's Supper, that church offers a commemorative and eucharistical sacrifice. This inference seems not to be wholly without foundation. In the order for the administration of the Lord's Supper, according to the form of the Book of Common Prayer set forth by act of parliament in the second and third years of King Edward the Sixth, the elements were solemnly offered to God as a sacrifice of praise and thanksgiving; and though the prayer containing that oblation was, at the review of the liturgy some years afterwards, removed from the prayer of consecration, to which it was originally joined, and placed where it now stands in the post-communion service, yet the very act of parliament which authorized that alteration calls King Edward's "a very godly order, agreeable to the word of God and the primitive church, and very comfortable to all good people desiring to live in Christian conversation."

So Eng- lis vines ho he Lo s Sup- pe be a e haris- tic sacri- fic

The English church, however, has not positively determined any thing respecting this great question; and while she condemns the doctrine of the real presence, with all its dangerous consequences, she allows her members to entertain very different notions of this holy ordinance, and to publish these notions to the world. Accordingly, many of her most eminent divines have maintained that, in the celebration of the Lord's Supper, the elements of bread and wine are offered to God as a sacrifice commemorative of Christ's one sacrifice for the sins of the whole world; that these elements, though they undergo no substantial change, yet receive such a divine virtue by the descent of the Holy Ghost, as to convey to the worthy communicant all the benefits of Christ's passion; that they are therefore called his body and blood, because being, after their oblation, eaten and drunk in remembrance of him, they supply the place of his body and blood in the feast upon his sacrifice; and that it is customary with our Saviour to give to any thing the name of another of which it completely supplies the place, as when he calls himself the *door*[1] of the sheep, because there is no entrance into the church or kingdom of God but by faith in him. They observe, that the Eucharist's being commemorative, no more hinders it from being a proper sacrifice, than the typical and figurative sacrifices of the old law hindered them from being proper sacrifices: for as to be a type does not destroy the nature and notion of a legal sacrifice, so to be representative and commemorative does not destroy the nature of an evangelical sacrifice. To prove that, in the celebration of the Lord's Supper, there is a real sacrifice offered to God as well as a sacrament received by the communicants, they appeal to St Paul, who says expressly,[2] that "Christians have an *altar*, whereof they have no right to eat who serve the tabernacle," and who by contrasting the cup of the Lord with the cup of devils, and the table of the Lord with the table of devils,[3] teaches plainly that those cups and those tables had the same specific nature. That the table of devils spoken of by the apostle was the Pagan altars, and the cup of devils the wine poured out in libations to the Pagan divinities, will admit of no dispute; and therefore, say the advocates for the eucharistical sacrifice, the table of the Lord must be the Christian altar, and the cup of the Lord the wine offered to God as the representative of the blood of Christ; otherwise there would not be that absurdity which the apostle supposes, in the same person drinking the cup of the Lord and the cup of devils, and partaking of the Lord's table and the table of devils. They observe further, that in all the ancient liturgies extant there is a solemn form of oblation of the sacramental elements, and that all the Christian writers from the second century downwards treat of the Lord's Supper as a sacrifice as well as sacrificial feast, having indeed no value in itself, but acceptable to God as representing Christ's one sacrifice for the sins of the world. Our limits will not permit us to give even an abstract of their arguments; but the reader who shall attentively peruse Johnson's "Unbloody Sacrifice and Altar unveiled and supported," will discover that their notions are better founded than probably he supposes, and that they are totally irreconcileable with the doctrine of transubstantiation and the Popish sacrifice of the *mass*.

Others, a mere memorial;

Other English divines of great learning, with the celebrated Hoadley bishop of Winchester at their head, contend strenuously that the Lord's Supper, so far from being a sacrifice of any kind, is nothing more than bread and wine reverently eaten and drunk, in remembrance that Christ's body was broken and his blood shed, in proof of his Father's and his own love to mankind; that nothing is essential to the sacrament but this remembrance, and a serious desire to honour and obey our Saviour as our head; that the sacrament might be celebrated without uttering one prayer or thanksgiving, merely by a society of Christians, whether small or great, jointly eating bread and drinking wine with a serious remembrance of Christ's death; that St Paul enjoins a man to examine himself before he eat of that bread and drink of that cup, not to discover what have been the sins of his past life in order to repent of them, but only that he may be sure of his remembering Christ's body broken and his blood shed; that, however, it is his duty in that, as in every other instance of religious worship, to resolve to obey from the heart every precept of the gospel, whether moral or positive; and that to partake worthily of the Lord's Supper is acceptable to God, because it is paying obedience to one of these precepts; but that no particular benefits or privileges are annexed to it more than to any other instance of duty. Bishop Hoadley acknowledges, that when St Paul says,[4] "The cup of blessing which we bless, is it not the communion of the blood of Christ? the bread which we break, is it not the communion of the body of Christ?" he has been supposed by many learned men to affirm, that all the benefits of Christ's passion are in the Lord's Supper conveyed to the worthy communicant; but this, says he, is an idea which the apostle could not have in his thoughts as at all proper for his argument. The Greek word κοινωνία and the English *communion* signify only a partaking of something in common with others of the same society; and the apostle's meaning, he says, can be nothing more than that in the Lord's Supper we do not eat bread and drink wine as at an ordinary meal, but as memorials of the body and blood of Christ, in honour to *him* as the *head* of that body of which we are all *members*. That the word κοινωνία is not meant to denote any inward or spiritual part of the Lord's Supper, he thinks evident, because the same word is used with regard to the cup and the table of idols, where no spiritual part could be thought of, and in an argument which supposes an idol to be nothing.[5]

To this view of the nature and end of the Lord's Supper it must appear no small objection, that "he who eateth and drinketh unworthily is said to be guilty of the body and blood of the Lord, and to eat and drink a judgment to himself, not discerning the Lord's body." No doubt it would be sinful to eat and drink a mere memorial of Christ's death without serious dispositions; but we cannot conceive how a little wandering of the thoughts, which is all the unworthiness that the author thinks there can be on such and others, a feast upon our Saviour's sacrifice.

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[1] St John x. 7.

[2] Heb. xiii. 10.

[3] 1 Cor. x. 16, &c.

[4] 1 Cor. x. 16.

[5] Hoadley's Plain Account of the Nature and End of the Lord's Supper.

an occasion, should be a sin of so deep a dye as to be properly compared with the guilt of those who murdered the Lord of life. Other divines, therefore, feeling the force of this and similar objections, steer a middle course between the mere memorialist and the advocate for a real sacrifice in the holy Eucharist, and insist that this rite, though no sacrifice itself, is yet a feast upon the one sacrifice offered by Christ and slain upon the cross. The most eminent patrons of this opinion have been Dr Cudworth and Bishop Warburton; and they support it by such arguments as the following. In those ages of the world when victims made so great a part of the religion both of Jews and Gentiles, the sacrifice was always followed by a religious feasting on the thing offered; which was called the feast upon or after the sacrifice, and was supposed to convey to the partakers of it the benefits of the sacrifice. Now Jesus, say they, about to offer himself a sacrifice on the cross for our redemption, did, in conformity to general practice, institute the last supper, under the idea of a feast after the sacrifice; and the circumstances attending its institution were such, they think, that the apostles could not possibly mistake his meaning. It was just before his passion, and while he was eating the paschal supper, which was a Jewish feast upon the sacrifice, that our blessed Lord instituted this rite; and as it was his general custom to allude, in his actions and expressions, to what passed before his eyes, or presented itself to his observation, who can doubt, when, in the very form of celebration, we see all the marks of a sacrificial supper, but that the divine institutor intended it should bear the same relation to his sacrifice on the cross which the paschal supper then celebrating bore to the oblation of the paschal lamb? If this was not his purpose, and if nothing more was intended than a general memorial of a dead benefactor, why was this instant of time preferred for the institution to all others throughout the course of his ministry, any one of which would have been equally commodious? Indeed any other time would have been more commodious for the institution of a mere memorial; for the paschal lamb and unleavened bread were certainly a sacrifice; and the words used by our Saviour, when he gave the bread and wine to the apostles, were such as must necessarily have led them to consider that bread and wine as bearing the same relation to his sacrifice which the paschal supper bore to the paschal sacrifice. At that Jewish feast, it was the custom of every father of a family to break the unleavened bread, and to give to every guest a portion, saying, "This is the bread of affliction, which our fathers did eat in the land of Egypt;" a custom which we may be sure that Christ, as a father of his family, would religiously observe. The apostles knew well that they were not eating the identical bread which their fathers did eat in Egypt, but the feast upon the sacrifice then offered in commemoration of their redemption from Egyptian bondage; and therefore, when they saw their Master after supper break the bread again, and give it to each of them, with these remarkable words. "This is my body which is given for you, do this in remembrance of me," they must have concluded, that his meaning was to institute a rite which should to the end of the world bear the same relation to his sacrifice that the paschal supper bore to the sacrifice of the passover.

This inference, from the circumstances attending the institution, Bishop Warburton thinks confirmed by St Paul's mode of arguing with the Corinthians on their impiety and absurdity in partaking both of the Lord's table and the table of devils; for "what," says he, "had the eaters of the sacrifices to do with the partakers of the bread and wine in the Lord's Supper, if the Lord's Supper was not a feast of the same kind with their feasts? If the three feasts, Jewish, Pagan, and Christian, had not one common nature, how could the apostle have inferred that this intercommunity was inconsistent? 'Ye *cannot*,' says he, 'drink the cup of the Lord and the cup of devils; ye *cannot* be partakers of the Lord's table and the table of devils.' For though there might be impiety in the promiscuous use of Pagan and Christian rites of any kind, yet the inconsistency arises from their having a common nature, and consequently, as they had opposite originals, from their destroying one another's effects in the very celebration. Sacrifices, and feasts upon sacrifices, were universally considered as federal rites; and therefore the Lord's table and the table of devils being both federal rites, the same man could no more be partaker of both, than he could at once engage to serve both God and the devil. This is the apostle's argument to the wise men to whom he appeals; and we see that it turns altogether upon this postulatum, that the Christian and Pagan feasts had the same specific nature, or were both feasts upon sacrifices. If this be admitted, it is easy to see why St Paul deemed those who ate and drank unworthily guilty of the body and blood of the Lord; for if the Lord's Supper be a feast upon his sacrifice, it must have been considered as the means of conveying to the communicants all the benefits of his death and passion; and the profanation of such a rite, by rendering his death ineffectual, might be fitly compared and justly equalled to the enormous guilt of those by whom his blood was shed." In reply to Bishop Hoadley's remarks upon the word κοινωνία, his brother bishop observes, that "had the apostle meant what the learned writer makes him to mean, he would doubtless have said κοινωνία ὑμῶν εἰς τὸ σῶμα, 'your communion in the body—your eating it jointly.' St Paul," continues he, "knew how to express himself properly, as appears from a passage in his epistle to the Philippians, where, professedly speaking of the joint participation of a blessing, he uses these words, κοινωνία ὑμῶν εἰς τὸ εὐαγγέλιον, 'your communion in the gospel.'" To the other remark, that no spiritual part could be thought of in the table of idols, because an idol is said by the apostle to be *nothing*, Bishop Warburton replies, "that by St Paul the Gentiles are said to have sacrificed to devils, and those who ate of such sacrifices to have had communion with devils; now the *devil*," continues his lordship, "was in St Paul's opinion *something*." But the inference which the apostle draws from the acknowledged truth, that the cup of blessing which we bless is the communion of the blood of Christ, and the bread which we break the communion of the body of Christ, puts his meaning, our author thinks, beyond all doubt. He says,[1] that the partaking of one bread makes the receivers of *many* to become *one body*. A just inference, if this rite be of the nature of a feast upon the sacrifice; for then the communion of the body and blood of Christ unites the receivers into one body, by an equal distribution of one common benefit. But if it be only a general commemoration of a deceased benefactor, it leaves the receivers as it found them, not one body, but many separate professors of one common faith.

The o nance generally under stood.

Thus have we given such a view as our limits would permit us to give, of the principal opinions that have been held respecting the nature and end of the Lord's Supper. It is an ordinance which seems not to be generally understood; though, being intended to show forth the Lord's death till he come, it is surely of sufficient importance to engage the attention of every serious Christian. The most considerable English divines who have expressly written upon it are, Johnson in his Unbloody Sacrifice; Cudworth in his Discourse concerning the true Nature of the Lord's Supper; Hoadley in his Plain Account; and Warburton

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[1] 1 Cor. x. 27.

porters || irat.

in his Rational Account. The notions of Cudworth and Warburton are the same, and perhaps they differ not so much from those of Johnson as many readers seem to imagine. At any rate, the arguments by which Warburton supports his doctrine must have some force, since it is said that Hoadley himself acknowledged they would be unanswerable, if it could be proved that the death of Christ was a real sacrifice. (H. H. H. H.)

SUPPORTERS, in *Heraldry*, figures in an achievement, placed by the side of the shield, and seeming to support or hold up the same. Supporters are chiefly figures of beasts: figures of human creatures for the like purpose are called *tenants*.

SUPPOSITORY, a kind of medicated cone or ball, which is introduced into the anus for opening the belly. It is usually composed of common honey mixed up with soap or oil, and formed into pieces of the length and thickness of the little finger, only pyramidal.

SUPRALAPSARIANS, in *Theology*, persons who hold that God, without any regard to the good or evil works of men, has resolved, by an eternal decree, *supra lapsum*, antecedently to any knowledge of the fall of Adam, and independently of it, to save some and to condemn others; or, in other words, that God intended to glorify his justice in the condemnation of some, as well as his mercy in the salvation of others; and for that purpose decreed that Adam should necessarily fall, and by that fall bring himself and all his offspring into a state of everlasting condemnation. These are also called *antelapsaries*, and are opposed to sublapsaries and infralapsaries. According to the supralapsarians, the object of predestination is, *homo creabilis et labilis*; and, according to the sublapsarians and infralapsarians, *homo creatus et lapsus*.

SURAJEGHUR, a town of Hindustan, in the province of Bahar, district of Monghier, sixty-eight miles east-south-east of Patna. Long. 86. 15. E. Lat. 25. 14. N.

SURAJEPOOR, a small town of Hindustan, in the province of Allahabad, fifty-one miles south-west by south from Lucknow, pleasantly situated on the west side of the Ganges.

SURAT, a large and populous city of Hindustan, in the province of Gujerat, situated on the south side of the Taptee river, about twenty miles above its junction with the sea. It is one of the largest cities in Hindustan; and is termed by Bishop Heber a very large and ugly city, with narrow winding streets, and high houses of timber-frames filled up with bricks, the upper stories projecting over each other. The city is about six miles in circuit, in the form of a semicircle, of which the river Taptee or Tuptee forms the chord. Near the centre of this chord, and washed by the river, stands a small castle, with round bastions, glacis, and covered way, in which are stationed a few sepoys and European artillerymen; and which is distinguished by the singularity of two flag-staffs, on one of which is displayed a union jack, on the other a plain red flag, the ancient ensign of the emperors of Delhi; an arrangement which was adopted in courtesy when the fort was conquered from the nawab of Surat, and was continued, though the nawab is only a pensioner on the bounty of the government. In the neighbourhood are most of the English houses of a good size. Without the walls is a French factory, containing some handsome and convenient buildings, but now quite deserted by their proper owners, and occupied by English officers. A French governor with several officers came to take possession of the factory, which was restored in 1814 at the conclusion of peace; but the governor died, and his suite was so thinned by disease that the survivors returned to the isle of Bourbon, and no one has appeared to supply their place. The city is protected on one side by a river; and on the other three sides by a brick rampart, or a ditch. The wall is entire and in good repair, with semicircular bastions and battlements. There is also a strong citadel, erected on the bank of the river, and surrounded by an esplanade.

Surcingle || Surf.

Surat formerly carried on a very extensive trade. In 1775 a greater quantity of ships belonged to the port than to Bombay. Large exports of cotton were formerly sent to China, but they are now chiefly sent by the way of Bombay. The trade has greatly declined, consisting of little but raw cotton, which is chiefly shipped in boats for Bombay. In manufactures the native artisan is now undersold by the English; a dismal decay, says Heber, has consequently taken place in the circumstances of the native merchants; and he mentions an instance of an ancient Mussulman family, formerly of great wealth and magnificence, who were reduced to dispose of their library for subsistence. The most thriving people in Surat are the Boras, or money-lenders, who drive a trade all through this part of India, and the Parsees. The last are the proprietors of half the houses in Surat. They are dexterous mechanics, good servants, and skilful merchants. They intermarry with each other, and retain all their ancient customs and prejudices, among which is their repugnance to extinguish fire, and the exposure of their dead to be devoured by birds of prey. The boats which lie in the river are of thirty or forty tons, with two masts. Vessels of greater burden must lie about fifteen miles off, below the bar, at the mouth of the Taptee; but few larger vessels ever come to Surat. There is a very neat and convenient church, as well as an extensive and picturesque burial-ground, full of large and numerous tombs of the former servants of the Company; most of them from 120 to 180 years old, and in the Mussulman style, with large apartments surrounded by vaults. There are no remarkable buildings in Surat. The nawab's residence is modern, but not particularly handsome. The British society is numerous and agreeable, this city being the station of a considerable force, of a collector, a board of customs, and the courts of justice. Of the ancient history of Surat under the Hindoo dynasties there are no authentic records. It was taken by the emperor Akbar in 1572, after a vigorous siege of forty-seven days. It was in 1664 taken and plundered by Sevajee, the great Mahratta chief, and was again visited by him in 1671, and laid under contribution, as it was by his successors in 1702 and 1707. Surat was surrendered to a British force in 1759 by the nabob, the ancestor of the present nawab, who was compelled to have recourse to foreign aid. He was succeeded by his sons, the last of whom agreed in 1800 to resign all his authority to the British for an annual pension of L.12,500. Surat is fifty-one miles south-west by south from Lucknow. Long. 73. 3. E. Lat. 21. 13. N. (F.)

SURCINGLE, a girdle with which the clergy of the Church of England usually tie their cassocks.

SURCOAT, a coat of arms, to be worn over body armour. The surcoat is properly a loose thin taffety coat, with arms embroidered or painted on it; such as is worn by heralds, and anciently used by military men over their armour to distinguish themselves by.

SURD, in *Arithmetic* and *Algebra*, denotes any number or quantity that is incommensurable to unity: it is otherwise called an *irrational number* or *quantity*.

SURDASTRUM, the ancient name of a drum used as an accompaniment to a pastoral pipe in a dance which was supposed to have the virtue of rendering harmless the bite of the tarantula.

SURDY, a small uninhabited island in the Persian Gulf, situated to the south of Kishme. Lat. 25. 54. N.

SURF is a term used by seamen to express a peculiar swell and breaking of the sea upon the shore. It sometimes forms but a single range along the shore, and at others three or four behind one another, extending perhaps half a mile out to sea.

SURGERY.

The term *Surgery*, or *Chirurgery*, from χειρ, *the hand*, and εργον, *work*, originally signified, as its derivation implies, the manual procedure, by means of instruments or not, directed towards the repair of injury and the cure of disease; in contradistinction to the practice of *medicine*, denoting the treatment of disease by the administration of drugs, or other substances supposed to be of a sanative tendency. Such a meagre description applied but too justly to surgery in its infancy, and still more after its separation from its twin-sister medicine, in the twelfth century. When its practice was denounced by the Council of Tours as derogatory to the dignity of the sacred office of the priesthood, and beneath the attention of all men of learning, the term chirurgery, in its most literal interpretation, was quite sufficient to comprehend the duties of the degraded and uninformed surgeon, who had become a mere mechanic, attached to and completely dependent on the learned and philosophic physician. But the matured progress of the healing art has, fortunately for science and humanity, rendered such a definition of surgery in these days utterly untenable. Its complete separation from medicine would now be attended with the utmost difficulty; nor is it desirable that the attempt should be made, because its success, however partial and imperfect, would be most hurtful to both. They are now, and it is to be hoped will ever remain, one and inseparable. Their principles are the same throughout, and the exercise of their different branches requires the same fundamental knowledge; but their details are so numerous and intricate as to render it most difficult, if not impossible, for any one individual to cultivate all with equal success. The consequence has been, that while the theory and principles of physic and surgery remain united, as constituting one and the same science, the practical parts are now frequently separated into distinct professions, each person adopting that department most congenial to his pursuits, and for the management of which he conceives himself best qualified. The separation however is not that of acquirements, but merely of practice. It should never be forgotten, that the physician, before he can be either accomplished or successful in his profession, must be intimate with the principles, if not with the practice of surgery. And most certainly no one can ever lay just claim even to the title of surgeon, far less hope for eminence or success, unless he be equally qualified to assume both the appellation and the employment of the physician.

Many and laboured have been the attempts to define surgery according to its present state, so as to prevent interference with the department of physic. This example we will not follow. The arrangement as to what is medical, and what surgical, must in a great measure depend on custom, not on fixed and permanent rules. The paths of the practical surgeon and physician are distinct, but in their course they must often cross each other; and these collisions, so far from being avoided, ought rather to be sought, as probable sources of mutual benefit, so long as those enlightened feelings are entertained, and that honourable conduct pursued, which ought ever to distinguish the followers of a liberal, useful, and learned profession.

The limits allotted to this article not permitting us to enter into the details of surgery, we must content ourselves with a sketch of its history, and with some account of its improved condition as it is at present practised.

Origin.

That surgery is as old as man himself, that it was coeval with his fallen state, there can be little doubt. The fall entailed the frequent reception of injuries by external violence; and to assuage their pain and remove their inconvenience, the ingenuity and contrivance of the sufferer were powerfully excited. Thus it would seem, that as to antiquity of origin, surgery must take precedence of medicine. And after wars and dissensions began to prevail, and wounds and injuries became both more frequent and more deadly, it is most probable that to these the practitioners of the healing art alone directed their attention, before the nature of disease began to be understood, or its cure was supposed to be within the reach of human means.

Early Egyptians.

As to the state of surgery among the early Egyptians, we know but little, except that it was customary, in the time of Joseph, to embalm the dead; a process which appertains closely to both medicine and surgery. There are some grounds, however, for suspecting that they were more conversant with surgery than is generally supposed; for it is said that on "the ruined walls of the renowned temples of ancient Thebes, basso-relievos have been found, displaying surgical operations, and instruments not far different from some in use in modern times." Their medical practice, entirely founded on incantation and astrology, was sufficiently simple. They divided the body into thirty-six parts, believing in an equal number of demons, to whom those parts were intrusted, and to invoke whose aid in sickness was the principal duty of the physician, each spirit being called upon to cure his own peculiar portion.

Jews.

Among the Jews, the operation of circumcision was performed, no doubt skilfully and dexterously, though with rude implements, by the priesthood, an order which, for many ages, and in many climes, conjoined the cure of the body with that of the soul.

Greeks.

The earliest notice of this art is from the ancient Greeks, who, it is probable, had derived their medical traditions from the Egyptians. They considered medicine to be of divine origin; and its first professors, as they inform us, were no less personages than gods and sons of gods.

Medicine and surgery, at their origin, were conjoined; and both continued to be practised indiscriminately, until separated by the Arabian school. Their complete estrangement occurred, as we have already stated, about the middle of the twelfth century. At first, surgery chiefly occupied the attention of the ancient leech, as the more certain and more obviously useful branch of his profession; but ultimately it became very secondary to medicine when dignified by philosophy and priestcraft.

Chiron.

Chiron the Centaur, born in Thessaly, is presumed to have been the father of surgery, celebrated for skilfully applying soothing herbs to wounds and bruises. But his fame is somewhat endangered by that of Æsculapius, the son of Apollo, by some held to be the pupil of Chiron, by others, his predecessor and superior. Æsculapius is supposed to have been deified, on account of his skill, about fifty years before the Trojan war. His very existence however has been questioned. Apollo was the original god of physic among the early Greeks; but he appears to have resigned in favour of Æsculapius, whose temples became the depositories of medical and surgical knowledge; more particularly those of Epidaurus, Cnidos, Cos, and Pergamus.

Æsculapius.

Podaliri and Machaon, B. C. 119

Certain it is, according to the testimony of Celsus, that Æsculapius is the most ancient authority in surgery. His immediate descendants, two sons, Podalirius and Machaon, have been immortalized by Homer. They followed Agamemnon to the Trojan war, and there their services were so highly valued as to secure them a not unconspicuous niche among the heroes of the Iliad. Of the two, Machaon seems to have been the more distinguished. When he is wounded by Paris, the whole army is represented as interested in his recovery. Even the stern Achilles inquires anxiously after "the wounded offspring of the healing god;" and the valiant Nestor, to whose care he is intrusted, is exhorted to unwonted exertion in his behalf; "for a leech who, like him, knows how to cut out darts, and relieve the smarting of wounds by soothing unguents, is to armies more in value than many other heroes." Podalirius enjoys the distinction of being reputed the first of phlebotomists, and probably the most successful, from his time to this; having opened a vein in either arm of the king of Caria's daughter, who had been severely injured by a fall from the house-top, having, after her recovery, been rewarded with the hand of the fair princess, and having been presented by her munificent father with the Chersonese as her dowry. As to medicine, they seem to have been either ignorant, or in no great repute; for, on the breaking out of pestilence in the Grecian camp, Homer neglects them entirely, and applies at once to Apollo. And even their surgical attainments, for which they are celebrated by him, seem to have extended no farther than to the simple extraction of darts and other offensive weapons, the checking of hæmorrhage by styptics or pressure, and the application of lenitive salves. The poet takes notice of his warriors sustaining fracture of the bones; but in such emergencies he adopts the same course as in the pestilence, and invokes the aid of the non-professional deities; from which circumstance we may infer, that in those days surgery had made but little advancement.

A piades.

For upwards of 600 years after the Trojan war, there are scarcely any accounts of medicine and surgery. They seem to have remained strangely stationary during the whole of that period. Their practice was confined to the Asclepiades, or reputed descendants of Æsculapius; whose lore was orally communicated from father to son in that family, until they received an extraordinary impulse from the great Hippocrates, himself a branch of the family, and said to have been the fifteenth in lineal descent from the deified founder. The Asclepiades, in the course of their monopoly, established three schools of medicine, at Rhodes, at Cnidos, and at Cos. The last gave Hippocrates to the world, and thus attained a proud and enduring pre-eminence.

Py goras,
B. 00.

Pythagoras was the first who brought philosophy to bear upon the practice of the healing art, and led the way in raising it to the dignity of a science. Democritus, the happy sage, likewise turned his attention to medicine as a branch of general philosophy, and pursued it zealously. He lived in terms of friendship with Hippocrates, by whom he was held in great respect. By Pythagoras a school at Crotona was founded, about the time of Tarquinius Superbus, espousing doctrines somewhat different from those of Cos and Cnidos. It produced Damocedes, a contemporary of Pythagoras, who seems to have practised in Athens, an honoured and successful surgeon. By Polycrates, king of Samos, he was presented with two talents of gold for having cured him of a troublesome distemper. He was afterwards taken captive by the Persians. Their king, Darius, was intrusted to his care for a dislocated ancle, as well as the queen, Atossa, for a cancer of the breast; and he was soon loaded with honour and wealth on account of his wonderful cures, performed after the Egyptian physicians, previously in attendance, had signally failed.

D cedes.

But we cannot suppose such men as Damocedes and the Asclepiades to have attained any great proficiency in surgery; for the touch of a dead body was interdicted as a profanation both by Jew and Greek, and consequently they must have been almost entirely ignorant of anatomy. They may have understood something of the skeleton, from their practice amongst fractures and dislocations; and they may have formed some general idea of the viscera, from researches in comparative anatomy, and from instruction by the Egyptians, whose practice in embalming afforded ampler scope for observation. But the minute structure of the human body must have been to them a profound mystery. And, knowing that anatomy is, was, and ever must be, the foundation of true surgical knowledge, we cannot evade the conviction that surgery, though occasionally successful and honoured in ancient times, must have been nothing more than a rude, imperfect, and uncertain art. The practice of its professors seems to have been extremely limited, consisting of little more than the binding up of wounds, and the staunching of hæmorrhage by styptics and the cautery; the extraction of darts and other missiles from the wounds which they had inflicted; phlebotomy, both general and local; and cupping by scarification. Whether they practised the capital operations or not, we are not informed; but it is probable that their comparative ignorance of anatomy effectually deterred them from any extensive division of the soft parts, as extremely hazardous and uncertain.

Hipppocrates,
B. C. 400.

Hippocrates, born in the 80th Olympiad, upwards of 400 years before the Christian era, did more for medicine and surgery than all who had preceded him; and indeed few of those who have succeeded him have been of equal service to the profession. He soon freed medicine in a great measure from the absurdities with which ignorance and superstition had invested it; and through a long, honoured, and glorious life he set a splendid example of persevering industry, philosophical research, and high moral worth. His fame soon raised the Coan school far above its rivals. Though his anatomical knowledge seems little better than a blending of ingenuity with error, yet he appears to have had some indistinct notions of the circulation of the blood; but Dr Pitcairne, in his "Solutio Problematis de Inventoribus," has sufficiently evinced that he was very far from anticipating the great discovery of Harvey. With all his deficiencies, and notwithstanding all the disadvantages under which he laboured, so correct was his observation, and so faithful his chronicling of disease, that many of his descriptions may be fairly inserted in our modern nosologies. Though his attention was chiefly directed towards the improvement and promotion of physic, now begirt with philosophy, and studied as a science, and though his practice was principally confined to the treatment of internal disease, yet he was not wholly inattentive to surgery. And his practice seems to have been tolerably bold and decisive; for, in regard to external disease, it was with him a maxim, that "when medicine failed, recourse should be had to the knife, and when the knife was unsuccessful, to fire;" a substance of which all the ancient doctors seem to have been particularly fond, from Prometheus downwards. Hippocrates employed it not only in a variety of diseases, but in various forms. Sometimes he applied red-hot irons to the part; sometimes he raised a conflagration on it, and of it, by a piece of wood dipped in boiling oil, or by burning a roll of flax after the manner of the modern moxa. He also made use of tents and issues, as more gentle means of counter-irritation. He seems to have performed the capital operations with boldness and success, excepting lithotomy, the practice of which appears to have been confined to a few who made it their exclusive study. He however recommends the removal of calculus, large and firmly lodged in the kidney, by incision; adding, probably in apology for the daring of the procedure, that otherwise there are no hopes of a cure, and that the disease must prove fatal. He reduced dislocations, and set fractures, but clumsily and cruelly; extracted the fœtus with forceps when necessary; and both used and abused the trepan, employing it not only in depression and other accidents of the cranium, but also in cases of headach, and other affections to which the operation was inapplicable. In cases of empyema and hydrothorax, after ascertaining by percussion that fluid was present in the cavity of the chest, he did not hesitate to make an incision between the ribs; and having allowed part of the fluid to escape, he placed a tent in the wound, and by withdrawing it regularly once a day, the whole was ultimately evacuated. He seems to have been perfectly acquainted with tetanus and spontaneous gangrene; observing, that even minute wounds of tendinous parts, as the fingers and toes, sometimes produce convulsions which terminate fatally; and that black spots on the feet frequently increase to extensive gangrene and incurable mortifications. Some of his practices have been long and justly exploded, some have been successfully continued, and others have, after disuse, been revived as modern inventions. For example, his method of ascertaining the presence or absence of fluid in the chest was by percussion, and applying the ear to the part, thus anticipating the use of the modern stethoscope. One of his modes of counter-irritation, we have seen, was by burning flax on the part, as in the modern moxa; and he strongly recommends the production of eschars on the back and breast in the earlier stages of pulmonary disease, thus anticipating the supposed valuable discoveries of a celebrated modern charlatan. His writings are elegant, and well repay a careful perusal. By them he made posterity his debtor; his contemporaries were not insensible to his merits, and endeavoured to reward them during his life. The inhabitants of Argos voted him a statue of gold; he was more than once crowned by the Athenians, and, though a stranger, was initiated into the most sacred mysteries of their religion, the highest distinction which they could confer; after his death, universal and almost divine honours were paid to his memory; temples were erected to him, and his altars covered with offerings.

Ctesias.

Plato,
B. C. 370.

Diocles
Carystus.

Praxagoras.

Aristotle.

We have already seen that surgery had long been stationary before the time of Hippocrates; and it made but little advancement during many succeeding generations. The Asclepiades had confined the knowledge of medicine among themselves; Hippocrates, however, gave oral instructions in anatomy and the art of healing, and thus disclosed its mysteries to the world. But few of his disciples seem to have profited much by his liberality. One of them, his kinsman Ctesias, we are told, acquired considerable renown for his skill; and having been taken prisoner by Artaxerxes Mnemon, in a battle fought against his brother Cyrus, was successful in curing him of a severe wound, and thus obtained favour with his captor. Plato began to flourish about this time; but though he was connected with medicine, we cannot lay claim to him as eminent in surgery; and he was more famous for his philosophy than his physic. Perhaps the most distinguished in surgery, among the more immediate successors of Hippocrates, was Diocles Carystus. He devoted more attention to anatomy than any of his predecessors, was curious in bandaging wounds of the head, and invented the bellulon, an instrument for extracting darts. Carrying his surgery into the practice of medicine, he was not very happy in the result; from observing that external wounds, abscesses, and inflammations were attended with fever, he supposed that general fever was uniformly occasioned by one or more of these causes operating internally. He followed Hippocrates in practice, and, like him, cultivated his profession, "not for lucre or vain-glory, but from real love of the medical art, and a pure spirit of humanity." Praxagoras of Cos was the last of the Asclepiades who succeeded in leaving a name behind him. As a surgeon he is reported to have been bold in the extreme, incising the fauces freely, and excising portions of the soft palate, in bad cases of cynanche; and making incisions into the bowels to remove obstructions, when milder measures failed. Aristotle, the celebrated preceptor of Alexander the Great, although not strictly in the medical profession, was the promulgator of doctrines which for a long time had a powerful effect on medicine. While he followed out the general principles of the healing art, and was curious in anatomical research, he seems to have disdained to meddle with the practical details, and among the rest those of surgery.

Egypt.

B. C. 300.

Herophil
and Eras-
tratus.

Xenoph

Mantius

Andreas
Carystu

Ammon

On the dismemberment of the vast empire of Macedonia after the death of Alexander the Great, learning took up its chief abode at Alexandria, under the protection of Ptolemy Soter. And here it was that popular prejudice first gave way, and permitted the examination of dead bodies, the greatest possible boon to the medical profession, inasmuch as it removed what had hitherto been the most serious obstacle to its advancement, ignorance of human anatomy. Herophilus and Erasistratus, the two great heads of the Egyptian medical school, were the first who had an opportunity of practising human dissection, the bodies of criminals having been given to them for that purpose; and they consequently not only corrected many errors, but made numerous and important discoveries, in anatomy; thus imparting a fresh stimulus, and affording a new and more solid basis to both medicine and surgery. By some they have been accused of carrying their enthusiasm in this inquiry to such an extent as to "open the bodies of living criminals for the furtherance of their physiological views;" but this is probably a mere exaggeration, originating in the horror with which human dissection was at first regarded; a horror which unfortunately is not even in our day altogether extinguished, notwithstanding the recent legislative enactments in favour of anatomical research. But we find even these privileged men falling into most palpable mistakes; for example, Herophilus plainly confounds the tendons and ligaments with the nerves. Yet the fact that the names which he gave to many parts still remain in use, will of itself remind posterity how much they are indebted to him for his anatomical labours. He was likewise one of the greatest surgeons of ancient times, and, as well as Erasistratus, acquired as much fame for brilliant cures as for anatomical knowledge. The surgical practice of the latter was characterized by peculiar boldness and decision, and strongly marked with the failing of his time and school, a love of multiplying and inventing murderous implements, and the relentless use of them. "In schirrosities and tumours of the liver, he did not scruple to make an ample division of the integuments, and try applications to that viscus itself. He followed the same practice in diseases of the spleen, which he regarded as of little consequence in the animal economy." And perhaps he was right in his supposition, though not in his practice. In cases of retention of urine, he made use of the particular catheter which long bore his name. Xenophon of Cos, said to have been a follower of Erasistratus, seems to have been among the first who arrested hæmorrhage from a member, by encircling it tightly with a ligature. Mantius, a pupil of Herophilus, wrote a treatise on surgical dressings, which he rendered complicated in the extreme. Another, Andreas of Carystus, wrote on the union of fractured bones, and invented several ponderous machines for reducing luxations of the femur. Indeed the surgeons of the Alexandrian school were all distinguished by the nicety and complexity of their dressings and bandagings, of which they invented a great variety. Among them, as in the time of Hippocrates, lithotomy was practised by particular individuals, who devoted themselves exclusively to that operation; and we are told that one of them, Ammonius, employed an instrument, by means of which he broke down stones in the bladder, plainly anticipating Civiale, and furnishing a marked example to the present age of the truth of Solomon's apophthegm, that "there is nothing new under the sun."[1] It is not improbable that some of their other practices might have afforded equally striking examples of this sometimes unpalatable truth; but unfortunately the greater part of the writings of the Alexandrian school perished in the conflagration of the famous national library in the time of Julius Cæsar; a calamity fraught with immense loss to the healing art, as well as to almost every other branch of knowledge.

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[1] A curious illustration of this is given by Dr James Johnson, in the narrative of his visit to Pompeii. "The Dilator or Speculum, for which Mr Weiss of the Strand obtained so much repute a few years ago, has its exact prototype in the Bourbon Museum at Naples. The coincidence in such an ingenious contrivance would be absolutely miraculous; but unfortunately there is a key to the similitude, which de-

The arts and sciences followed the seat of empire in its transfer to Europe under Julius Cæsar, and Rome became the grand centre of intellectual illumination. Notwithstanding the shrewd sense displayed by the ancient Romans in most matters, it is strange, yet true, that for centuries all ranks of society, from the mere plebeian rabble to the censor, had entertained an abhorrence of all practitioners of medicine and surgery, and trusted for cures to spells and incantations. Indeed public edicts were issued, "discouraging all countenance to the professed exercise of physic, and recommending faith in traditionary prescriptions and religious rites." Cato the censor managed the sick of his own family according to the terms of this edict, and gravely wrote down the words of incantation for curing dislocation or fracture. For nearly the first 600 years of its existence, Rome, accordingly, had no regular practitioner of medicine. The first we read of was Archagathus, a Greek, from the Alexandrian school, who practised in Rome, chiefly as a surgeon, during the consulates of Lucius Æmilius and Marcus Livius. At first his surgical skill obtained for him no inconsiderable fame, but the ancient prejudice soon revived in full vigour. An enraged populace—perhaps not without some reason, for he seems to have been particularly fond of the knife and cautery—compelled him not only to suspend his practice, but, changing his original title of "healer of wounds" to that of "executioner," caused him to be banished from the Roman capital. Afterwards, however, a native of Bithynia, assuming the name of Asclepiades, established himself in tolerable repute by virtue of insinuating manners, shrewd common sense, and the performance of several fortunate cures "tuto, cito, et jucunde." But with him we have little concern, for his sagacity soon taught him that it was essential to his welfare to avoid the unpopular practice of surgical operations, and accordingly he confined himself entirely to the apparently less hurtful administration of medicine. The only important traces of his surgical practice are, that in ascites he practised and recommended discharge of the accumulated fluid by minute punctures of the abdominal parietes; and that for quinsy, which term probably comprehended many of the various acute diseases of the throat now known and distinguished, he not only employed bold blood-letting, local and general, by the lancet and by cupping, but also had recourse to scarification of the fauces, and even attempted laryngotomy. By novel and successful cures in his medical practice, and frequent indulgence in skilful quackery, he obtained great personal reputation, and so far overcame popular prejudice as to establish a tolerably fair field in Rome for future practitioners. He was the contemporary of Cæsar, and the personal friend of Cicero. The latter is eloquent in his praise, and through him seems to have formed a high estimate of the medical character. "Nothing," says he, "brings men nearer to the gods, than by giving health to their fellow-creatures." It would thus seem that, in his time at least, the ancient grudge against the doctors had abated in Rome. Among the disciples and immediate followers of Asclepiades was Cassius, described as Iatro-Sophista, who left behind him several works on anatomical and surgical subjects. In one of the latter he distinctly accounts for wounds on one side of the head producing paralysis on the other, from the decussation of the nerves; a tolerable proof that he was not only a good anatomist for the time, but also an observant practitioner.

Cassius.

Celsus.

Rome itself did not produce a single medical practitioner of any reputation before the age of Aulus Cornelius Celsus, although he himself chooses to be complimentary to some of his immediate predecessors, "Tryphon, Euelpistus, and Meges, the most learned of them all." Celsus, the contemporary of Horace, Virgil, and Ovid, likened to Hippocrates for the quantity of his sound practical information, and to Cicero for the elegance of his style, lived in the reigns of Tiberius, Caligula, Claudius, and Nero, in the beginning of the first century of Christianity, upwards of 150 years before Galen.[1] In his celebrated medical work, he places great reliance on Hippocrates and Asclepiades, more particularly the latter, and gives a complete and excellent digest of all the true medical and surgical knowledge of his times, although it is not certain that he himself either practised medicine or operated in surgery. "Of his surgical operations and remarks, many are yet far from being obsolete, and impress us with a high idea of his ingenuity and judgment. His mode of performing lithotomy (on the gripe) has been in recent times warmly defended by Heister, especially as applicable to children. He describes the operation for cataract by depression, and the method of forming an artificial pupil. The whole of his account of injuries of the head is admirable, and evinces wonderful tact and discrimination. His rules for distinguishing fracture, and for the application of the trepan, have been highly eulogized; nor is what he says about contrecoups less accurate. He is the first who has remarked that there may be rupture of a vessel within the cranium without fracture or depression." And he is the first who recommended the application of ligatures to a wounded artery, with the view of arresting its hæmorrhage, after pressure has failed. He improved amputation, an operation then not much in use; and recommended its adoption in cases of gangrene from external causes. He is minute in his details as to the treatment of fracture and dislocation; his description of carbuncle is good, and its treatment similar to that now pursued, namely, free application of the strongest escharotics to the gangrened part. He describes several species of hernia, and gives directions for their reduction. "It would be endless however to particularise. Whoever wishes to know the exact state of surgical knowledge in the world at the time of the Cæsars, may turn to the pages of Celsus, with the hopes of a gratification which will not be disappointed."[2]

Aretæus, born in Cappadocia, practised in Rome, proba-

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stroys the charm of astonishment. A crafty Frenchman imitated from memory, and with some awkward deviations, the Pompeian Speculum, and passed it off as his own. Weiss improved upon the Frenchman, and hit upon the exact construction of the original! Many modern discoveries may probably have originated in the same way."

[1] A life of Celsus by Joannes Rhodius is subjoined to the second edition of a work of that learned Dane, entitled "De Acia Dissertatio, ad Cornelii Celsi mentem, qua simul universa Fibulæ ratio explicatur." Hafniæ, 1672, 4to. We must likewise refer our philological readers to "Jo. Baptistæ Morgagni in Aur. Corn. Celsum et Q. Ser. Samonicum Epistolæ, in quibus de utriusque Auctoris variis Editionibus, Libris quoque manuscriptis, et Commentatoribus disseritur." Hagæ-Com. 1724, 4to. The prænomen of Celsus appears to have been Aulus, and not Aurelius, which is a "nomen gentile." See Fabricii Bibliotheca Latina, tom. ii. p. 37. edit. Ernesti.

[2] He relates an interesting anecdote of Hippocrates, illustrative of his abuse of the trepan. "Knowing and skilful as he was, he once mistook a fracture of the skull for a natural suture; and was afterwards so ingenuous as to confess his mistake, and leave it on record." To this he adds, "This was acting like a truly great man: little geniuses, conscious to themselves that they have nothing to spare, cannot bear the least diminution of their prerogative, nor suffer themselves to depart from any opinion which they have embraced, how false and pernicious soever that opinion may be; while the man of real ability is always ready to make a frank acknowledgement of his errors, especially in a profession where it is of importance to posterity to read the truth:" a moral which cannot be too often forced upon the attention of the present generation.

Aretæus, A.D. 50–80.

Heliodorus.

Antyllus.

Rufus, A.D. 96–117.

Archigenes.

bly about the time of Domitian. He was the first who made use of blisters, using cantharides for that purpose. Dissection in his time was prohibited under the severest penalties: his anatomical knowledge was therefore neither profound nor exact; "nevertheless he had the sound penetration to regard anatomy as the only legitimate basis on which either medical or surgical science could rest." Heliodorus, the celebrated physician of the emperor Trajan, has left some excellent observations on injuries of the head; and Antyllus, almost a contemporary, was a zealous and successful surgeon. He boldly recommends bronchotomy in cases of threatened suffocation induced by disease of the throat; and, in inflammatory affections of emergency, advises arteriotomy in preference to venesection, showing that excessive loss of blood thereby need not be dreaded, it being readily prevented by dividing the artery completely across. He also alludes to the operation for cataract by extraction, which he however recommends very cautiously, and only when the cataract is small. He obtained the radical cure of hydrocele by free incision of the parts. Rufus the Ephesian, who seems also to have lived in the time of Trajan, was a zealous anatomist and surgeon, and has left a treatise on diseases of the kidneys and bladder. About the commencement of the second century, Archigenes the Syrian settled in Rome, and distinguished himself both in medicine and surgery. His writings, which were chiefly confined to the latter subject, are unfortunately lost. Between Celsus and Galen, however, we meet with no great Roman writer on medicine or surgery. These were among the last of the liberal arts that were encouraged by the Romans; and the proud patricians refusing to educate any of their family to such a profession, the medical practitioners of Rome were at first importations from Greece and Alexandria, and afterwards self-educated slaves and freedmen.[1]

Galen, A.D. 131.

Claudius Galenus was born at Pergamus, in Asia Minor, in the 131st year of the Christian era. After studying at Smyrna and Corinth, he completed his medical education at Alexandria, and ultimately settled in Rome, where he soon obtained a great reputation, both as a successful practitioner, and as a public lecturer on anatomy. Professional jealousy of his talents, however, drove him from Rome, to which he did not return until recalled by Marcus Aurelius. Shortly afterwards he was appointed physician to the young emperor Commodus, with whom, as well as with the public, he rose to great favour. A man of great erudition, brilliant genius, and indomitable industry, he produced works which exerted a most powerful and extensive influence over medical practice. He has the merit of rescuing medical inquiry from the chaos in which he found it, and restoring it to the paths of light and nature. His fame indeed was so great as to prove, in one sense, detrimental to the advancement of the medical profession, inasmuch as his opinions were received as oracular in the schools of all the civilized countries for no less a period than 1300 years, thus seriously retarding further investigation. His works were both numerous and elaborate; but unfortunately he seems to have been debarred from the study of the groundwork of his profession, human anatomy. His dissections appear to have been limited to the simiæ and other mammiferous animals, as most resembling the human structure, though on one occasion "he felicitates himself on the opportunities he had enjoyed of examining two skeletons preserved in Alexandria, and recommends all anxious to obtain a thorough knowledge of osteology to repair to that city." In his early years, he practised surgery at Pergamus with marked success; but in Rome he seems to have confined himself almost entirely to medicine, excepting the occasional performance of phlebotomy: probably the valorous Romans had not yet lost their hatred and dread of the terrible operations of surgery. Like others, however, he was still so much of a general practitioner, as to practise pharmacy as well as medicine, with a little of surgery; and he himself informs us, that he had a drug-shop in the Via Sacra. "He established two general principles as the basis of all surgery—synthesis, or the reunion of parts—diæresis, or their complete division, as by amputation or extirpation. In four cases he detected luxation of the femur backwards, a variety not mentioned by Hippocrates; and records two instances of spontaneous luxation of the same bone. He also treats of more than one species of hernia. But although in his writings we meet with a few bold chirurgical attempts, as in the application of the trepan to the sternum in a case of empyema, yet it must be confessed that by far the greatest part of his surgery seems to have been confined to fomentations, ointments, and plasters, for external affections, together with the art of bandaging, a love for which he necessarily acquired at the Alexandrian schools; and the employment of complicated machinery in fracture and dislocations." His researches were not limited to medical science, but comprehended literature and philosophy.[2]

Oribas

A D. 3

The early Christians unfortunately appear to have injured medicine and surgery, by attributing to martyrs and their relics the power of healing wounds and curing diseases; "acknowledging the active interference of demons and blessed spirits in the affairs of men, and leaving true philosophy in total abandonment." A Cimmerian gloom was then fast overspreading the world, by which science and art were destined to be long obscured; and shortly after the time of Galen, we accordingly find the medical along with the other sciences encompassed by the dark clouds of ignorance and barbarism. One or two names however occur worthy of notice, but more from having preserved than advanced medical knowledge. Oribasius, a pupil of Zeno, lived in the time of the emperor Julian, whose friendship he enjoyed, and became a celebrated practitioner, as well as of great importance in the state. His works are principally compilations, though judicious and useful. His surgery is marked with timidity, discouraging operations, except in most extreme cases, and is chiefly confined to unguents and embrocations. He abstracted blood locally, by making deep and extensive scarifications, or rather incisions, with the knife; a proceeding somewhat resembling the important modern improvement in the treatment of erysipelas, but adopted under different circumstances, and with other objects in view.

Aëtius

A D. 5

550.

During the fifth century the west was repeatedly invaded by the Huns, Goths, Alans, and Lombards. Science greatly suffered in consequence; and no name worthy of remembrance is to be found, until, nearly two centuries after Oribasius, appeared Aëtius, a native of Amida, and a pupil of the

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[1] On this subject, a remarkable controversy took place in England during the earlier part of last century. It was occasioned by Dr Mead's "Oratio Anniversaria Harveiana, in Theatro R. Medicorum Londinensium Collegii habita, ad diem XVIII. Octobris, MDCCXXIII. Adjecta est Dissertatio de Nummis quibusdam a Smyrnæis in Medicorum honorem percussis." Lond. 1724, 4to. This was followed by a publication of Dr Middleton, "De Medicorum apud veteres Romanos degentium Conditione Dissertatio; qua, contra viros celeberrimos Jacobum Sponium et Richardum Meadium, servilem atque ignobilem eam fuisse ostenditur." Cantab. 1726, 4to. To this dissertation Dr Ward of Gresham College published an answer in 1727: Middleton published the first part of a defence in 1728, and Ward having rejoined in the course of the same year, his antagonist prepared a second part, of which Dr Heberden printed a few copies in 1761, eleven years after the author's death.

[2] Here we must refer our classical readers to a most important collection published under the title of "Medicorum Græcorum Opera quæ exstant. Editionem curavit D. Carolus Gottlob Kühn, Professor Physiologiæ et Pathologiæ in Literarum Universitate Lipsiensi Publicus Ordinarius." Lipsiæ, 1821–30, 26 tom. 8vo. Three of the volumes are each divided into two parts. This collection includes the works of Hippocrates, Aretæus, Dioscorides, and Galen. Dioscorides was edited by Sprengel, and the other writers by Kühn.

Alexandrian school. "His surgical writings are copious and valuable. His opinions were guided by experience, and his methods of management and cure are characterised by much caution and discrimination. We find a variety of surgical queries and suggestions which had escaped Celsus and Galen, as well as the description of several diseases which have been omitted by Paulus Ægineta. He recommended and practised scarification of the legs in anasarca, and made free use of both the actual and potential cauteries; he cut out hæmorrhoidal tumours; operated for aneurism; tried to dissolve urinary calculi by the administration of internal remedies; and has given a series of interesting chapters on inflammation of the intestines followed by abscess, on encysted tumours, on the varieties of hernia, on diseases of the testicle and castration, on the pricks of the nerves and tendons, and in fact on almost every important branch of surgical knowledge. If, mixed up with these, we find some things which the matured experience of ages has abolished, it is less to be marvelled at, than that surgery was already enriched with so many valuable facts and observations." He makes no reference to the reduction of fractures and dislocations, whence it has been plausibly inferred, "that in all likelihood quacks were at that time in complete possession of this branch of practice. Better were it for society that it was quite out of their hands now!" He seems to have been the first to open up a field of medical inquiry, which has since been so successfully cultivated,—the nature and composition of urinary calculi. He appears also to have turned much of his attention to diseases of the eye, and is the first who speaks of the dracunculus or Guinea-worm. Alexander of Trallis, a famous physician in the time of Justinian, about the middle of the sixth century, was an author of more originality than either Oribasius or Aëtius. He wrote on diseases of the eye, and on fractures; but both treatises have been lost, which is the more to be regretted, as, with this exception, he confined himself entirely to internal disease. The celebrated Paulus Ægineta, also of the Alexandrian school, lived about the middle of the seventh century, and made both large and valuable contributions to surgery. He frequently performed the operations which he describes, and abandoned the labours of the mere theorist, for the more valuable results of practical observation and experience. "His sixth book has been considered by many, and not without reason, as the best body of surgical knowledge, previous to the revival of letters." He recommended bleeding from the immediate neighbourhood of the part affected, in preference to general blood-letting, because more effectual; and, for the like reason, opened the temporal artery in cases of very severe ophthalmia. He had recourse to copious venesection, with the view of accelerating painful descent of calculus in the ureter. He opened internal abscesses by caustics, and defined the points at which he thought it advisable to perform paracentesis in the different alleged species of ascites. In lithotomy, having first endeavoured to ascertain the situation of the calculus by the rectum, he made his incision, not in the centre of the perineum, as recommended by Celsus, but to one side of the raphe, as is now practised. Of the impropriety of extensive incision of the bladder he seems to have been well aware, directing that the external wound should be much freer than the internal, and that the latter should be in extent merely sufficient to admit of the passage of the stone. While Celsus limited the operation to patients between nine and fourteen years of age, he sanctions its performance after the age of puberty, but admits that the chances of success increase with the youth of the patient. He described more than one variety of aneurism, pointing out those cases in which he thought it advisable to attempt a cure by operation; and extended this to the aneurisms of the head and joints, excepting only those of the groin, arm-pit, and neck, instead of confining it to the tumours of the arm alone, as had been done by Aëtius. All aneurisms, excepting aneurism by anastomosis, which he clearly and accurately distinguished, he conceived to originate in rupture of the coats of the artery. He performed extirpation of the mamma by crucial incision, and practised both laryngotomy and tracheotomy. He is the first who seems to have performed the latter operation as a means of carrying on respiration during occlusion of the larynx, but naturally enough falls into the error of transverse instead of longitudinal incision. He describes different species of hernia, and did not hesitate to operate when the tumour became strangulated. He is also the first who treats of fracture of the patella. He was pre-eminent as an accoucheur, and was the originator of the obstetric operation of embryotomy.[1] From the time of Paulus, we find no Greek or Roman surgeon of note, until the appearance of Actuarius, a Greek, who practised with great distinction at Constantinople, probably about the beginning of the twelfth century, but at what exact period it is impossible to ascertain. Among his writings are found several surgical treatises, which however possess no greater merit than as compilations from previous authors.[2]

Actuarius.

Arabia.
A.D. 640.

Having thus traced surgery from its origin, through the Egyptian, Greek, and Roman dynasties, we come to notice the prolongation of its feeble existence in Arabia.[1] From Alexandria, captured by the Saracens under Amrou in 640, knowledge was gradually communicated to Arabia. Its people became acquainted with medicine through the medium of translations of the Greek authors; and the "seat of learning was transferred, for a time, from beneath the shadow of the cross to the empire of the crescent; from the classic shores of Italy and Greece, to the warlike followers of Mahomet, and the fiery descendants of Ishmael." Many valuable manuscripts, rescued from the savage destruction of the Alexandrian library, were carefully transcribed, or translated into the Syriac or Arabic languages, and dispersed in various directions. The first Arabic translation was made about the year 683, by Maserjawaihus, a native of Syria; but the most eminent in this labour was Honain, called, by way of eminence, "the translator," a Christian, born at Hira in 764. Towards the end of the eighth century, a college was founded at Bagdat by the Caliph Almanzor; and there medicine obtained a permanent footing, under the fostering care of the far-famed Caliph Haroun al Raschid. Public hospitals and laboratories were founded by him for the benefit of students, who are said to have amounted at one time to no fewer than six thousand, consisting chiefly of Christians banished on account of their religion; and the Caliph Almamon surpassed even his predecessors in munificent patronage, extended to every department of art and science, and in unwearied exertions to restore and propagate the various branches of learning. By supplication he prevailed upon the Grecian emperors to send him many works in philosophy; and, employing the best interpreters that he could find, ordered all these books to be translated, and encouraged the industrious study of them by his own personal example. The medical school at Jondisabour, the capital of Chorassan, established by Sapores the First as early as the end of the third century, had by this time risen to great celebrity; and from it Rhazes, Hally Abbas, and Avicenna derived their medical education. Mesue lived during the caliphate of Haroun al Raschid, in the end of the eighth century, and Serapion during that of Almamon, about a century later; both eminent medical men in their time, but both pure physicians.

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[1] Mr Francis Adams, a very erudite surgeon practising in the vicinity of Aberdeen, has published the first volume of "The Medical Works of Paulus Ægineta, the Greek Physician, translated into English: with a copious commentary, containing a comprehensive view of the knowledge possessed by the Greeks, Romans, and Arabians, on all subjects connected with medicine and surgery." Lond. 1834, 8vo.

[2] Le Clerc, Histoire de la Médecine. Geneve, 1696, 8vo. Amst. 1723, 4to. Freind's History of Physick, from the time of Galen to the beginning of the sixteenth century. Lond. 1725–6, 2 vols. 8vo. Le Clerc only continues the history till the age of Galen. The literary history of the Greek physicians may be sought in the *Bibliotheca Græca* of Fabricius.

Rhazes, A.D. 852-932.

The first Arabian worthy in the surgical department was the celebrated Rhazes, who presided over an hospital at Bagdat in the end of the ninth and beginning of the tenth centuries. His works are not remarkable for anatomical knowledge, which is not surprising, since the study of anatomy was strictly forbidden by the Mahommedan religion, and consequently the Arabians had to rest contented with the writings of the Greeks on that subject. "One of their religious prejudices against dissection was, that the soul did not instantly forsake the body, but lingered in some particular portion of it for some time after apparent dissolution, so that the dismemberment of it might be a species of hideous martyrdom;" a very sufficient reason why a professor of such a belief should strenuously object to the anatomization of himself and his friends. Rhazes is the first who has described spina ventosa and spina bifida. Of the real nature of the latter, however, he does not seem to have had any clear idea. Regarding cancer, he advised that the knife should never be used except when the disease was limited, and the whole tumour could be completely removed; condemning the opposite procedure as cruel and unavailing; an opinion which after-experience has shown to be most just and true. In bites from rabid animals, he first cauterized the wounds, and then prescribed emetics to expel the "black bile;" an evacuation considered most essential to the cure. His account of hernia is better than any to be found in the Greek writers. His works on surgery, however, are little more than compilations from Hippocrates, Oribasius, Aëtius, and Paulus. His confidence in oculism does not seem to have been great; for, having in his old age become blind from cataract, he could not, though urged, be prevailed upon to undergo an operation for its removal. In his time lithotomy, and some other operations, seem to have been entirely in the hands of juggling impostors.

Hally Abbas.

Hally Abbas, surnamed the Magician, on account of the extent of his knowledge and acquirements, lived in the end of the tenth century.

A.D. 980.

His great work, the Al-meleky, written about the year 980, is, in its anatomical and physiological department, a mere transcript from the Greeks; and his surgery possesses but few peculiarities. "From the idea that caustics were efficacious when a redundancy of the humours flowed to a particular part, he recommended their application for the cure of hydrocele. In the management of dropsical affections his attention was always directed to the remote causes; and he preferred puncturing in the linea alba, a little below the umbilicus, for the relief of ascites."

Avicenna.

Avicenna, who divides with Rhazes the honour of having first introduced chemistry into physic, flourished later than the two preceding Arabians. He was termed, in his day, the Prince of Physicians, and seems to have been regarded as almost miraculous for the extent and variety of his knowledge.

A.D. 980-1036.

He was born in 980, and died in 1036, without a rival, either in the medical profession, or in general science. In his great medical work, the Canon, the surgical department is not altogether forgotten, but holds a second place to physic; indeed, before the appearance of Albucasis, surgery seems to have been all but extinct amongst the Arabians. He has distinguished between closure of the pupil and cataract, and in operating for the latter recommends depression; extraction he considers a very dangerous experiment. It is probable that to him we owe the first use of the flexible catheter. His works are said to have remained the oracles of medical knowledge for nearly six hundred years.

Albucas A.D. 112

Albucasis, who died in 1122, exerted himself more than his predecessors in behalf of surgery, which, by his own account, he found in a most deplorable condition; and he is chiefly distinguished as a surgical writer. Cauteries and caustics seem to have been his favourite remedies; and he becomes enraptured when speaking of the "divine and secret virtues" of fire surgically employed. The actual cautery he looked upon with veneration, and describes more than fifty affections in which his experience had found it beneficial. He is minute in his directions for its application, and forbids its use, "except by persons acquainted with the anatomy of the frame, and the position of the *nerves, tendons, veins, and arteries*;" from which latter circumstance some idea may be formed of the extent to which he himself was in the habit of roasting his unfortunate patients. He checked arterial hæmorrhage by his favourite method of cauterization, but also employed styptics, as well as complete division of the vessel, and ligature. He is supposed to have been the first to remark, that it is by the formation of a coagulum in the orifice of an artery that its calibre is closed and hæmorrhage arrested. He has described a particular instrument of his own for the cure of fistula lachrymalis, and the needle used by the surgeons of Irak for cataract. He speaks of operating for the relief of hydrocephalus, but the success of the practice does not seem to have been greater then than in its revival in our own time; for he confesses that he knew of but one successful case, and therefore does not recommend the operation. He seems to have been conversant with the mode of removing tumours by ligature when the knife is inexpedient; he advises amputation in gangrene of the extremities; and is the first who has described the mode of extracting calculus by incision in the female. His method of lithotomy resembled that practised by Paulus Ægineta; and, like him, he seems to have been bold in puncturing and excising the tonsils, removing the uvula when obstinately relaxed, and extracting polypous tumours from the fauces. He mentions bronchocele as occurring most frequently among women; but, fond of the knife and cautery as he was, he does not seem to have employed either for the removal of that tumour; indeed he tells us of "an ignorant operator who," in attempting extirpation of a bronchocele, "by wounding the arteries of the neck, killed the patient upon the spot." He invented the probang, for dislodging foreign bodies from the gullet; and in wounds of the intestines practised union of the divided parts by suture more than once with success. Though thus bold in his operations, and, like all the Arabians, too fond of the employment of instruments, he was not however without judgment and caution. For example, he condemns tracheotomy as worse than useless when the inflammatory affection of the windpipe is acute, and has extended to the bronchi; an opinion which is acknowledged as true, though unfortunately not always followed in the present day. And he exceeds even Rhazes in his dislike to operative interference with cancerous tumours, declaring that he never either cured, or saw cured, a single instance of that disease; a conclusion too nearly consistent with the history of that most implacable malady in all succeeding ages. His remarks on abscesses are most judicious; directing particular attention to their situation, and recommending their being early opened, whether "matured" or not, when in the neighbourhood of joints or other important parts, which would be injured by their continuance; a rule of practice which, if more faithfully followed, would materially diminish the number of diseased joints and bones. He also advised what has since been so much insisted on by Mr Abernethy, that when the abscess is very large, its contents should be evacuated by degrees. He is the only one among the ancient writers on surgery who has described the instruments used in each particular operation.

Avenzoar

Avenzoar, a Spanish Arab, practised physic with distinction, about the beginning of the twelfth century, at Seville in Andalusia. He describes inflammation and abscess of the mediastinum, from which he had himself suffered; and mentions a case of abscess of the kidney, from which fourteen pints of matter were evacuated. He speaks of bronchotomy as expedient in dangerous cases of inflammation of the tonsils: and in stricture of the gullet proposes three modes of treatment; the occasional passage of a tin or silver tube; the use of a milk bath, that nutritious particles may be taken up by the pores on the skin; and the injection of nutritious fluids by the rectum. He also details cases of "rupture, fracture of the hip-bone, wounds of the arteries and veins, tumours, and other varieties of surgical disease, which he appears to have understood well, and treated with discretion." He does not complain, like Rhazes, that lithotomy was in the hands of mountebanks, but tells us that the Arabians then reckoned such operations "filthy and abominable, and unfit for any man of character to perform;" and held that "no religious man, according to the law, ought so much as to view the genitals." The brightest name in the history of Arabian philosophy is that of Averrhoes, the pupil of Avenzoar, born at Cordova about the middle of the twelfth century, and said to have died in the year 1206. But he cultivated the study of medicine only as a branch of general philosophy, and surgery he seems to have altogether neglected.

rrhoes, 1206.

Such were the Arabians. Of these, Albucasis was the most famous in surgery, as Celsus had been among the Romans, and Paulus Ægineta among the Greeks. But even he could not escape the unfortunate failing of the Saracenic school; endless invention of manifold and complicated instruments, attaching far too much importance to the mechanical part of their profession, and mistaking the inspiration of terror and infliction of cruelty for energetic and judicious surgery. In order, for example, to arrest hæmorrhage from a wounded surface, if time pressed and assistants were scarce, it was not uncommon to dip the part into boiling pitch, a liquid which was then dignified with the appellation of a styptic. They however systematically divided physic, surgery, and pharmacy into three distinct professions; and so, by commencing the division of labour, may be considered as having done something not unimportant towards the ultimate advancement of medical knowledge. "The last traces of their intellectual illumination appeared among the Spanish Moors in the thirteenth century, when the Christian arms having become more and more powerful, they were compelled to substitute the field for the study—the sword for the pen—and, before an overwhelming opposition, were at length driven from a region whose fields they had tilled, and whose olives they had gathered, for a thousand years. With the decline of the Saracenic school, the daylight of science went down over the nations; and an intellectual darkness, which endured for three hundred years, enveloped the general face of society. All the fountains of science were dried up, and the world seemed retrograding into the unillumined chaos of ignorance."[1]

ool of erno.

A knowledge of the Greek and Arabian systems of medicine was introduced into Italy, at Salerno, in the beginning of the eleventh century; and this school soon rose to celebrity as a seat of medical learning. In the time of the Crusades, Salerno was a place of great resort for warriors of all nations passing between Europe and Palestine; and by these wanderers, on their return, the light of medical science was thence slowly conveyed over Europe. It obtained the privileges of a university; but the medical school of Salerno did not long retain its high reputation. In modern times, it is chiefly remembered on account of the *Regimen Sanitatis Salernitanum*, a singular production, of which more than one hundred and sixty editions are known to have been published. Though written in the name of the *Schola Salernitana*, it has generally been ascribed to Joannes de Milano. The English king to whom it is addressed is supposed to have been Robert of Normandy, whose claims to the English crown were recognised by some of his contemporaries. The poem opens with these lines:

> Anglorum Regi scripsit Schola tota Salerni.
> Si vis incolumem, si vis te reddere sanum,
> Curas tolle graves, irasci crede profanum,
> Parce mero, cœnato parum, non sit tibi vanum
> Surgere post epulas, somnum fuge meridianum,
> Non mictum retine, nec comprime fortiter anum.[2]

In the twelfth century, the Jews practised medicine, not only among their own tribes, but also among the Moors and Christians; and though, like all others of this age, merely treading in the beaten track of the Greeks and Arabians, yet, from their superiority in such learning, they came to be reputed the most skilful practitioners. About the middle of that century, as has already been stated, surgery was completely separated from physic, by the edict of the Council of Tours prohibiting the clergy,[3] who then shared with the Jews the practice of the healing art in Christian Europe, from in any way causing the effusion of blood, at least as a means of curing bodily ailment. Surgery was in consequence abandoned to the uneducated laity, and sunk to a deplorable state of prostration; it became a mere matter of plasters and unguents; and if any thing happened to be written on the subject, it was but a bad compilation from the Arabians.[4] We shall however notice some of the more remarkable events in connection with it during its temporary abasement. In the year 1271, the foundation of the College of Surgeons at Paris was laid by Pitard, a surgeon of eminence in those days, and whose enthusiasm effected something towards raising his humbled profession. About the same time lived Gulielmus de Saliceto, a professor at Verona, said to have been "a powerful man" in both surgery and medicine. He seems to have earnestly dissuaded men from the copying and study of books in preference to practical experience, and he himself set a better example. In our own country Gilbertus Anglicanus is the first name connected with surgery; but he seems to have been little more than a compiler from the Arabians. He lived about the beginning of the fourteenth century; and shortly after him appeared John of Gaddesden, author of the *Rosa Anglica*, and said to have been an erudite and ingenious man, as well as a skilful practi-

A. D. 1271.

Fourteenth century.

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[1] Moir's Outlines of the Ancient History of Medicine. Edinb. 1831, 16to. Of this work we have not scrupled to make free use in the course of the preceding observations.

[2] *Regimen Sanitatis Salernitanum:* a Poem on the Preservation of Health, in rhyming Latin verse, addressed by the School of Salerno to Robert of Normandy, son of William the Conqueror, with an ancient translation; and an introduction and notes by Sir Alexander Croke, D.C.L. and F.A.S. Oxford, 1830, 12mo.

[3] The early clergy claimed the practice of medicine as their peculiar privilege, and, using it chiefly as a means of personal power and gain, disgraced it by ignorance, charlatanry, and imposture. It was to check this that the Roman council assembled by Pope Innocent II. in 1139, threatened with the severest penalties those monks and canons who applied to the practice of medicine, "neglecting the sacred objects of their own profession, and holding out the delusive hope of health in exchange for ungodly lucre." But even this, though followed by the more peremptory edict at Tours in 1163, where Alexander III. presided, did not make them altogether forego what they found so convenient and profitable. It was necessary to repeat the edict in 1179 and 1216; but notwithstanding, the monks continued still to practise physic, and it was chiefly by their evil influence that the school of Salerno was brought to decay.

[4] The writers of that age were aptly termed by Severinus, Arabistæ.

tioner. About the middle of the fourteenth century, Guy de Chauliac practised with renown at Avignon, and is "accounted one of the revivers of the languishing art." In his *Chirurgia*, a history of the state of surgery in his day,[1] we find the first mention of the Cæsarean operation. Contemporary with him was John of Ardern, an English surgeon. He wrote with simplicity and honesty, and may be regarded as a reviver of surgery in that country. In his practice he was peculiarly successful in the treatment of fistula in ano, and thereby acquired a great reputation. Valesco de Taranta, a Portuguese, practised at Montpellier, and wrote on surgery in the beginning of the fifteenth century. He was the first who proposed the cure of cancer by the application of arsenic. About the middle of the same century, lithotomy, the practice of which had hitherto been confined to itinerant and ill-informed operators, was restored to the regular profession by Germain Colot, a French surgeon, high in favour with Louis the Eleventh. He first contrived to witness the operation by the itinerants, then practised it on the dead body, and at last performed it successfully on a condemned criminal who happened to be afflicted with stone, and who consented to undergo the operation on condition of being pardoned if he survived. His success, in having thus doubly saved life, obtained for Colot much renown; and lithotomy ever after continued a regular part of surgical practice.[2] The fifteenth century contains other two events important to surgery; 1450. the discovery of the art of printing, about the year 1450, which gave a new impulse to science and literature, by rendering the accumulated stores of knowledge more accessible; and the importation of the venereal disease from America, by the first discoverers of that continent, giving the *small* pox as if in exchange, about the year 1492.[3] In this century also the Turks captured Constantinople, thus overthrowing the last remains of the eastern empire; and by the multitude of Christians who fled from that city many manuscripts of the Greek medical writers were brought to Italy, and their contents thence slowly disseminated over Europe.

Sixteenth century.

Hitherto surgery can scarcely lay claim to an actual revival. Occasional attempts had been made to raise it from its low position, but all proved abortive. At length, however, in the beginning of the sixteenth century, the practitioners of the healing art were happily convinced that the observation of nature was superior to compilation from the ancients, whether Arabian, Roman, or Greek; they consequently ceased to tread blindly and servilely in the footsteps of their predecessors, and a new era arose to the profession. 1539. About the same time Vesalius gave birth to anatomy, properly so called;[4] illuminated by which science, surgery became a worthy object of pursuit to men of talents and education, and under their cultivation it was gradually raised to an enlightened and liberal profession.

A. Paré.

The most conspicuous name in this new era of surgery is that of Ambrose Paré, a Frenchman. In this country surgery was then sadly depressed, having retrograded since the time of John of Ardern. Its list of practitioners comprised barbers, farriers, sow-gelders, cobblers, and tinkers; and it is not matter of surprise that from among these no name has been handed down as worthy of remembrance. The combination of the practice of surgery with the more harmless manipulations of the barber, was not confined however to this island, but existed also in France, and continued in both countries for upwards of 200 years. The great Paré does not reject the appellation of barber-surgeon, as applied to himself; nor does he seem to think that there is any thing derogatory in the title. He was surgeon successively to Henry the Second, Francis the Second, Charles the Ninth, and Henry the Third, of France; and followed the French armies in all their campaigns down to the battle of Moncontour in 1569. His consequent experience of gunshot and other wounds, on the field of battle, naturally directed his attention to the subject of hæmorrhage; and it is to him that we owe the revival and improvement of the method of arresting bleeding from arteries by ligature, and discontinuance of the cauteries and styptics, which, to the disgrace of surgery, had hitherto been in exclusive use for this purpose. Yet so averse are mankind to abandon their ancient customs, that the improvement of Paré was not sanctioned till after much abuse and persecution, directed both against himself and his discovery; indeed so bitter and unrelenting were his jealous brethren, that he was compelled for his own safety to adduce garbled and incorrect extracts from Galen and other ancients, in proof that to them, and not to him, the invention was to be referred. So far he was less in error than he himself supposed, for we have already stated that he has merely the merit of reviving the use of the ligature.[5] Celsus distinctly advises its employment when pressure fails to stop arterial hæmorrhage; and Albucasis sometimes condescended to use it instead of his favourite cautery and cruel styptics. Paré, however, was amply repaid by future fame for the opposition which he had at first sustained. He rose to an unparalleled height of popularity with the army, by whom he was absolutely adored. On one occasion, his mere presence among the garrison of a beleagured city about to capitulate, re-animated the troops to such an extent, that their resistance became more energetic than before, and the besieging army perished beneath the walls. By his sovereigns he was also highly esteemed. From the general massacre on the fearful night of St Bartholomew he was rescued by the personal exertions of Charles the Ninth, his great merits being appreciated even by that weak and cruel monarch. But he was not content with the respect and praise of his contemporaries; his writings, the result of great experience and accurate observation, freed from the yoke of authority, and digested by genius of a high order, have rendered him immortal. His works, first published in 1535, and afterwards more fully in 1582, exerted a most powerful and beneficial influence upon his profession. The influence was not however immediate; for at his death the light he had shed was for a time obscured, surgery reverting to the state of degradation in which he found it, in consequence of its baneful association with barberism. Pigrai was his successor, but an unworthy one: endeavouring to follow the footsteps of his master, he obscured and almost effaced them. The most interesting of Paré's surgical treatises is that on gunshot wounds, a class of injuries then of recent introduction, and little understood: the murderous cannon and firelock had not long been in use.

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[1] Some idea may be formed of the languishing state of surgery at this time, from his division of the surgeons into the following five sects. The first applied cataplasms indiscriminately to every description of ulcer and wound. The second in similar cases employed wine only. The third used emollient ointments and plasters. The fourth, chiefly military surgeons, promiscuously employed oils, wool, potions, and charms. The fifth, "consisting of ignorant practitioners and silly women, had recourse upon all occasions to the saints, praised each other's writings perpetually, and followed each other in one undeviating track, like cranes."

[2] In the beginning of the sixteenth century, cutting upon the staff was introduced by Johannes de Romanis and Marianus Sanctus, and very successfully followed by Laurence Colot, a descendant of Germain.

[3] The first author who clearly describes the venereal disease is Marcellus Cumanus, who wrote in 1495. It was not till 1530 that Fracastorius wrote his celebrated poem *De Morbo Gallico*, in reference to which it has been said that the chaste and classic elegance of its language was worthy of the best days of imperial Rome, and the mellifluence of its versification hardly surpassed by the bard of Mantua himself. By G. Torella, physician to Pope Alexander the Sixth, we are informed that the insane abuse of mercury as a means of cure was not quite a universal practice on the outbreak of the disease; for, in describing some particular forms of mercurial ointment, he himself states that "they destroyed an infinite number of people, who in this case did not die, but were downright killed; and these bold empirics must give an account, if not in this, in the next world, of their practice, and be drowned in the pit of repentance." It is but very lately that the "pit of repentance" ceased to be useful under very similar circumstances.

[4] A little later in the century, Fallopius taught anatomy at Pisa, and Eustachius at Rome, and to their efforts, as well as to those of Vesalius, the advancement of that science is much indebted. Fallopius died in 1563; Eustachius in 1574.

[5] As an example of how little the hint of Celsus was attended to, we may mention, that Procopius relates how Artabazes perished of a wound in the neck, "the artery of the neck having been cut through, so that the blood *could not be stopped*." Their cauteries and styptics had no effect on the carotid, or its larger trunks.

S n- te h c ury. C aga- tu. T iaco- tu. Se rinus. F qua- pe ute.

In the seventeenth century surgery again revived, resuming the impulse which the genius of Paré had imparted. Italy produced Cæsar Magatus, who simplified, and consequently must have improved, the treatment of wounds; the never-to-be-forgotten Tagliacotius, with his rude repairs of the human face; and Marcus Aurelius Severinus, a skilful and intrepid operator. At the end of the sixteenth and beginning of the seventeenth centuries, Padua was favoured with Fabricius ab Aquapendente, the preceptor of Harvey, a most distinguished physiologist, and the most eminent surgeon of his time. His *Opera Chirurgica* passed through no less than seventeen editions, and contain not only an excellent digest of surgery as it then was, but also many improvements of his own. About the middle of the seventeenth century arose the true father of British surgery, our own Wiseman, the Paré of England. One or two English names are to be found before him: William Clowes, a military surgeon of some eminence, attended the Earl of Leicester's army in the Low Countries, and wrote on gunshot wounds; and Lowe, a Scotchman, gave to the world a Discourse on the whole Art of Chirurgery, dated 1612: but Wiseman doubtless is the first Briton worthy of note in surgery. He was serjeant-surgeon to Charles II., and amidst the horrors of the civil wars had ample scope for the study of his profession. His surgical works, consisting of eight treatises, dated 1676, contain much information, at that time most valuable, and still amply rewarding an attentive perusal. In military practice he strongly advocated immediate amputation, "while the patient is free of fever," in the case of such injuries as rendered preservation of the member improbable, of course allowing the primary shock of the accident to be past; a point of practice which long discussion in after years served to confirm. It was not till his time that surgeons ceased to believe that gunshot wounds were necessarily envenomed by the powder and ball, and had to be treated accordingly with potent and cruel dressings. The immortal Harvey, contemporary with Wiseman, cannot perhaps be classed among the eminent surgeons, having principally confined himself to anatomy and physiology, yet he is inseparably connected with that science by his discovery of the circulation of the blood; a discovery which has done so much for the advancement of all medical knowledge, but of surgery in particular. James Young, a surgeon in Plymouth, may be said to have been also contemporary with Wiseman, having written in 1679. He is the first who proposed amputation by a flap, an improvement to which two French surgeons, Verduin and Sabaurin, lay claim; and he is also the first who recommends limited compression of the main artery in amputation.

W man.

H v.

628.

You

F. da- nus. Scu us. Pur nn. Hei .

Germany boasts of several eminent surgeons of this time; Fabricius Hildanus, a most successful practitioner, and author of a surgical treatise dated 1641; Scultetus, author of the work, celebrated for its horrid array of lethal weapons, called *Armamentarium Chirurgicum*, 1653; and Purmann, who displayed too great an attachment to the dangerous representations of Scultetus. Heister, a professor in the university of Helmstädt, wrote a system of surgery, which has been translated into most of the European languages, and is still in high repute.

Rau.

Holland likewise possessed successful practitioners of surgery, but tainted with an unworthy concealment of their methods of cure. Rau, a native of Germany, though a professor at Leyden, was perhaps the most successful lithotomist that ever lived, but he kept his method of operating a profound secret, and made it a mystery even to his own pupils; as appears from the circumstance that his two favourites, Heister and Albinus, of a more liberal spirit than their master, in attempting to divulge his secret for the benefit of the profession at large, have varied most materially in their statements. This illiberal spirit pervaded the other branches of medicine as well as the surgical. The famous anatomist Ruysch preserved inviolate the secret of his wonderfully minute injections, although really the discovery of his friend De Graaf; and Roonhuysen the accoucheur worked stealthily with his invented lever. The succeeding generation however removed this stigma from the Dutch; and their great Camper was equally celebrated for the number of his discoveries and the zeal with which he made them known.

Dionis.

From the time of Paré, France produced no surgeons of great eminence until the eighteenth century. In the seventeenth, we find the names of Dionis, Belloste, Saviard, and a few others of some renown, but not at all equal to their contemporaries in other nations. Some idea may be formed of the then feeble condition of surgery in France, from the fact, that Louis XIV. was not cured of a simple fistula in ano, until after his life had been in no small degree endangered by repeated abortive operations. That the French can boast of surgeons of the first class in the next century, however, is indisputably shown by the simple mention of Petit and Desault; names that must ever occupy a proud place in the annals of surgery. The former, adding to the most powerful talents great industry, and an innate love of his pursuits, rose rapidly to eminence, though not without much envious opposition, which seems to be the portion of nearly all those who occupy a pre-eminent place in the profession. On general surgery, he has left a work of much value; and his treatise on diseases of the bones, though produced at an early age, entitles him to be called the father of that branch of pathology. For many years it remained the best work on the subject. He was the inventor of the screw-tourniquet, and the first who operated for fistula lachrymalis by transfixion of the sac. He contributed largely to the Memoirs of the Royal Academy of Surgery; an institution which has done much for the advancement of surgery, not only in France, but throughout the world. Its Memoirs, containing the result of the labours of many eminent men, constitute a work of the greatest value. Desault, also of high reputation, both as an anatomist and as a surgeon, was the first who taught surgical anatomy, and gave clinical lectures on surgery. His improvements on the apparatus for fractures were most important; and a splint invented by him is still in use for fractures high in the femur. His modifications of cutting instruments were also good; among others, changing the amputating instrument to a straight knife, instead of the old curved weapon. He was the first who contemplated the cure of artificial anus, resulting from strangulated hernia; and he further improved Paré's revival of ligature of the arteries. The proposal of curing aneurism by ligature of the vessel on the distal side of the tumour originated with him; a proceeding, however, of which the merit is still dubious. His writings are both valuable and extensive. After the great names of Petit and Desault, not a few French surgeons of the same century, though less eminent, yet deserve mention; Le Dran, a copious and excellent author; Sabatier, famous in the department of operative surgery;

Eighteenth century.

Petit.

Desault.

Le Dran, &c.

Garengeot, Louis, La Motte, Frère St Cosme,[1] Portal, Pouteau, Lecat, Chopart, Morand, Moreau, &c.

America.

It is about the middle of the eighteenth century that our attention is first attracted to our transatlantic brethren. In 1763, lectures on anatomy and surgery were delivered in Philadelphia by Dr Shippen; and in 1791 the medical school of that city was completely established, under Benjamin Rush, the Hippocrates of Colombia; a school which has since lent invaluable aid to the progress of both medicine and surgery.

Pott.

Our own country was at this time by no means barren in surgery. Percival Pott and John Hunter are names which occur, the one in the middle, the other in the end, of the eighteenth century, and are fully equivalent to Petit and Desault; indeed Hunter may be justly ranked as the greatest man that ever graced the profession. Pott, the best author, operator, and practical surgeon of his time, greatly improved the practice of surgery in England, both by his writings and by personal example. Like Desault, his attention was particularly directed to the treatment of fractures, of which he had some painful experience in his own person, having sustained a severe compound fracture of the leg. He has left a justly celebrated treatise on the subject. On amputation his observations are most important, clearly discriminating between those cases, of injury more particularly, which demand the operation, and those which do not; at the same time marking the period most advantageous to its performance. Regarding injuries of the head, he wrote with more precision, and at the same time with more originality, than any previous author, and will ever remain a valued authority upon that subject. The same may be said of his description of vertebral disease, he having been the first who clearly distinguished between those curvatures of the spine depending on mere change of form in the bones, and those occasioned by caries or abscess: the latter formidable affection is still known as "Pott's disease" of the vertebræ. He greatly improved the treatment of fistula in ano, and abscesses in general; and by simplifying the whole art of surgery, discarding the cautery and escharotic unguents, or rather limiting them to their proper place and use, employing also the cutting instruments with caution and reserve, and placing more implicit trust in, and showing more respect for, the powers of nature than had hitherto been the custom, he achieved a most important and beneficial reform in surgery. Until his time, the maxim "Dolor medicina doloris" remained unrefuted. The actual cautery, for example, was in such general use, that "at the time when surgeons visited the hospital, it was regularly heated and prepared in the wards, and in the presence of the patients, as a part of the necessary apparatus. Mr Pott lived to see these remains of barbarism set aside, and a more humane and rational plan, of which he was the originator, universally adopted." John Hunter, a native of Scotland, the pupil, first of Cheselden, and afterwards of Pott, though not remarkably distinguished as an operator, was the most gifted surgeon of which the medical profession can boast, and no less eminent as an anatomist, physiologist, and general philosopher. His researches comprehended a wider range than those of Pott, but arrived at the same end, the improvement of surgery. The knowledge obtained by his vast inquiries into physiology, pathology, and human and comparative anatomy, was, with all the power of his genius, brought to bear upon the practice of the profession, and with the happiest success. The doctrines of adhesion, granulation, ulceration, and inflammation with its various results, were, until detected and explained by him, comparatively obscure and uncertain; and no one is ignorant how much the successful treatment of disease, either by surgery or medicine, must ever depend on an accurate and familiar knowledge of these rudiments. To him we are indebted for the simplification of more than one operation, the discovery of the vitality of the blood, important advice as to the treatment of gunshot wounds, the enforcement of excision of bitten or poisoned parts, many new facts as to the physiology and pathology of teeth, and other valuable additions to practical surgery. But these assume an unimportant place among his deeds, when placed beside the two with which his name is indelibly associated—the cure of popliteal aneurism by ligature of the femoral artery, and the elucidation of the venereal disease; his work on the latter subject still remaining standard, and in many respects unsurpassed. His improvement of the operation for aneurism marks an era in the history of surgery, being one of the most important of its advances. Dissatisfied with the cruel, formidable, and unsatisfactory operation for popliteal aneurism, by incision of the tumour and ligature of the vessel at its diseased part, he made himself aware of the causes of failure by the old system, contemplated the plan of cure which bears his name, satisfied himself of its practicability by diligent study and experiment, successfully brought it to the test of actual practice; and then, extending the principle to all aneurisms, effected for surgery a great triumph over that formidable disease.[2] His first operation was performed in 1785, and was successful; proving that permanent removal of the force of the circulation in the aneurism is sufficient for its cure, by permitting consolidation and ultimate obliteration of the tumour. Since his time the method of applying the ligature has been considerably improved, and the certainty of success consequently increased. But "the more brilliant a discovery, and the more beneficial its results, the more certain is its author of becoming the butt of envy and the object of detraction." And accordingly we find that Hunter has not been permitted to remain in undisturbed possession of his discovery. Its merit has by some been claimed as due to Aëtius: others, with better hopes of success, support the pretensions of Guillemeau (a pupil of Ambrose Paré), Anel,[3] and Desault; but a candid inquiry into facts and dates will ever result in ascribing the honour to our illustrious countryman. Had he even been deprived of this, his name must still have been immortalized by other and more palpable labour of his mind and hand—his books and museum.

Hunter.

A. D. 17

White. Cheseld Sharp. Monro.

In the same century with Pott and Hunter, Britain also produced White, an excellent practical surgeon and lucid writer; Cheselden and Douglas, two eminent lithotomists, the former peculiarly successful; Sharp, famed for his Critical Inquiry into the State of Surgery; and Monro, a name indissolubly united with the birth and fame of the Edinburgh medical school.[4]

Scarpa.

In Italy, where, during the times of Pott and Hunter, several eminent surgeons lived, Lancisi, Morgagni, Bertrandi, Troja, &c.,—the labours of Hunter in aneurism were ably followed up by Scarpa, who still further elucidated the doctrines regarding the new treatment of that disease, and established the success of the operation. He was also eminently successful in his researches as to the anatomy and pathology of hernia, a subject which he has made peculiarly his own. The same century saw in Germany, Schmucker, Richter, and the great Haller, whose *Disputationes Chirurgicæ* bear, equally with his other works, the impress of both labour and genius of a high order.

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[1] Frère Jean de St Cosme, although a monk, had been educated as a surgeon. He was the inventor of the Lithotome Caché, and with it obtained wonderful success and celebrity as a lithotomist.

[2] "So discouraging were the results of the old operation, that many surgeons preferred performing amputation of the aneurismal limb."

[3] Guillemeau and Anel placed their incisions and ligatures in the immediate neighbourhood of the tumour.

[4] Dr Monro was appointed professor of anatomy to the company of surgeons in 1719, and during the ensuing year he was appointed to a similar chair in the university. Several other professors in the same faculty had previously been nominated; Sir Robert Sibbald, Dr Halket, and Dr Pitcairne, so early as the year 1685. But Dr Monro was the first who regularly delivered public courses of lectures, and he may in a great measure be regarded as the founder of the medical school of Edinburgh.

The nineteenth century will not yield to any former era in a numerous and bright array of names dear to surgery. It has seen the fall of Abernethy and Dupuytren, brilliant stars in the galaxy, and mourns others highly valued; but vast and powerful is the host who are still labouring, with distinguished success, in their noble calling. In all civilized countries, the dark days of the profession have, we trust, for ever passed away; and many are the illustrious names in which it now exults, more particularly in France and Germany. But we hesitate not to assert,—and we cannot think that national prejudice exerts any influence in leading us to the conclusion,—that no country can boast of such a crowd as that by which Britain, in the present century, has been and still is adorned. And we feel an honest pride in stating, that the medical school of Edinburgh can claim connection with not the least among these living names.

Having followed surgery thus far, from the earliest times, in its most notable points of history, we shall proceed to inquire briefly into the practice of the present day. And, first, of the art of operating. It is a favourite phrase by which operations are stigmatized as the "opprobria of surgery." Nothing can be more unjust. So long as injury and disease are permitted to afflict mankind; so long as bones are crushed, and flesh bruised and torn; so long as tumours grow, and gangrenes spread—and we know nothing short of direct divine interposition that can wholly prevent such accidents—it is only by operation, dexterously executed and skilfully timed, that the human frame can be kept in repair, and life prolonged. To be able safely and expeditiously to remove parts which accident has rendered totally useless, and which would prove highly injurious if longer attached to the body; to take away diseased formations, or other noxious substances, and, at the expense of but brief suffering, to dispel torture which had rendered existence a burden for previous weeks, months, and years; to accomplish such results, though it be by blood and pain, is alike creditable to the operator and beneficial to the sufferer. It is not a disgrace to the profession that certain injuries and diseases are of so grievous a nature as to be incurable but by operation, for such is the dispensation of Providence; it is the surgeon's boast to have recourse to the knife as seldom as possible; but it is also his pride to be able by it, as a last, and, to both parties, painful resource, to ward off suffering, deformity, and death. It is not, to operate, but to operate unseasonably, unnecessarily, unskilfully, that can ever bring disgrace; and to refrain from performing an operation when it is loudly and plainly called for, would carry not only opprobrium to surgery, but guilt and shame to the surgeon. We are speaking of surgery as it now is, not as it was. In former times operations were its disgrace. Knives, hot irons, screws, files, and saws, were employed with cruel and ignorant recklessness; but of late years, it has been the object of each truly good surgeon to simplify and diminish the number of instruments, and at the same time to use them as seldom as possible. He does not hesitate to employ them when his knowledge and experience tell him they have become indispensable. On the contrary, he will probably be urgent in their application, knowing that an early wound may save much after-suffering; but, in the first place, he will exert all his skill and all his powers, by milder measures to counteract injury and restrain disease, so as to supersede the necessity of operating. To effect this is doubtless the true triumph of his profession; and this triumph he often attains. But he must be Utopian indeed who can seriously hope that the period will ever arrive when operations shall have altogether ceased to be required. In the progress of surgery, many a murderous weapon, at one time in frequent use, has grown thick with rust, and become almost unknown; those retained are few, effective, and never employed without good cause. The growth of science and experience is bringing the ravages of disease more and more under control; operations are not only less frequent, but more simple and less dangerous in the performance; and it is the pride of the modern surgeon to witness and promote this great improvement of his profession. But there are, and ever must be, diseases which we cannot expect to cure, and injuries against which we cannot hope to strive successfully, so as to preserve life, by any measure short of operation. Modern surgery, accordingly, while anxious to limit the necessities for operation, is not the less aware of its importance as a means of cure; and has not only directed attention towards its improvement, but also extended its application, and with the happiest result, to diseases formerly unopposed. Many patients, for example, are now by the knife freed from morbid growths and natural deficiencies, who were formerly left an unprotected prey to deformity and disease.

The necessity for an operation having been clearly established, our object then is to perform it as safely and expeditiously as possible. We now no longer hear, as we did even so lately as fifteen or twenty years ago, of a poor patient being tortured for the space of an hour, by cruelties misnamed lithotomy: in a few minutes the bladder is cleared of extraneous matter; and almost the like number of seconds will suffice for amputation.[1] With this celerity, the safety of the patient is not only equally, but more secure; for rapidity is still held subservient to, though conjoined with, excellence of performance; and the mere absence of protracted pain confers a most important advantage on the reparative powers of the system. A prominent cause of this improvement in the art of operating, is an increased simplicity of the instruments, their arrangement, and use. On this subject, one who is *facile princeps* among the operators of the present day,[2] observes: Our armamentaria should contain simple and efficient instruments only; the springs, grooves, notches, and curves, seeming to be chiefly intended to compensate for want of tact and manual dexterity. The apparatus, though simple, ought to be in good order, and should always be placed within easy and convenient reach of the operator, so that he may be in a great measure independent of the lookers-on, who, owing to anxiety or curiosity, hurry and agitation, are apt to hand any thing but what may at the instant be required. He will consider well what place he himself will most conveniently occupy during the operation; and having obtained proper assistants, he will make sure that they all understand what is expected of them. In short, before he ventures to begin, he will ascertain that every thing is arranged, and in proper order; more particularly, that the cutting instruments have good points, that their edges are keen, and that the joints of forceps and scissors move freely and readily. The principle on which the instrument is made to cut should be well considered. Every knife is to be looked upon as a fine saw; the teeth of some are set forwards, and these cut best from point to heel, as does a razor; but the greater number are set in the opposite direction,—for example, the common scalpel and bistoury,—and act efficiently only in being drawn from heel to point. The cutaneous tissues, and in many instances the subjacent parts, should be divided at once and completely, by a single incision made lightly and rapidly; for the pain experienced is in proportion to the pressure and tardiness of movement in the instrument applied. The pain of partial division of the skin, in tails left at each end of an incision, is very great; and, besides, such wounds are not so available, as they would otherwise be, for the intended purpose of evacuating fluid, for permitting the extraction of foreign bodies, or for the dissection of morbid growths. Also, the pausing of a surgeon in the midst of a dissection, and the resort to fresh and more extensive incisions of the surface, is not only always awkward, but attended with much additional and unnecessary pain to the patient. Every cutting instrument should be well balanced, and placed in a steady, smooth handle; the point should either be in a line with the back, which ought then to be perfectly straight, or both edge and back should be so far convex, the point being in the middle of the blade. The form and size of the instrument ought always to be in proportion to the extent of the proposed incisions, both as regards their length and depth: nothing can be imagined more cruel and reprehensible, for example, than an attempt to remove the lower extremity of a full-grown person with a common scalpel or dissecting knife. If an extensive incision is necessary, an instrument should be employed possessing length of edge sufficient to separate the parts smoothly and quickly. Should the operator be required to cut on important parts, to perform a delicate dissection of the living tissues, he will choose a short-bladed instrument, with a handle rather long and well rounded; and after the superficial incisions have been effected, he will hold it as he would a writing pen, lightly but firmly, so that he can turn the edge, and cut either towards or from himself, as occasion may require. A small well-made scalpel, with a good point, and less convexity than those usually employed, is the instrument best adapted for such a purpose. Grooved probes and directors should be used as little as possible. With a little practice, incisions may be made upon the most delicate parts, without risk, by the hand unsupported, one layer being cut after the other. If any instrument is wanted to make the proceeding more safe—if the closely investing fasciæ of a hernial tumour, for example, are to be cautiously raised—dissecting forceps will be found the most convenient instrument for elevation previous to incision. In dividing the skin, the knife, whether a scalpel or a bistoury, is to be held and entered with the point and blade at right angles to the surface. It is carried with a decisive movement down to the subcutaneous cellular tissue; the blade is then inclined towards the part to be divided, and by a rapid and slightly sawing motion—as little pressure being applied as possible—the division is effected to the desired extent. The incision is finished by withdrawing the knife in a position perpendicular to the surface, so as to divide the entire thickness of the skin at the extremity as well as origin of the wound. For dexterously effecting such manipulations, the "fingers must be educated;" and diligent practice in the dissecting-room will be found the best foundation for surgical dexterity, as it is for sound surgical knowledge: "it is only when we have acquired dexterity on the dead subject, that we can be justified in interfering with the living." By practice the pupil will be enabled to use either hand almost equally well, and none should neglect to attain this power, for an ambidexterous surgeon possesses a great advantage as an operator. An ordinary degree of expertness is within the reach of any one who will industriously seek for and improve the opportunities for its acquirement; but yet a certain combination of natural qualifications is undoubtedly necessary to the attainment of pre-eminence in operative surgery; for a great operator in one respect resembles a great poet,—"nascitur, non fit." The importance of these natural gifts did not escape Celsus. "He must be young, or at most but middle aged," says he, "and have a strong steady hand, never subject to tremble. He must be ambidexterous, and of a quick, clear sight. He must be bold, and so far void of pity that he may have in view only the cure of him whom he has taken in hand, and not, in compassion to cries, either make more haste than the case requires, or cut less than is necessary, but do all as if he were not moved by the shrieks of his patient." The coolness and courage thus inculcated are the most valuable natural gifts of the surgeon; and it would be well did every patient remember that they are equally important in himself, for on his steadiness and patience under suffering much of the celerity and success of an operation depends. Expert skill in operation contributes greatly towards perfect self-possession; for the dexterous surgeon, like an adroit master of the sword, "will not enter rashly into difficulties, but being engaged from necessity or conviction, will bring himself through with courage." He who has what is strangely termed "*common sense*," enjoys another of nature's choicest gifts; and to no possessor does it prove more valuable than to the surgeon, as by its judicious application the want of more than one of the prominent qualifications considered as essential to his success may be fully compensated.[1] But a combination of the natural essentials for an eminent operator, as may readily be imagined, falls to the lot of only a small number; and to that gifted few it were well, when circumstances will admit of it, to delegate the performance of the more dangerous and difficult operations. Every surgeon, however, should be ready to undertake the greater number of surgical proceedings without hesitation or delay; for though, as we have already stated, operations do not form the most important part of surgery, they still are, and ever must be, inseparable from its successful practice.

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[1] Nor are there many now, who, alluding to their operative powers, would be likely to express themselves as did the preceptor of the immortal Harvey, first surgeon of his time though he was: "If it be a moveable tumour, I cut it away with a red-hot knife, that sears as it cuts; but if it be adherent to the chest, I cut it without bleeding, with a wooden or horn knife, soaked in aquafortis, with which, having cut the skin, I dig out the rest with my fingers!"

[2] Mr Liston.

Hæmorrhage.

Hæmorrhage, the most prominent accompaniment of surgical operation, is now in much better command, both temporarily and permanently, than it used to be, and consequently is less dreaded by the surgeon. During the operation, complicated machines, encircling the whole limb—very painful from the great and general pressure, and increasing the loss of blood by swelling the venous torrents and retarding retraction of the minor vessels—are now superseded by the skilful application of the "educated" and steady hand of an assistant, compressing the trunk of the main artery, and it alone. This change is particularly advantageous to amputation, admitting of its performance with greater despatch, less hæmorrhage, and less pain. In more tedious proceedings, the cautious extirpation of tumours, for example, the surgeon commences his incisions where he knows the principal vessels enter the part about to be the scene of operation: they are consequently divided at once; an active and steady assistant secures their orifices by the pressure of one or more fingers, and the proceedings are completed with comparatively little loss of blood, and without the hinderance of applying ligatures to any arterial branches until all the knife-work has been completed. Sometimes, when the part is unusually vascular, and important vessels come from all sides, this rule cannot be followed, and ligature must be applied to each important branch as it is divided; but this necessity for delay does not often occur. The ligature,—a firm hempen thread, well waxed,—ought in all cases to be applied very carefully, and made to enclose the orifice of the artery alone, which for this purpose is pulled out by common well-pointed dissecting forceps, or, when the parts have been consolidated by infiltration, by a sharp tenaculum. A double knot, carefully secure, having been made upon the isolated orifice, one end of the ligature is cut off close to the knot, the other being left protruding from the most dependent part of the wound, that the ultimate separation of the ligature and its enclosed slough may thus be watched and made certain. It was lately recommended, and is still practised by some, to cut away both ends of the ligature close to the knot, in the belief that the union of the wound by the first intention would thus be favoured, and in the hope that the noose would become encysted in its original situation, and produce no further annoyance; that hope however has been disappointed. It was then thought, that by making the ligature of an animal substance, as catgut, it might be slowly removed by absorption, and thus be prevented from becoming a source of future irritation; but that plan also failed. No doubt, ligatures in such circumstances have long remained quiescent, but that has been seldom; sooner or later, perhaps after the cure has been thought complete, they occasion the formation of abscess after abscess, and produce much irritation, until they themselves are expelled; and thus recovery is in the end much protracted. The usual practice therefore now is, to leave one end of each ligature a little protruding from the lips of the wound, in order to secure their complete expulsion at the proper period. These remarks of course apply only to wounds which are approximated soon after infliction, with the hope of their adhesion. When the cut surface, on the contrary, is left open, in order to suppurate, both ends of each ligature should be removed close to the knot, the practice being then unexceptionable. Another innovation lately practised, was the substitution of torsion for ligature of the arterial orifice, thereby imitating the natural means of suppressing bleeding. The method has only been found to succeed well with vessels of the second class, such as those of the fore-arm—being inapplicable to the smaller twigs, and not safe in the case of the larger arterial trunks. In every extensive wound, therefore, some ligatures must be applied; and that being the case, it has been found more convenient and satisfactory to apply ligatures to each orifice requiring artificial closure. Hæmorrhage from veins usually ceases spontaneously when the position of the part is attended to, and all pressure removed that might prove an obstacle to the venous return. If it should be found obstinate, pressure applied to the orifice will be sufficient. Under any circumstances, cauteries and caustics are now seldom if ever required for arresting hæmorrhage.

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[1] The ancient Athenians had a law, that no slave or woman should study medicine; probably fearing want of education in the one class, and deficiency of common sense in the other. Perhaps it were well if a similar protection to the practice of the profession were in present force, as was proposed by the late Mr Alexander Wood of this city. In addition to the usual examination for the diploma of surgeon, he wished to establish a jury to determine on the common sense of the candidate, stating as his reason, "If they have not *that*, I would not give a —— for *the rest of* their medical knowledge."

Wou s.

These remarks naturally lead to the consideration of incised wounds, and here we again find that simplicity and improvement in surgery are synonymous. "Hot dressings, filthy unguents, greasy poultices, stimulating plasters, and complicated bandages, have given place to light water-dressing, unirritating plaster sparingly applied, and careful position of the part."[1] To no one does a larger share of merit belong in this, than to him from whom we have made the above quotation; and we cannot do better than continue to glean from him a little more on this subject. "Formerly (and they are even still) wounds were put together without delay, and their edges squeezed into apposition, and retained by various means, such as sutures, plasters, compresses, and bandages. They were carefully covered up, and concealed from view for a certain number of days. Then the envelopes of cotton and flannel, the compress-cloths, the pledgets of healing ointment, and plasters, were taken away, loaded with putrid exhalations, and a profusion of bloody, ill-digested, fetid matter. A basin was forthwith held under the injured part, and the exposed and tender surface was deluged with water from a sponge, and then well squeezed and wiped. Then came a re-application of retentive bandage, of the plaster, of the grease mixed with drying powder, all surmounted by some absorbing stuff, as charpie or tow, to soak up the discharge. This was not unaccompanied by pain, often more complained of than that attendant on the original injury or operation. This process was repeated day after day, the patient was kept in a state of constant excitement, and often, worn out by suffering, discharge, and hectic fever, fell a victim to the practice. The wound was, as it were, put into a forcing bed, excited action beyond what was required was hurried on, and the consequence was, that immediate union seldom if ever could or did take place. A suppurating surface, on the contrary, with bad profuse discharge, and a very tedious cure, if any, were obtained." This was an uncomfortable state of matters, but there is now a change. Surfaces are not disposed to unite for many hours after the division and separation have occurred. So long as there is oozing of blood, no good end is to be attained by their close apposition. Should this be attempted, the blood which continues to be discharged from the smaller vessels is necessarily prevented from escaping; and the consequences are, infiltration of the loose cellular tissue, distention of the cavity of the wound, and separation of the surfaces probably throughout their whole extent. Then ensues a congested state of the surrounding vessels, with perhaps a troublesome hæmorrhage from branches that would otherwise have become sealed up; at all events, much constitutional disturbance, a heated swollen state of the injured parts, profuse, bloody, and putrid discharges, must occur; and this will certainly be followed by wasting suppuration from a foul cavity, which will be long in assuming a healthy action. It is only when re-action has occurred, when gentle vascular excitement has taken place in and around the solution of continuity, and when plastic matter begins to be secreted and thrown out, that the process of adhesion can be expected to commence. The edges of a large wound, as that resulting from amputation of the extremities, may be approximated in part, either by position, or by a few points of interrupted suture, as soon as bleeding from the principal vessels has been arrested. But the close apposition, and application of all the retentive means, had better be delayed for six or eight hours at least. In the interval, sensibility will be abated, the oozing moderated, and the chance of secondary hæmorrhage much diminished, by lightly covering the parts with lint dipped in cold water, and frequently renewed; or a piece of lint may be placed between the cut surfaces, and a constant irrigation of them be kept up for some time, by threads passing from a vessel containing cold water. When all oozing has ceased, and the surface become glazed, the surrounding skin, previously shaved, is made thoroughly dry; coagula are removed, the edges are put carefully and neatly in contact, and are retained by narrow slips of adhesive plaster placed at intervals. The plaster commonly in use does not retain its hold sufficiently long, is loosened by discharge, heats the surface, and often gives rise to erythema. A better kind is made by spreading a strong solution of isinglass in spirit on the unglazed side of oiled silk, cut into slips of the necessary length and size;

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[1] Liston's Practical Surgery.

this plaster is quite unirritating, and often retains its hold until the very completion of the cure. Being transparent, it does not prevent any untoward process that may be going on underneath from being observed; and if any fluid collects under it, an opening can be made for its escape. If sutures have been previously employed for the partial approximation of the wound, they can be removed by cutting the thread, shortly after the fixing of the plasters, for these alone are sufficiently retentive. No other dressing need be employed in the first instance; no compress, no pledget, no bandage; for in general they will not promote union of the wound, and may do harm. The slight discharge that oozes out is from time to time wiped from the surrounding skin, and from the glazed cloth on which the part is laid. In some cases of amputation, after a few days a roller may be applied, to encourage the subsidence of any slight œdema that may have arisen, and to bring the stump into a good form. By such simple treatment, a great deal of suffering is saved to the patient, and he enjoys much comfort and cleanliness; besides, the surgeon is relieved from a load of most unpleasant and harassing duty.

Wounds produced accidentally are almost always attended with more or less bruising of the parts, and can be united only by the second intention. After bleeding has been suppressed by the method recommended for incised wounds, the cold applications are to be superseded by those of an agreeable warmth, such as poultice of bread and water, or, what is much to be preferred, from its simplicity and lightness, lint of thick texture, and of sufficient size to cover the wound, soaked in tepid water, and overlaid by an ample piece of oiled silk to prevent evaporation. Heat and moisture, by which qualities a poultice produces its soothing and beneficial effects, by which the surface is relaxed, its capillary circulation encouraged, and discharge promoted, are thus amply afforded, without any of the weight, putrefactive fermentation, stench, and filth, inseparable from the best of common poultices. The edges of the wound are approximated as much as possible by attention to position; and by the same means the return of blood is favoured, and engorgement of the vessels and inflammatory swelling prevented to a very great degree. If the wound run across the fibres of the skin and muscles underneath, these are to be relaxed by flexion or extension, as may be, of the neighbouring articulations. Rest of the injured parts is also essential, and to obtain this it is sometimes proper to apply splints. Contraction of the wound takes place naturally, and generally with sufficient rapidity; should the surface, however, from any cause become weak and flabby, the lint is to be wet with a gently stimulating solution, as of zinc, instead of tepid water. Support, by bandage or plaster, may for a like reason sometimes be required. But healing is often retarded by the plasters and bandages which are inconsiderately employed to hurry it on; the granulations are absorbed, the surface of the sore becomes foul, the discharge thin and offensive, perhaps inflammation of the surrounding skin takes place, with extension of the sore by ulcerative absorption. Sometimes adhesion and suppuration may be happily blended in the cure. Thus, when, in a suppurating wound, whether accidental or incised, the discharge begins to thicken, and diminish in quantity, when the granulations are florid, small, and acuminated, and when the surrounding parts are sufficiently lax to admit of easy approximation, the granulating surfaces may then be brought into close apposition, with every prospect of immediate adhesion taking place.

Under some circumstances, the rule laid down as to the propriety of delay in permanently closing wounds, may be departed from with advantage; as when the entire surface can be brought into close and accurate apposition, so that no clot of blood can be interposed; as, for instance, in penetrating wounds of the mouth; in division of the lip, as for harelip; and in repairing some deficiencies of the genital organs. In such cases, either the twisted or quilled suture is used, usually the former, and no other dressing should be applied. To put on strips of plaster, to cover the part with lint smeared with ointment, to interpose dossils of lint between the skin and ends of the pins, to support the wound by a uniting bandage—all this is mischievous, and a remnant of the old meddlesome surgery. Any kind of application collects and retains the secretions, heats and excoriates the surface, promotes suppuration, and interferes with the process of union.

Such is an outline of the simple treatment of wounds now employed, with the happy effects of saving the patient from much pain, and the surgeon from much trouble; obtaining a more frequent occurrence of adhesion in incised wounds; shortening the process of suppuration, and depriving it of much of its inconvenience. It is almost needless to observe, that this, as well as every other treatment, will however prove of little avail, unless accompanied with a careful attention to the general health: in other words, the surgeon, not hesitating to encroach thus far upon the duties of the physician, must ever be employing his medical science.

Diseases of the joints.

In no class of diseases is the operating knife now more happily in abeyance, in comparison with former practice, than in affections of the joints. Many a limb is now saved, with its usefulness little if at all impaired, that would, in days not long passed, have been doomed at once, and with very little ceremony, to amputation.[1] This important saving of life and limb is mainly attributable to the advance of pathology. The cultivators of that science, among whom the name of Brodie deserves prominent notice, have shown with great perspicuity the various changes which morbid actions induce in the structure of articulations, and established a wonderfully accurate diagnosis of each affection. We can often tell in what tissue of the joint disease originated, of what nature the morbid action is, and can predicate almost with certainty the actual state of the parts, as to extent and manner of degeneration. According to the principle that "the knowledge of a disease is half its cure," great advantage is thus obtained in adopting and regulating the treatment suitable to the circumstances of each case. Besides, we can tell at once, and with tolerable accuracy, in what cases we shall probably succeed; and in those in which we are made aware that the disease is of such a nature, or has proceeded to such an extent, as to baffle all attempts to cure, we are enabled to save valuable time, and thereby to save life, by proceeding at once to the only cure available, amputation. In whatever part of the joint diseased action may have originated,—bone, cartilage, bursæ, or synovial apparatus,—if not arrested, it soon extends to all, converting the whole joint into one mass of disorganization. It is of the utmost consequence, therefore, to be early in the employment of the appropriate means of cure. The first and most important object is to secure absolute want of motion in the diseased parts; and here it is that the greatest improvement has taken place in the treatment of joints. "If perfect repose and quiet of the affected parts be omitted, all other means are found nugatory, and were as well untried. Nothing but disrepute can accrue to the profession, if hot irons, moxas, and issues continue to be used inconsiderately, to the neglect of more powerful and less appalling means. Instant relief invariably follows the securing a state of perfect rest; other means, local and constitutional, are thus afforded a fair chance of doing good, and the natural efforts towards a cure are no longer thwarted and interrupted. But, above all, the effect on the general health is most remarkable and cheering. Even in very complicated and bad cases, in which sinuses communicate with the cavity of the joint, and the heads of the bones are ascertained to be in a state of ulceration, or partially necrosed, the good effects of perfect quietude of the joint will soon be manifested by cessation of pain, diminution of discharge, and speedy improvement of the general health. A cure of the local mischief may not be possible by this means alone, but much will often be gained, as regards the success of ulterior proceedings, by the rapid and certain amendment of the patient's condition." This salutary rest is the first part of the treatment of all diseased joints, and is continued, in general, throughout the whole period of cure; it is obtained by the application of splints, varied in form and construction according to the particular joint affected.

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[1] John Hunter himself seems to have been in the habit of making very unwarrantable abbreviations of living limbs, as the following anecdote abundantly proves. "He once had a patient whose leg he considered it necessary to remove. He had got on his *dress*, and a profound silence reigned in the theatre. The surgery-man disappeared. In two minutes he returned alone, with a face as long as the leg. 'Why do you not bring in the patient?' demanded the expectant operator. 'Because, sir,' said the astonished surgery-man, 'because, sir, he has run away!'" It is to be hoped that the custom of amputating legs that are able to "run away" has fallen into complete desuetude.

Disease of the soft parts of the joint usually commences in an inflammatory form, requiring depletion; when acute, the antiphlogistic treatment, local and general, must be very active, so as at once to arrest the morbid action; and hot fomentation and poultice will generally be found more soothing than cold applications. When the more violent symptoms have subsided, the disease giving way, a determination to the surface, with discharge, lends powerful aid towards its final extinction. For this purpose vesication may be produced, by cantharides or by nitrate of silver; or an eruption may be established by friction with a liniment of croton oil, or an ointment of tartrite of antimony, their strength proportioned to the nature of the part, and age of the patient. In chronic swelling of a joint, whether the effect of inflammatory action, or slowly and gradually supervening after injury, the diseased action must not only be arrested, but absorption also procured of the deposit and effusion within the synovial capsule and bursæ. To obtain the former indication, local depletion and counter-irritation are employed, according as the circumstances of the case require; and to obtain the latter, uniform pressure of the whole swelling, and gentle irritation of the surface, are combined with the means of securing the all-important rest of the joint, according to the method first recommended by Mr Scott. The limb having been uniformly supported by a roller, from its extremity up to the diseased articulation, the surface of the swelling is covered by lint spread with some gently stimulating ointment,—soap cerate with camphor, for example, or that with a greater or less proportion of the unguentum hydrargyri; and the whole articulation is then surrounded by long strips of adhesive plaster, drawn with moderate and uniform tightness, so as to support and gently compress the parts, without producing absolute pain or uneasiness. Above all, splints are applied to secure total immunity from motion; and they may either be of leather or wood, as most suitable to the joint affected. When this dressing has become loose, from subsidence of the swelling, it is re-applied as often as may be necessary. Should fresh excitement occur in the joint, from any accidental cause, during this treatment, the apparatus must be discontinued, until such excitement has been subdued by the usual means already described; and when the pressure is resumed, it should at first be very moderate. During the treatment the limb must be kept or gradually brought into the most advantageous position for ultimate use, particularly if, from the duration, nature, and extent of the disease, there is reason to expect impairment of the joint's motion. Thus, by steady extension with splints, the knee-joint may be brought into nearly a straight position, so that it shall be serviceable in progression; and the elbow may be bent, to form a right angle with the humerus, so as to be convenient for prehension. But such alterations of stiffened limbs must be proceeded with very cautiously, otherwise they may occasion undue excitement, and consequent renewal of disease in the joint.

The preceding treatment will be found applicable to almost all joints, the hip not excepted. In morbus coxarius, for example, it is useful for securing immobility of the articulation, an object of such paramount importance towards arresting the progress of that formidable disease; and in its advanced stages it is productive of at least relief. The joint is placed extended, that being the preferable position, in case of anchylosis, and surrounded by "soft lint soaked in a strong solution of gum acacia, which is laid on in strips over the side and pelvis, from the short ribs to the knee, and made to embrace the limb fully. A layer of dry lint is first applied, and then two or three others, soaked in the mucilage, follow: these are covered by a fold or two of coarse calico, and the whole is retained by a roller." Sometimes it is necessary to preserve the limb steadily in position by a wooden splint, as in fracture, until the composition has dried, and the splint, so formed, adapted itself closely to the parts. "This gum-splint can be made of any form, so as to allow of its being taken off, trimmed, lined with wash leather, or protected with a layer of oiled silk, and re-applied with a clean bandage. It can also be fashioned so as to leave any part exposed: the discharge from issues and abscesses can thus be allowed to escape, and the parts can be dressed, and otherwise attended to, without disturbing the limb. In fact, the apparatus can be varied as circumstances demand, and is applicable in a great variety of cases, and to any articulation." A similarly useful splint is made "of leather dressed without oil, cut to a proper form, moistened in hot water, and applied with a roller. It soon becomes firm, and forms a case which fits the part accurately; it is then pared, fashioned neatly, and lined. In many chronic cases such splints answer admirably; but the gum-splints can be applied with less disturbance of the limb, which in many instances is a great recommendation."

"In the painful and dangerous affections of the articulations, when the cartilages are extensively absorbed, and when the cancellated texture of the bone is more or less diseased, good effects may yet follow judicious treatment. Besides following out the principle of preventing all motion, great relief will often be experienced from establishing a permanent discharge from the neighbourhood of the diseased tissues. This can be done simply and effectually, without causing alarm, or exciting much pain, by confining a small piece of caustic potash on the skin near the diseased joint. The sore thus formed is deepened, and made to discharge freely, when disposed to heal, by a few hours' application of the antimonial ointment. A seton may be preferred in some situations: certainly discharge can be thus kept up, and derivation obtained from the affected parts, fully as well as by actual cauteries, moxas, pea-issues, or other farrier-like practices. Great care must be taken in the placing of issues; they should be near to, but not upon a joint. Serious results have sometimes followed their careless application; diseased action has been increased, they having reached, or even penetrated, the synovial capsule."

Resection of joints.

By the careful and judicious employment of such treatment, many affections of joints which resisted the less simple modes of cure formerly in use, are now successfully combated; and many limbs are saved which our forefathers would not even have attempted to cure. But still there are too many cases which baffle all efforts to arrest the progress of morbid action; and it becomes necessary, in order to relieve the labouring constitution, and preserve life, to remove either the diseased parts alone, or the remainder of the limb along with them by amputation. The former operation is termed resection, and is the preferable, because the less mutilating and severe, when the case is such as to promise a tolerable certainty of success. Should it fail, amputation then becomes necessary; but by the failure, the chance of the patient's ultimate recovery is very much diminished. The cases for resection, therefore, should be carefully selected. The general health must not have been much impaired; the soft parts must not be extensively affected; the disease must be almost entirely limited to the articulating surfaces; the joint must be such that the bones can be reached easily, and without the risk of wounding parts of great importance; and the patient must be of that age and constitution most favourable to the reparation of injury. The articulating extremities of the bones are exposed by free incisions, planned according to the circumstances of the case, and the diseased portions are removed by suitable saws, or by cutting pliers. The soft parts are then replaced, and the cavity treated as a suppurating wound, the intention being that it should heal by healthy granulations from the bottom. In patients tolerably advanced in life, it is well to keep the maimed joint in perfect quiet, and in the position most favourable to the subsequent use of the member, in order that the cure may be by ligamentous anchylosis, otherwise the limb will prove weak and not much available, and disease will be liable to return. But in young persons of healthy constitution, motion of the part is encouraged during the cure, with every prospect of the new articulation becoming both free and strong. The elbow-joint is the one to which the operation is most applicable. In the shoulder-joint it sometimes is expedient, also in the carpus and tarsus; but in the knee and hip joints experience loudly forbids its performance.[1]

Amputation.

When however all milder means have failed, and resection is inapplicable, amputation must not be deferred until the disease has grown riotous in its progress, and the general health has been seriously impaired. When the surgeon is satisfied that amputation has become absolutely necessary,—that nothing else can save life,—the sooner it is performed, the greater is the chance that this severe remedy will not fail in its issue; and it is consolatory to reflect that modern improvement has greatly mitigated its horrors, and increased the probability of its success. It is performed more rapidly, more skilfully, and the suffering is infinitely less both during and after the operation. The tedious dissection of a limb, called the "circular method," has now given place to the "flap-operation" by transfixion; the only valid objection that can be brought against which is, that perhaps a greater surface of wound is made; but this is much more than counterbalanced by the many benefits which it otherwise insures. The operation is more rapid, and less painful; the cut surface is smooth and regular; adhesion, or union by the first intention, is much more frequent; whether union be by the first or second intention, the cure is more speedily completed; the end of the bone is infinitely better covered, and the stump consequently more useful; and if the flaps have been skilfully formed, there will be no exfoliation of the end of the bone protruding through ulcerated integuments, and no formation of excruciating neuromata in the cut extremities of the nerves, rendering a renewal of operation necessary for final cure. The manipulations of the flap-operation are simple and well known, so need not be here detailed; but some rules necessary for its dexterous accomplishment are not always sufficiently attended to. The first regards transfixion; and it is, that after the first flap has been formed, the knife should not be again entered close to the top of the wound, but about an inch below, as thus cross-cutting of the integument is avoided. Another is, that in sawing the bone, the surgeon must not trust the distal portion of the limb entirely to an assistant, but, grasping it in his left hand, must himself regulate its support, and so avoid splintering the bone. Pressure to command the bleeding need not be severe, but must be true. As was formerly stated, the tourniquet is seldom if ever used when the fingers of an assistant can be obtained who is cool, steady, and well conversant with the course of the vessels. The pressure thus obtained is not applied until the instant the incisions are commenced, and then only on one point; the limb consequently is not gorged with blood, as it would have been by the ordinary tourniquet: less blood therefore is lost, and besides, the flaps are much more easily retracted from the bone. When skilful assistants cannot be obtained, or when it is probable that many vessels will require ligature, and that consequently pressure must be long continued, a strong metallic spring may be used, each extremity terminating in a pad, one placed over the course of the vessel, the other resting on the opposite part of the limb: the assistant preserves its just application, and regulates its pressure, and the risk is avoided of his fingers giving way from cramp or fatigue. When the surgeon, from want of other means, is compelled to use the ordinary screw-tourniquet, its principal pressure should never be applied until the moment before incision; and as soon as the larger vessels have been secured, the whole apparatus should be removed, as thus the loss of much blood by regurgitation, and particularly from veins, will be avoided. The arterial orifices are secured by ligature, according to the method already mentioned; and should the venous trunks continue to pour out their contents, notwithstanding the removal of all constriction of the limb, pressure by the fingers of an assistant, though for only a short time, usually suffices to arrest the hæmorrhage. The wound is treated according to the principle of delay formerly explained; and thus adhesion is not only favoured, to the saving of time and pain, but the occurrence of secondary bleeding is also made much more improbable; for no warm coagulum is bound up in the wound, to act as a sponge, and encourage escape of blood from all the untied vessels; and even when it does take place, the bleeding point is much more easily secured than when the stump is bound up tight and close from the first. Should the stump bleed seriously, six, eight, ten, twelve, or fifteen days after the operation, in consequence of sloughing or some other unhealthy action having supervened, the ununited wound is to be laid open, all coagula removed, and direct pressure applied. But should this fail, the surgeon ought instantly to secure the trunk of the vessel whose branches are at fault, at some distance above the stump—in amputation below the knee, tying the femoral, for example—at the same time supporting the stump by bandage. This practice has been found almost invariably successful.

Dislocation.

Amputation is also less frequently resorted to in cases of severe injury than formerly. In fractures, skilful and careful management preserves many a limb useful and but little out of shape, which before would have been considered too seriously injured to retain its vitality. Nor are compound luxations regarded with the same dread. In compound dislocation of the ankle-joint, for example, with protrusion of the bones, instead of at once amputating the limb, the dislocation is reduced, the protruding portions of bone having been removed in whole or in part, if so injured as to render that proceeding necessary; the limb is retained in a favourable position, and in a state of complete rest; the wound is treated by the simple soothing plan; undue excitement is warded off or held in subjection by the usual means; if abscesses form, they are early evacuated; the parts are uniformly and gently supported; the surgeon's *medical* acquirements are kept constantly on the alert; and thus, in very many cases, the limb is retained, with the injured joint, though stiff, exceedingly useful. The ordinary simple dislocations are now at once detected by the observant and well-educated surgeon, and as readily reduced if recent; so that branch of the profession promises to be soon rescued completely from the maltreatment of ignorant empirics.

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[1] For further information on resection of joints, see Mr Syme's excellent treatise on this subject.

F ures.

The whole treatment of fractures has been simplified and improved; the process of reparation in disunited bone is better understood, and the means which favour it are more skilfully and effectually adapted. In fractures, whether compound or simple, of the smaller bones, more particularly of the upper extremity, the gum-splint will be found very suitable. By the employment of these or other light splints,—of wood, pasteboard, leather,—well padded, so as not to fret the integument, and always of sufficient length to command the neighbouring joints, the bones are not only kept accurately in their proper place, but perfect quietude and freedom from all motion are likewise secured,—a point all-important here, as in the treatment of diseased joints. Broken limbs are no longer laid out in state on pillows, altogether unrestrained. Absolute rest, following early reduction of the bones, and combined with strict attention to the workings of the general system, usually succeeds in preventing interruption of the cure by undue excitement in the neighbourhood of the injury. Should this nevertheless occur, the retentive apparatus can be so arranged as to admit of the part in fault being attended to as freely and as often as is necessary, without disturbance of the rest of the limb; for example, blood may be abstracted locally, fomentation or poultice applied to a particular part, abscesses opened, and wounds dressed, without undoing all the retentive apparatus, and so jarring the fracture. In severe compound fractures this advantage is particularly important. The soft parts can be looked after as well as if no apparatus at all were applied; and the untoward results likely to follow such a serious accident can consequently be sometimes averted, and always moderated, while the hard parts are uniformly kept in the condition most favourable to their union. In fractures of the lower extremity near the hip-joint, Desault's splint is still in use, somewhat modified When the break is lower in the limb, an improvement of Macintyre's double inclined plane is by much the most suitable apparatus, combining in an eminent degree the advantages of complete rest of the whole limb, with ready and convenient dressing of particular parts.[1] The patient is also able, with safety, to be out of bed, and in the erect posture, at an early period of the cure; a circumstance very favourable to the preservation of the general health.

Ga ene.

When, notwithstanding care and skill, gangrene occurs after severe fracture, either immediately, or in consequence of greater vascular excitement having taken place than the hurt parts are able to bear, amputation must be had recourse to, and the period of its performance is now no longer a subject of dispute. It must be done immediately, in sound parts, at a distance from the gangrene, without waiting for a line of separation, as in chronic gangrene, else the surgeon will expect the opportunity in vain, and meanwhile his patient will sink.

Dis ted frac e.

Sometimes, either by the carelessness of the surgeon and inefficiency of his treatment, or from the fault of his patient or defect of his constitution, union of the fracture fails to take place. In recent cases of such disunion, adjustment of the broken ends in accurate apposition, and undisturbed rest of the fracture and of the whole limb, will occasionally effect a tardy union. But usually it becomes necessary to rouse the parts; and the method now followed, the most convenient, as well as most successful, is the introduction of a seton between the fractured extremities, gradually increasing the size of the tape, but taking care to remove it altogether as soon as it appears that excitement has been produced, sufficient for establishing the regenerative process. A few days are usually enough; when ignorantly permitted to remain for a long period, the mere presence of the foreign body, and more particularly the constant discharge which it maintains, tend most powerfully to prevent the result in favour of which it was employed. After removal of the seton, the limb is placed in the proper position, and must be preserved in a state of most complete rest.

Fractures of the cranium.

In fractures and other injuries of the cranium, the trephine is now used with better judgment than formerly; more sparingly in most cases, more readily in others. It is not considered necessary to convert every fissure of the skull into a chasm, by following it out with the trephine; in depressed fracture with compression of the brain, the application of the trephine is imperative, but no more bone is taken away than is necessary for the raising of the depressed portion, and the removal of what is so injured by the accident as to render its retention of vitality improbable; and to bore one or more holes in the cranium in search of extravasated blood, is generally regarded as a proceeding equally mischievous and unprofitable.

Punctured fracture.

But in punctured fracture, the necessity for the trephine is urgent; it must be used freely and at once; and as this important point of practice is perhaps not yet sufficiently attended to, we shall be a little more explicit on the subject. The punctured or star-like fracture is occasioned by a sharp body striking the head with considerable force. The integuments are divided, and the surface of the bone presents an appearance of injury somewhat resembling what is often seen in ice when struck in a similar way. But this is a very slight extent of damage compared with what the inner table suffers, when the puncturing weapon has passed through the diplöe, as is usually the case. The inner table, being by much the more vitreous, is shivered into numerous spiculæ, which being driven inwards by the force of the blow, perforate, or at all events grievously irritate, the coverings of the brain, producing inflammatory action, soon affecting that important viscus, and, if not arrested, proving speedily fatal. After the infliction of such an accident, therefore, even should the patient be at the time so little affected as to walk to the surgeon to have his wound dressed, the trephine should be immediately applied to the punctured point, in order that a portion of the bone may be removed, sufficient to allow extraction of all the displaced portions of the internal plate. In no other way can we avert intense inflammatory action from the wounded dura mater, extending in all probability to the brain and its more immediate investments. Even should the practitioner be in some degree successful in moderating the more immediate mischief by antiphlogistics alone, the necessity for trephining will still remain, on account of abscess under the bone, occasioned and kept up by the spiculæ; the matter must be evacuated, and the cause of its formation must be removed. It is surely infinitely better, therefore, to operate in the first instance, and so avert all such calamities. Abscess sometimes forms between the dura mater and the bone, as a consequence of mere contusion; its occurrence, and usually its site, are indicated by constitutional disturbance, peculiar œdema of the scalp, unhealthy discharge from the wound, and a pale necrosed appearance of the bone. In such cases, also, perforation of the skull should not be delayed; for it will usually succeed in evacuating the matter, and relieving the patient. But, on the whole, "trepanning of the skull, which, with our forefathers, appears to have been an everyday occupation, is an operation now very rarely resorted to." After its performance, from whatever cause, there is now no rasping of the bone, or cutting away of the integuments; the edges of the circular aperture are denuded of their periosteum as little as possible, and the soft parts, having been carefully replaced, are treated as a suppurating wound; the deficiency of the bone is filled up by a ligamentous expansion, incorporated with the granulating integument. When a large portion of the skull has been removed, it is well to afford support to the cranial contents, by the application of a compress and bandage.

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[1] For more minute details regarding these splints, see Liston's Practical Surgery, p. 80, *et seq.*

Erysipelas. There is no more successful caterer to the amputating knife than erysipelas inertly treated; destruction of bones and joints has been too often its result. The improved treatment by incision, however, now in general use, saves many a limb entire and unscathed. So soon as tension of the surface indicates that the cellular substance is so infiltrated as to threaten destruction of the tissues, free incision must be immediately had recourse to; the knife is used not only to evacuate matter, but to anticipate its formation, and prevent its baneful consequences. In the milder cases,—and in erysipelas of the face, where incisions cannot be practised with propriety,—sufficient relief is obtained by making, with the point of a lancet, numerous punctures in rapid succession; effusion from which is encouraged by hot fomentations. In most cases, even when severe, division of the integument and subjacent cellular tissue suffices; but if the infiltration has extended to the inter-muscular tissue, the knife must follow: its free use may appear harsh, but is in reality a valuable kindness. The burrowing of matter is prevented, and consequently also sloughing of the soft parts, the opening up of bursæ and articulations, and the denuding of bones by destruction of their periosteum, ending in necrosis more or less complete. Museums were at one time copiously enriched with splendid specimens of necrosis of the long bones, throughout almost the whole extent of the limb, all the result of neglected erysipelas; but the bistoury has superseded the amputating knife, and such preparations fortunately are now become valuable by their rarity.

Abscess. Similar remarks will apply to the early opening of abscesses in general. "Pointing" is not now waited for; before that takes place, irretrievable mischief may have been done. The *tactus eruditus* having acquainted the surgeon with the existence of purulent formation, it must be reached by his bistoury, at whatever depth, if it be in the neighbourhood of joints, bones, or vessels, and more particularly if close to important cavities or canals. The mere contact of purulent matter will not injure these, but its pressure will, and from it they must be relieved, lest their functions be interfered with or their structure destroyed. For example, purulent collections in the fauces are evacuated by the bistoury before the patient is threatened with suffocation; and abscesses in the perineum, and neighbourhood of the anus, are drained by an external opening before they have become troublesome fistulæ.[1] The knife must of course be used cautiously when the abscess is deep, lest the vessels and other important parts be wounded; but let not the fear of this deter the surgeon from relieving abscesses in their immediate neighbourhood, for "the vessels and nerves are displaced by the morbid accumulation, and the knife is passed safely, in their course, to such a depth as would greatly endanger them in the healthy state of the parts." The opening should in all cases be made sufficiently large to afford a free exit to the matter; it should be placed in the most dependent part of the cavity, with which view the prevailing position of the patient should be considered; and sometimes more than one opening should be made at once, to prevent the necessity for future counter-openings, or the formation of sinus,—as when the abscess extends over a considerable surface, and cannot be made to discharge through one aperture. After evacuation, in assisting which no pressure or squeezing should be employed, fomentations and the water-dressing are applied. When the rule of early opening has not been attended to, and the abscess in consequence has become chronic and of large size, free incision should still be made at the most dependent point of the tumour, notwithstanding the advice of the late Mr Abernethy to the contrary; for experience has shown that the Abernethian treatment of chronic abscess is more likely to produce constitutional disturbance, with unhealthy excitement of the cavity, than when the matter is allowed a free and constant drain, and the parts are at the same time duly supported. **Improv seton.** In establishing an artificial abscess, or issue, the modern caoutchouc seton is a great improvement on the skein of silk or cotton formerly used, requiring no renewal on account of decay, and absorbing no discharge.

Ulcers. Ulcers, like wounds, are now treated more simply and better; and better because more simply. The healthy suppurating sore is covered, like a suppurating wound, with the plain and light water-dressing; simple in the first instance, afterwards medicated by gentle stimulants or not, according as the progress of the sore may seem to require. When stimulants are used, their solution is at first weak, and is increased in strength very gradually, lest the discharge should be suddenly suppressed and the sore consequently inflame; the object is simply to moderate discharge, and check weak exuberance of granulation. An inflamed ulcer is subdued by the hot-water dressing, combined with antiphlogistic regimen, rest, and elevation of the part. An irritable ulcer is soothed by the water-dressing, and occasional slight application of the nitrate of silver to the jagged angry edges of the sore; or the lint may be dipped in a bland anodyne solution. In all such dressings, the lint is kept constantly invested by a portion of oiled silk, larger than itself, to prevent evaporation of the fluid in which the lint has been soaked. When granulations prove exuberant, they are to be reduced to the proper level by the application of sulphate of copper, or may be shaved off by the rapid sweep of a thin sharp bistoury; or the surface may be compressed by dry lint and bandage. An indolent ulcer is stimulated to healthy action by pressure and support, combined if necessary with a direct stimulant application. This last description of sore is the most common, and is usually found afflicting the labouring classes, to whom the restoration of a limb is of more importance than to any other class of patients; a speedy cure is therefore of no little consequence. It is best effected by the method first recommended by Mr Baynton. When the patient applies for relief, there is usually considerable excitement around the sore, and this must in the first instance be corrected by the usual means. Then the foot and lower part of the leg, for it is the part commonly affected, having been uniformly supported by bandage, the sore is compressed by adhesive plaster, applied in strips encircling the whole girth of the limb, and with their extremities crossed over the sore; if this is large, and pouring out much discharge, it is well to cut a small hole in the plaster where it covers the ulcer. The application having been made to extend about an inch on each side of the sore, a little fine tow is placed above it, to absorb discharge, and the whole is retained by continuation of the bandage which supports the lower part of the limb. This dressing is removed at the end of forty-eight hours, or sooner if necessary. The sore itself is not to be washed or rubbed, for its own secretion is its natural and best protection; but the surrounding skin is wiped clean, and, if excoriated by the pressure, bathed with a spirituous lotion; the dressing is then re-applied as before. By such manipulation, repeated as often as is necessary, the indolent surface of the sore is stimulated to the formation of healthy granulations for raising its depressed surface, while at the same time the swelling of the surrounding skin and cellular tissue is diminished by absorption; and thus, the sore and its margins having been brought to one level, cicatrization proceeds. After the ulcer has in this way been converted into the simple suppurating sore, either the same dressing may be continued, exerting less pressure, or it may be superseded by the medicated lint and oiled silk. When nearly closed, all dressing may be discontinued; the natural secretion forming a crust, under which cicatrization is speedily completed. Of course healing will be materially assisted by rest and elevation of the limb; but the labouring man cannot always afford this, and the treatment by plaster, just described, possesses, in addition to its other virtues, this advantage, that with it the patient can continue in the erect posture with much greater impunity than when using any other application. For some considerable time after cicatrization, the limb should continue to be supported by a bandage or laced stocking. Another frequent ulcer is the weak sore, with thin, dark-red margins, based on cellular tissue almost sloughing, and emitting a thin unhealthy discharge. Such generally form in clusters, and can be brought to heal only after the unsound parts have been destroyed by the potassa fusa, so as to obtain a sound foundation on which the reparative granulation may arise. This description of sore, however, is too often combined with and dependent on a strumous diathesis, and is healed only to break out afresh.

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[1] Dr Radcliffe has probably few imitators at present in his clumsy method of emptying abscess of the fauces. "He was once sent for into the country to visit a gentleman ill of the quinsy. Finding (supposing) that no external or internal application would be of service, he desired the lady of the house to order a hasty pudding to be made; when it was done, his own servants were to bring it up. While it was preparing, he gave them instructions how they were to act. When the pudding was set upon the table, the doctor said, 'Come, Jack and Dick, eat as quickly as possible; you have had no breakfast this morning.' Both began with their spoons; but, on Jack's dipping once for Dick's twice, a quarrel arose. Spoonsful of hot pudding were discharged on both sides; handsful were pelted at each other. *The patient was seized with a hearty fit of laughter, the quinsy burst, and the patient recovered.*" A moment's use of a straight sharp-pointed bistoury would have saved both time and the pudding.

Such is a bare outline of the modern treatment of ulcers, to which however no fixed and absolute rules can be made to apply; for sores are often changing their character and appearance, though perhaps but slightly, and consequently demand as frequent a change in the treatment. "A judicious practitioner, by varying his applications according to the appearance and disposition of the sore, will serve and benefit his patient much more efficiently than by trying empirically this or the other new specific, or blindly applying one remedy for every sore, because he has seen its good effects, or been informed of its answering miraculously in one or two instances." Be it likewise remembered, that in no class of diseases is attention to the general health more requisite.

Hospitals.

We may here allude to the general improvement in hospital practice, in consequence of which the hospital sore, so long and so frequently a scourge in those valuable institutions, is now almost unknown. The ventilation, cleaning, and general arrangement of the wards, the diet, clothing, and classification of the patients, are all improved; but probably nothing has tended so much to the disappearance of this formidable disease, as the substitution of tow for sponge in the dressing of sores; a change apparently simple and insignificant, but in reality most important. Formerly both nurses and dressers were in the habit of using one sponge for the sores and wounds of a whole ward, and if in one patient unhealthy action supervened, the vitiated discharge was soon afforded an opportunity of inoculating all. Now, sponges are not seen but in the operating theatre; washing of wounds and sores has been discontinued, because found to be prejudicial to cicatrization; and when the parts around require cleansing, this is effected by means of tow, which, when used, is immediately thereafter destroyed or thrown away.

Aneurism.

In aneurism, the discovery of Hunter has been most successfully extended. Further investigation in arterial pathology, especially as to the effects of ligature, has produced the most important results. The accumulated knowledge and experience, applied to practice by the talents and courage of Scarpa, Abernethy, Astley Cooper, Liston, Stevens, and Mott, have achieved most triumphant advancement in surgery; for thus the means of cure have been happily extended to cases of aneurism, formerly regarded as irremediable. There are many aneurisms, and not of unfrequent occurrence, on which the surgeons of the last century were content to look until the tumour burst, and their patient perished under their very gaze, which are now fearlessly encountered, and with the best hopes of success. In aneurism of the neck, Hunter and Scarpa led the surgeon to believe that a ligature placed on the carotid, between the tumour and the heart, might effect a cure, and Cooper proved that it did so. This arresting of the cephalic circulation is no longer looked upon with insurmountable dread; for experience has shown, that even both carotids may be tied, with but a short interval between the operations, and without any untoward result. The surgeon's knife and ligature have, in the cure of aneurism, ventured even so near the heart as the arteria innominata, but hitherto unfortunately without ultimate success; indeed it is doubtful whether the operation on this vessel can ever prove successful, there being so many inevitable obstacles to complete consolidation by ligature; as yet, ulceration has always supervened, occasioning fatal hæmorrhage. The subclavian has been deligated on account of axillary aneurism. Mr Liston had the honour to be the first who did so with success; and an equally happy result has not been unfrequent since. Ligature of the axillary and humeral arteries, though difficult, is regarded as scarcely unusual. The aneurisms of the groin and hip were left to run their course unmolested, until Abernethy and Stevens showed that the Hunterian operation could be extended even to them. "The common, external, and internal iliacs, are now tied without much difficulty, and very often with a successful issue. These operations are quite justifiable, provided always there has been no mistake in diagnosis, and that there is nothing in the state of the patient's health, or in the condition of the arterial system, to contra-indicate interference." The original operation on the femoral, on account of aneurism in the ham or in the lower third of the thigh, is now looked upon, when skilfully executed, as at once the simplest, most beautiful, and most successful interference with the larger arteries. Thus we see that all aneurisms of the extremities are within the reach of art, and that a certain degree of success has attended the approaches towards the trunk, as far as the common iliac and arteria anonyma.[1] It is to be feared that "the force of surgery can no further go." It is indeed a triumph that it has gone so far; and we cannot reasonably expect that ligatures, placed nearer the great centre of circulation than either of the above-mentioned vessels, can ever be productive of a successful result. Surgical invention and enterprise have not, however, been easily baffled; and in those cases of aneurism too deep to admit of the Hunterian method of operation, it has been proposed to reverse the procedure, and place a ligature on the distal side of the tumour. The operation has been put in practice, and in a few cases with some temporary advantage, but the general result is not encouraging. Great difficulty has sometimes been experienced in discovering the vessel destined for the ligature, in consequence of displacement by the tumour, or more or less obliteration of its calibre. It is an operation "which, in a favourable case, and at the earnest solicitation of a patient, a surgeon might be induced to adopt, as the only though desperate remedy for an otherwise incurable disease; but it is not a proceeding which he would be warranted in urging his patient to undergo." In false aneurism from wound, as at the bend of the arm, if pressure methodically and firmly applied—the whole limb below the wounded point being duly supported—fail to arrest the formation of tumour, recourse is had to the ligature. If the tumour be recent, soft, and superficial, and the parts around not much infiltrated, the wounded point may be exposed at once by incision, and ligature placed above and below the aperture. But if the tumour be of considerable duration and size, ligature of the trunk, between the tumour and heart, is the preferable and equally successful proceeding.

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[1] The aorta has been tied, but with a result which does not warrant repetition of the experiment.

The more important steps in effecting deligation of the larger arteries, whether for true or false aneurism, may here be briefly mentioned. The incisions are made with a small, finely-edged scalpel, used lightly and cautiously; neither directors nor blunt knives should be employed, for they must bruise or tear to a certain extent; and the simpler and smoother the cut is, the greater is the probability that both wound and artery will assume a healthy action. The vessel having been exposed, its sheath is opened on the anterior aspect, to the extent of about an inch, and the point of a blunt aneurism-needle is gently passed beneath and around the artery, great care being taken to exclude nerve and vein from its circuit. A strong silk ligature having been thus passed, its loop is cut, and one half withdrawn along with the needle; the other is firmly secured on the artery, its effect on the tumour having, by previous pressure, been ascertained to be satisfactory. In placing the knot on deep-seated vessels, Mr Weiss's instrument will be found to afford important assistance. "All this must be done without disturbing the position of the vessel, without detaching it from the sheath, or breaking up its fine cellular connections laterally and behind, further than is barely sufficient for the passage of the needle. There must be no lifting of the vessel on the handle of the knife, or on the director, as if in triumph; for ulceration of the arterial coats, and secondary hæmorrhage on or about the separation of the ligature, are the almost inevitable consequences of such proceedings." If by accident the vessel has been disturbed from its connections, two ligatures are to be applied, one at each termination of the separated portion; but in general one single ligature is much preferable. Both its ends should never be cut away close to the knot; for, in addition to the ordinary disadvantages found to belong to this plan, there is no slight risk of abscess, caused by the deserted knot, inducing secondary bleeding by ulcerative absorption of the arterial coats. And indeed the surgeon will feel more comfortable, in such anxious cases, if he leave both ends pendent from the wound. For a like reason, separation of the ligature should be throughout its whole course spontaneous; rash pulling at its ends may be productive of the most serious results. The wound is brought together, and otherwise treated, according to the principles formerly detailed. Should secondary bleeding unfortunately occur, the vessel must be exposed above and below the source of hæmorrhage, and a ligature applied at each point. But if the original operation have been judiciously as well as dexterously performed, and the after-treatment carefully conducted, such an untoward result need scarcely be dreaded. Should pulsation return in the tumour, on the complete establishment of collateral circulation, pressure well applied will suffice to perfect the obliteration of the sac.

Veins.

In dilatation or varix of the veins, if methodical pressure and attention to the bowels fail to remove the disease, or at least its inconveniences, a radical cure is obtained by obstruction of the calibre of the main trunk, on the cardiac side of the dilatation; and this is effected either by the application of potass, or by including about an inch of the vein, at that part, between two points of twisted suture; the needles being passed beneath the vessel, and removed as soon as sufficient excited action has been produced in the venous coats. Either method is effectual in obtaining obliteration of the vein's calibre at the selected point: the latter is, perhaps, in most instances the preferable; but in both the procedure must be cautious, and the after-treatment watchful, in order to guard against hæmorrhage and extension of inflammatory action.

Venesection.

The operation of phlebotomy has always been simple and of easy execution; in regard to it, the only modern improvement which we have to notice, is the comparative rarity of its performance. It was, and still is, too much the custom to bleed, so as to appear to be doing something active in treatment, not only when the proceeding has seemed to the ignorant practitioner likely to do no harm, but also when a wiser head could have told that it must do irremediable mischief. The good fortune of the first phlebotomist, Podalirius, seems to have produced in his successors an unfortunate attachment to the operation, which has been communicated from generation to generation, and from which our day is not yet wholly exempt. In very many cases it is doubtless the only certain means of relief, and must be employed readily and boldly; but in fully as many it had better be done with a sparing hand, or altogether omitted. What can be worse, for example, than to find a patient who has just sustained a severe accident—still labouring under the shock which the injury has produced, pulseless, and with the powers of the system all but extinguished—robbed by an ignorant or reckless man, unfortunately called to his aid, of that very fluid, and consequently of those very powers, of which he is at the time most in need, and without which the syncope must soon pass into death. Such a case is too frequent even now: but it is consolatory to know that the folly of such proceedings is becoming more and more extensively known, and that the thoughtless, mischievous practice of indiscriminate venesection is more and more abandoned.

Bruise.

A similarly absurd practice prevails in regard to the treatment of bruise. Leeches are instantly applied, in order that they may suck out the extravasated, or "bruised blood," as it is called. These little animals drink only from the running stream, drawing for themselves from the bloodvessels, and therefore fail to perform what is expected of them by their employers. At the same time, their bites, admitting the external air to the extravasated blood, may induce suppuration of an unhealthy kind in the cellular tissue. They are of use simply as a mode of local depletion, in order to moderate or avert inordinate excited action occurring as a secondary result of the accident.

Hernia.

In the treatment of hernia, the advancement of anatomical knowledge has rendered operative procedure more simple, safe, and effective. And pathological experience having now fully established the great danger of delay after the taxis, fairly tried, has been found unavailing, the operation is had recourse to at once, with a much more certain prospect of success. In the greater number of cases the taxis will prove successful, when employed early and with skilful perseverance. But as soon as the surgeon is satisfied that his unarmed hands, assisted by his medical skill, are incapable of reducing the tumour, each moment of delay is culpable until he assumes the knife, and by it relieves the constricted parts; for by its keen edge the patient is infinitely less endangered than by even brief continuance of the incarceration. This principle, now generally acted on, saves many a patient who formerly would either have perished in excruciating torture, or lingered on with artificial anus, noisome to others, and a burden even to himself. But this is a subject too extensive to be here more fully considered. Endeavours towards the cure of artificial anus are made by the apparatus, and according to the system of treatment, invented by Dupuytren; and sometimes they prove successful.

Calc us disor s.

In the treatment of calculous disorders, modern improvement has effected much. Chemistry, happily combined with pathology, has taught the surgeon in many cases to anticipate cure by prevention, detecting the tendency to deposit in the secretions of the kidney, ascertaining the exact nature of that deposit, and then applying, according to its nature, the suitable corrective. When there is reason to believe that calculus has actually formed in the bladder, its presence is to be ascertained by careful sounding. Many affections—for example, diseased kidneys or fundament, worms or other causes of irritation in the bowels—occasion all the ordinary symptoms of stone; and it is only after the surgeon has distinctly heard the stroke of his sound on the foreign body, that he can be certain that a stone exists. The most convenient instrument for exploring all parts of the bladder is a sound, steel throughout, with a sharp and sudden curve. When, by its cautious and patient use, the presence of a calculus is no longer doubtful, and some estimate has also been made of its size and form, the question then arises between patient and surgeon as to the preferable mode of its summary extrusion; for removal by chemical solvents, though sanctioned by act of parliament, is no longer trusted to. It is only within these twenty years that a power of selection has existed; till then, the knife alone presented hopes of relief. Now, however, *cutting* is often superseded by *crushing*, and rightly. Indeed it is a *quæstio vexata* among many, as to whether lithotomy or lithotrity be the better adapted for general use; and each has its zealous and uncompromising advocates. As is usual in such cases, we shall probably find that truth lies in the middle, and that both operations must still be employed, each finding cases to which it is peculiarly applicable. Lithotrity was at first a very imperfect art, difficult and complicated in performance, often failing in the attainment of its object, and not seldom followed by the most untoward results. Its practice was likewise in a great measure confined to a particular set of operators, not the best qualified for such undertakings, who, regarding it as a means of gain alone, were not long in bringing discredit on its reckless and indiscriminate use. Thus a great advantage was given to the old operation, over its imprudently managed rival. But the instruments and procedure of lithotrity have of late been greatly improved, and have become, as is usual in such improvements, more easy and simple, and at the same time more effective. They now receive the attention of every well-educated surgeon; the student applies to lithotomy and lithotrity with equal care and attention, and endeavours to perfect himself in the manipulations of both; and in consequence, the latter operation has been rescued from the empirical professor, and placed in the better qualified hands of the regular practitioner. There is not now, as in the time of "the invasion of professed stone-grinders," some years ago, an indiscriminate performance of one operation, in all cases, simply because the operator knows no other. The circumstances of the case had then very little influence in determining the nature of the operative procedure. If a surgeon was applied to, the knife was recommended; and "if the patient fell into the hands of the professed stone-grinder, he was certain, under all circumstances, of being subjected to the hammering and boring processes." Now, application being made to the regular practitioner, at least in the first instance, he, equally acquainted with either mode of operating, conscientiously advises the one which circumstances require, either operating himself, or employing one whom he may consider more dexterous and equally skilful. Lithotrity can only be safely performed by those "who understand well the healthy anatomy of the urethra and bladder; who are acquainted with their sympathies, vital actions, and pathological changes; and who understand and practise the treatment of their deranged functions." And by such it is now performed, in the cases to which it is applicable. In patients above the age of puberty, when the symptoms have not been of very long duration, when the stone has been ascertained not to exceed a chestnut in size, when the urethra is free from contraction, when the bladder is capacious, tolerably healthy in its coats, and free from irritability of its lining membrane, and when the individual is of an easy, patient disposition; under a combination of such circumstances, lithotrity is the preferable operation; in other cases, lithotomy. It is thus apparent, that possibly lithotrity may in time almost entirely supersede lithotomy in the adult; all that is necessary being, that the patient apply to a well-qualified surgeon at the very commencement of his ailments. But until wisdom shall pervade mankind to this extent, very many cases must occur in which the old operation, well performed, is much to be preferred; and this need not be greatly regretted, for the actual difference between the two operations as to pain and danger is not so great as is generally supposed.

The simple instrument of two branches, as made by the Messrs Weiss, has superseded all the more complicated and less effective apparatus for lithotrity; as also Cooper's forceps for removal of small stones by the urethra. The instrument having been introduced into the bladder, tolerably distended, is brought in contact with the stone; its blades are opened, and the stone brought between, great care being taken that the mucous membrane is uninjured; the blades are then approximated by the screw, and the interposed stone crushed more or less completely. When the stone is single, small, and friable, one such proceeding will suffice: if not, the fragments are seized and bruised in succession, either at the time, or at one or more subsequent sittings. The screw-power is preferred to that of the hammer, as equally efficient and more safe, not endangering the twisting or breaking of the instrument. Diluents are freely exhibited, to promote and facilitate passage of the detritus with the urine. Should the pain and irritation thus occasioned prove severe, opiates, blood-letting, and hot bathing, may be required. But, in general, if the case have been judiciously selected, and the operation skilfully performed, the subsequent irritation will be but slight; and after a few days, examination of the bladder may be resumed, to ascertain whether or not all the fragments have been extruded. This exploration cannot be too minute and careful, for the greatest stumbling-block to the advancement of lithotrity in the confidence of the profession, has been the uncertainty as to whether or not the bladder has by such proceedings been completely freed from every fragment, it being well known that but a very small portion of foreign matter remaining will become the nucleus of further deposit, and speedily re-establish the disease. The advantage of lithotomy is, that, for final exploration of the bladder, it has the finger, which, if at all experienced, can seldom be deceived. Lithotrity has but the sound for the same purpose, and must endeavour to make patience, dexterity, and care, compensate for the inferiority of the instrument.

But when the stone is large, and has been long resident in the bladder, this viscus has its cavity contracted, its coats fasciculated, and its surface irregular, affording receptacles for the fragments, from which the most careful manipulations may not dislodge them. Besides, such a bladder will not bear the annoyance of instruments often introduced; indeed the mere change of a tolerably smooth stone into angular fragments, may be sufficient to excite even fatal disturbance of the viscus and of the system. In all such cases, therefore, lithotomy is the preferable operation; it not only insures, with common care, complete removal of the source of irritation, but also, by suspending the functions of the diseased viscus, gives it the advantage of rest, as well as the relief caused by loss of blood from the neighbouring vessels. Even when the bladder is tolerably sound, a large stone of ordinary consistence is unfavourable to lithotrity; for the fragments must also be large, until after much manipulation; and attempts to pass such fragments must be attended with much pain and some danger. The immediate result of lithotrity in such cases is, "like the partial delivery of a pregnant woman," very unsatisfactory. The fragments may become firmly impacted in the urethra, causing retention of urine, and all its direful consequences. When this happens, and the impacted portion will not yield to an attempt to push it again into the bladder, it must at once be reached and removed by incision in the mesial line; and then the surgeon may take the opportunity of extending the wound a little farther, and with his finger and a scoop effectually clear the bladder of all remaining detritus. Lithotrity is scarcely applicable to young subjects; the parts are not sufficiently capacious, the patient is too restless, and the concretion, usually of oxalate of lime, is too hard to be easily pulverized. This is the less to be regretted, as in them well-performed lithotomy seldom if ever proves unfortunate. Among them, therefore, and "those of mature age who are so foolish or so ill informed as to permit the stone to attain an inordinate bulk," lithotomy must still prevail. It is an operation certainly more alarming to the patient, and to the surgeon may be more difficult and perplexing; but when dexterously and skilfully executed, we doubt much if its average risk exceeds, or even equals, that of promiscuous lithotrity; its efficiency is indisputably greater. The mode of operation pursued by Mr Liston, the most dexterous, elegant, and successful lithotomist of the present day, is similar to the method of Cheselden. For its details we beg to refer to Mr Liston's late work on Practical Surgery, where the modern lithotriteur is also minutely described. He attributes much of his success to limited incision of the prostate, so as to preserve the internal cellular tissue of the pelvis from infiltration of urine; and to the insertion of a gum elastic tube in the wound, so as to afford a free exit to the urine, and diminish the risk of its poisonous infiltration, while at the same time it facilitates the arresting of hæmorrhage, should this occur. "The operation of lithotomy," says he, "if performed in the easy and simple method recommended, is effected with much less pain than is supposed; it is completed, with perfect safety, in a short space of time, and offers very favourable results. It is, however, an operation which ought never to be undertaken without due consideration of all the circumstances that may arise; and the surgeon who does undertake it must have resources within himself to meet with and overcome difficulties in all the various stages of the proceeding."

Stricture.

In the treatment of stricture of the urethra, all armed bougies have been laid aside, in favour of the plain metallic catheter and bougie. The milder cases are easily overcome. A plated steel bougie, selected of such a size as will with no great difficulty pass the constricted part, is gently insinuated along the urethra. After three or four days, the introduction is repeated. Then at each farther re-introduction, at an interval of a few days, the size of the instrument is gradually increased, until it completely fills the orifice; a sign that sufficient distention of the canal has been achieved. After this, it is right to pass the last instrument occasionally, at long intervals, to counteract any tendency towards return of the contraction. Soft pliable bougies may sometimes be useful for mere exploration of the canal, but are not of much use otherwise; it being difficult to guide their points, or ascertain the exact direction which they assume. During the cure, the state of the urine should be strictly attended to; for its acridity—one of the causes of stricture—may, by irritation of the urethra, materially retard the progress. Should the bougie cause serious irritation of the urethra, as sometimes happens, the interval between its introductions must be increased, allowing the painful effects of each to subside before another is attempted, else much more harm than good will accrue from the use of the instrument. For the penetration of tight unyielding strictures, a firm silver catheter is the most appropriate instrument, its size being proportioned to the extent of contraction. For very obvious reasons, great caution must be observed in its use; steady, cautious, patient, and gentle pressure, in the right direction, must never be superseded by sudden and daring force, or irreparable mischief may ensue. "Lightness of hand, and gentleness of manipulation, will often enable a surgeon to overcome difficulties which to others may have proved insuperable. The operation of introducing a catheter through what has been called an impermeable stricture, is without doubt the most difficult in the whole range of surgical practice, and demands all the prudence, science, and skill of a master. The art can only be acquired, and that gradually, by frequent practice." When the stricture is very tight, and has afforded much opposition to the passage of the catheter, and more particularly when the operation has been undertaken on account of retention of urine, it is well to retain the instrument secured in the strictured part for twenty-four or eight and forty hours. The cure is thus much expedited, as well as recurrence of the retention prevented. The presence of the foreign body in the stricture calls up a natural effort for its extrusion, resulting in relaxation of the part, with profuse discharge; and so remarkable is the dilatation thus effected, that on withdrawing the instrument at the end of the time already specified, it is found "lying quite loose" in the passage, although at its introduction it had been grasped most tightly, and firmly fixed in the stricture. Immediately after its withdrawal, a much larger instrument can usually be introduced with ease, and the cure is then proceeded with as in ordinary cases. Sometimes the parts so strenuously resist the presence of the foreign body, that it is prudent to remove the instrument in less time than we have mentioned. Under no circumstances should it be retained beyond two days. It becomes coated with calculous deposit; and, besides, there is danger of its irritation proving excessive; ulceration may take place in the urethra, or abscess form along its course.

Thus the worst possible stricture may be overcome, and the urethra restored to its healthy functions and dimensions. But, as already said, prudence and experience are inseparable from the safe use of the small catheter; with them, it is a most valuable instrument, and saves many a patient now-a-days who would otherwise have become the victim of cruel and dangerous operation. It is seldom, indeed, that we now hear of puncture of the bladder, even by the rectum, a proceeding at one time so common here, as to be known as "the Edinburgh operation." And we as seldom hear of the catheter producing tears and wounds of the urethra, followed by abscess and fistula, or urinary infiltration ending in the death of the patient, or at least in the destruction of a large portion of his genital integument and cellular tissue. When from any cause urine has escaped into the cellular tissue of the perineum, free and deep incision, so as to afford ready escape to the poisonous fluid, cannot be too early resorted to. Should it happen that the surgeon, notwithstanding skill and perseverance, is foiled in passing the catheter, and relieving distention, then, instead of puncturing the bladder, the preferable procedure is to "make a free opening in the perineum, directly upon the obstructed part; to cut upon the end of the catheter, carrying the knife forwards; to open the dilated portion of the urethra, and then to pass the catheter on to the bladder." Thus the viscus is relieved, and a sure commencement made of the cure of the stricture, while no permanent inconvenience ensues, as after puncture of any part of the bladder. In passing the catheter to relieve retention caused by prostatic disease, it should never be forgotten that the urethra is in such cases much elongated, and that in consequence the instrument ought to be three or four inches longer than those in ordinary use. The treatment of the enlargement of that gland is entirely palliative; nor can proposals for its removal by operation be ranked among the modern improvements.

Diseases and injuries of the windpipe.

Diseases and injuries of the windpipe are better understood, and more successfully treated, than formerly. In the latter, the surgeon is less meddlesome, and his patient is benefited accordingly. In wounds of the throat it was formerly the custom, after having secured the larger arterial branches, to proceed at once to closure of the wound, dragging it together by stitches and plasters, and covering all by lint and bandage, as if the principal object were to conceal the horrid gash from view. The consequence was, that the blood which continued to ooze, finding no ready outlet externally, collected in the air-passages, and suffocated the patient, provided, as was most probable, he had not at the time sufficient energy for forcible expectoration; or if this danger was escaped, it was shortly succeeded by one equally imminent, closure of the windpipe at the injured part, from inflammatory swelling of the wound. Now the intelligent surgeon is less precipitate; he knows the danger of the old system, and avoids it by treating cut throat on the same principles as he would an ordinary wound, making no approximation until all oozing has ceased, and then only drawing together the corners, trusting the centre to the more gentle apposition by bending the head forward, and by bandage retaining the chin approximated to the top of the sternum. Thus a free outlet is left to the discharges which must form; for the transverse nature of the wound, and the constant motion of its edges in respiration and deglutition, render union by the first intention impossible. Immediate risks are thus avoided; and if the patient's energy prove sufficient, the wound will gradually close by granulation. But in general, at least in attempted suicides, a low fever ensues, against which all efforts toward cure are unavailing. The patient should be kept in a comfortably warm and equable temperature, and the fore part of the neck should be protected by some loose covering, that the inspired air may be, as nearly as possible, of the same temperature as in natural respiration. Thus the occurrence of bronchitis is so far obviated; and so long as air passes through the wound, no other dressing need be applied. When the pharynx is involved in the wound, nourishment is given from time to time through a tube introduced by the mouth; not through the wound, lest contraction of the tracheal opening should be interfered with, and its edges cicatrize separately, leaving the patient in a very miserable plight. Sometimes respiration becomes obstructed by swelling of the mucous membrane and accumulation of viscid mucus, so as to endanger suffocation, and render it necessary to open the windpipe longitudinally below the obstructed part. In injuries of the interior of the throat, tracheotomy is also sometimes necessary. When the glottis has been injured, for example, by the swallowing of acids, or hot water, or by the inhalation of steam, should the ordinary active treatment fail to arrest the urgent symptoms, tracheotomy must be had recourse to without delay, otherwise the patient will perish, either by immediate suffocation, or by effusion consequent on imperfect pulmonary circulation. A simple blow on the larynx may so completely paralyze the parts, as to render opening of the windpipe necessary for restoring the respiration. And the operation is also required when foreign bodies have lodged in the air-passages, and cannot be expelled by expectoration. If allowed to remain, they are productive of the greatest annoyance; perhaps suffocation is immediate; and if they do not speedily induce inflammatory action of the most serious nature, they are certain ultimately to occasion phthisis, or other chronic disease of fatal tendency. If the foreign body is loose, it will be spontaneously ejected from the opening; if fixed, it must be dislodged by forceps.[1]

In diseases of the air-passages, tracheotomy often becomes necessary, on account of obstruction at the top of the windpipe preventing free entrance of air into the lungs. In acute inflammatory affections, croup, for example, it is seldom admissible. In the early stage, "whilst active antiphlogistic remedies are indicated, and considered likely to afford relief, it could not with propriety be proposed; in the latter stages, after lymph has formed, when the lungs are gorged, and effusion has commenced at the base of the brain, no good purpose can be answered by an operation." Sometimes, in adults, a favourable opportunity for the operation may be selected between these stages, but it is seldom. To the chronic affections the operation is more applicable. Even in phthisis laryngea, the most intractable of these, advantage may be derived from it when performed at an early period; the diseased parts above the opening are set at rest, and an opportunity is afforded of making direct application, through the wound, of the suitable remedies to the ulcerated surface. But it is in œdema of the glottis, whether as a primary affection, or supervening on previous disease, that its beneficial results are most frequent and most apparent; the patient is at once relieved from impending suffocation; the swollen parts are put to rest, and in time subside; and after a while they so far recover their healthy condition, as to admit of closure of the wound and re-establishment of the natural course of respiration. In all cases where opening of the windpipe is required, whether on account of accident or disease, tracheotomy is preferable to laryngotomy, and though a little more difficult, is equally safe in performance. An opening in the cricoid membrane will not always suffice for detection and removal of a foreign body; and being placed in the ordinary site of laryngeal disease, will usually fail to afford relief when undertaken on that account. The incisions in tracheotomy are made very carefully, so that stray vessels may be pushed aside in safety; the trachea is pierced during the act of deglutition, when the larynx is elevated and the windpipe elongated; a silver tube is immediately introduced, of calibre proportioned to the object in view, and of such a form as to prevent oozing from the wound by compression of the edges. After a short time all irritation from the presence of the tube ceases; but during the whole cure great attention must be paid that it be kept clear of the vitiated mucus. It should also be protected by some loose covering, in the same manner and for like reasons as in cases of cut throat. In the treatment of all affections of the throat, the possibility of tracheotomy becoming requisite should always be kept in view; and the curative applications should consequently be confined as much as possible to the sides of the neck, leaving the fore part free, otherwise much difficulty may be thrown in the way of the operator.

Diseases of the rectum.

The treatment of diseases of the rectum has become simplified and improved along with the rest of surgery. "Many attempts have been made to mystify the subject of diseases of this region, and to separate them in a great measure from general surgery. There is no such difficulty as has been supposed in understanding their nature; the principles which should guide their management are simple, and the means, operative and otherwise, easily enough applied." Of late a variance of opinion has arisen in regard to the treatment after operation on the rectum; one party maintaining that in all cases little or no dressing is required; the other, that in every case stuffing and compression of the wound are essential to the safety of the patient. As is usual when opinions are in extreme opposition, we find that truth occupies a middle place. In some slight cases of operation, for fistula, hæmorrhoids, &c., no more dressing is required than what is sufficient to prevent immediate union of the divided parts; while in others, a degree of compression must be made on the divided surface, proportioned to the extent of the incision and the probability of hæmorrhage. It would be very unnecessary to cram the wound in the first class of cases; in the second, it would be equally unwise to leave the parts wholly unsupported.

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[1] A most interesting case of foreign body in the bronchus, successfully removed by operation, is detailed by Mr Liston, in his Practical Surgery, p. 371.

Tumours.

As the pathology of tumours has become more and more understood, operative procedure has been withdrawn from some and extended to others. Diagnosis having become both more easy and more accurate, we can now readily distinguish between those of a benign and those of a malignant disposition. In regard to the latter, experience has taught us to forbear from operative interference, unless at the very first accession of the disease; for though the more simple tumours, even when of large size and long duration, may be removed with every prospect of permanent cure, yet in those of a malignant nature, immunity from recurrence of the disease can be hoped for only when the removal is very early; when the local affection is still limited and loosely attached; when there is a certainty of being able to remove, not only the morbid structure itself, but some portion of the unaltered tissues which invest it; before any affection of the neighbouring lymphatics can be detected; and before the general system seems to have been permanently involved. Among the more benign tumours, the most remarkable extension of active surgery is in regard to the solid tumours of the jaw. Not long since these formidable formations were looked upon with horror and dread, as one and all of the most malignant tendency, and were consequently left to their own course. But now we have been taught that such is not, and ought not to be, the case; that many doubtless are most malignant, and must not be interfered with; but that others, and sometimes even those of the most formidable appearance, are sufficiently local and apathetic to warrant the adoption of active interference with the most sanguine hopes of success. Both the upper and lower jaws, involved in large and frightful tumours, have of late years been removed by operation; and when the case has been judiciously selected, good success has been invariable. In the soft medullary tumour of the upper jaw, commencing in the antrum, an opportunity warranting interference can seldom occur; for before the morbid formation has appeared externally in the mouth or nose, it has not only completely involved the bone in which it originated, but also included in the diseased mass the palate-bone, the ethmoidal cells, the orbit, and even the sphenoidal sinuses.[1] It is only when such a disease, at an early period of its existence, is confined to the antrum, that removal of the superior maxillary bone can be of service; but unfortunately its true nature is seldom discovered until a portion of the tumour has become apparent by the giving way of the parietes; and when that has occurred the case is hopeless, for its extension backwards very far exceeds the outward protrusion. In its first stage the prominence of the cheek has the same smooth glistening appearance as in chronic abscess of the antrum; but the parietes of the tumour are hard and unyielding; they soon thin at one or more points, there communicating a pulpy feeling to the finger; and when they have completely given way, the ravages of the disease are as rapid as uncontrollable. The more benign tumour in this situation—originating in the bone, and usually the result of injury—is, on the contrary, slow in its progress and of very firm consistence; its surface is lobulated, and if ulcerated by accident, soon heals again; the internal structure, of a firm fibrous character, is limited by a dense cellular cyst; and the neighbouring bones are either simply displaced, or removed more or less by interstitial absorption; the progress of the tumour is in consequence almost entirely towards the surface. It is in such cases that the surgeon does not now hesitate to remove the superior maxillary bone; for with it he knows that he can take the whole diseased formation. It is doubtless a formidable operation, and not unattended with danger; but the risk is insignificant when compared with the ultimate benefit likely to accrue. It is therefore evidently of the highest importance to distinguish accurately these two classes of tumour, the treatment suitable to each being so widely different; in the one case operation is wholly inadmissible, while in the other the sooner it is had recourse to, the greater is the probability of a successful result. Care should also be taken not to confound either with the more simple affection of accumulated fluid in the enlarged antrum; for it has happened that a surgeon, after having made up his mind to attempt removal of the superior maxilla, has, "on trying to divide the connections of that bone, had his hands covered with purulent matter, and himself with shame and confusion." The same general description applies to tumours of the lower jaw as to those of the upper, with this difference, that the relative position of the former somewhat prolongs the favourable opportunity at which tumours even of malignant tendency may be removed. The medullary tumours are also of much less frequent occurrence; there is no large cavity, like the antrum, in which they may originate, and the great majority consequently come under the denomination of osteo-sarcoma. That very many tumours of the jaws are attributable to disease, or even faulty position, of the teeth, and to unskilful dental operations, is a fact as true as it is important, and should direct both surgeon and patient to greater and more frequent attention to those influential little portions of the osseous system. After the operation on either jaw, an unseemly void of course remains; but nature, assisted occasionally by the dentist, does wonders in repairing this, and the actual deformity is in many cases surprisingly slight.[2]

In operations for the removal of tumours in the soft parts, we have elsewhere stated that the incisions should be so planned as to divide the principal vessels at the outset, as thus both time and blood are saved. If the vessels implicated are large, temporary pressure on the trunk may be made by the assistant; but it can seldom if ever be necessary to practise a preliminary operation for the securing of that trunk by ligature. In most cases the dissection of the tumour should be made as rapidly as is consistent with the safety of important parts in the neighbourhood. But when the tumour is suspected of a malignant tendency, the duration of the proceeding must not be considered; the dissection must be methodical and deliberate. As it proceeds, the parts must be examined carefully by both the finger and eye; and on its completion, the removed mass must be minutely surveyed, lest any shred of morbid formation be left in the wound. No successful result can be hoped for, unless the whole altered structure is completely and freely removed. Another point in regard to operations on tumours ought never to be forgotten, namely, that the most simple and best dispositioned formations may, in the course of time, degenerate into the most malignant and intractable, and therefore should not be exposed to this contingency; they should be early removed, for the merest steatom has, by circumstances, been transformed into the most frightful and deadly fungus.

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[1] Sometimes these tumours commence in the latter situations, and involve the superior maxillary bone secondarily.

[2] For details of the operation, we again refer to Liston's Practical Surgery; a work of great value, from the perusal of which both practitioner and student will derive much profit, and to which, we beg to acknowledge, we have been not a little indebted in the course of the present article.

Vascular tumours, of erectile tissue, are now safely and efficiently removed by ligature. Formerly they were usually left undisturbed. Sometimes attempts at excision were made, but the results were truly discouraging, the hæmorrhage proving most alarming, and not unfrequently fatal. In a mere nævus, obliteration of the vessels may be safely effected by vaccination, pressure, acupuncture, seton, or the application of escharotics. But such treatment is totally inapplicable to the erectile tumours. These, when very small, may be removed by excision; but it is not a safe proceeding, particularly in young patients, to whom loss of blood is of serious consequence. But by ligature, vascular tumours of almost any size and extent are safely removed, by arresting their circulation, and so producing sphacelus of the adventitious structure. When the formation is of a broad base, several ligatures are required, passed beneath the tumour by needles; and when the integument is free, or but slightly involved, it should be reflected by preliminary incision, so that these ligatures may be the more effectually applied. By such procedure, even enlargement of the thyroid gland may be removed. Of course no one would think of attacking the whole tumour on account of the mere deformity; but it sometimes happens that enlargement of the isthmus occasions difficult respiration, congestion of the cerebral vessels, and other alarming symptoms; and in such cases the offending part has been successfully removed by a combination of incision with ligature, using the knife as deeply as the hæmorrhage will permit, and then completing the isolation of the lobe by strong ligatures applied by transfixion.

Ven al dise.

In the treatment of venereal affections, mercurial supremacy has gradually given way to the influence of common sense, and the disease has consequently become more mild and tractable, particularly in its secondary forms. The primary symptoms are treated as simply local affections, until circumstances prove the contrary, which will be comparatively seldom. When the exhibition of mercury seems advisable, little usually suffices; it is used, not abused as formerly.

Hy cele.

Hydrocele, which was at one time the apology for very severe surgical proceedings, by knife, setons, and escharotics, is now under very simple treatment; the palliative, is mere tapping of the cavity; the permanent, injection of it, after tapping, by some gently stimulating fluid, port wine, for example. But great care must be taken during injection, that none of the fluid enter the cellular tissue of the scrotum, otherwise most violent inflammatory action must ensue in the infiltrated parts.

Resta- tive r- gery: The se.

Restorative surgery, in former years scarcely attempted, is now making rapid progress towards perfection. Noses are made and repaired most adroitly, not according to the old inconvenient system of the European father of rhinoplastics, but by a modification of the plan practised by the Koomas, a caste of Hindoos, and first introduced into this country by Mr Carpue. This decorative operation has been very successfully practised by Mr Liston, who is the author of an important change in the procedure—not bringing the columna from the forehead, but waiting till the new apex and alæ so obtained are consolidated, and then fashioning a column out of the upper lip.[1] By this little operation a more vigorous and substantial support is obtained for the new parts; and, besides, the lip, which formerly hung tumid and pendulous, is at the same time very much improved in appearance. His nasal constructions, he tells us, are scarcely to be distinguished from the natural feature at a little distance, are quite sufficient for the ordinary uses of that organ, and sometimes have been brought to desiderate and enjoy the questionable accomplishment of snuff-taking. He has likewise been very successful in relieving the nose from inconvenient and unseemly encumbrances, produced by lipomatous enlargement of the integument. The excrescence is simply pared off, care being taken not to interfere with the subjacent cartilages. The raw surface usually cicatrizes rapidly, leaving the feature of its natural form and size. By an operation conducted on similar principles as the rhinoplastic, the lower lip is renewed from beneath the chin; the ear, or rather portions of it, from the integument behind; and deficiencies in the urethra can be closed by adaptation of a portion of either the prepuce or loose neighbouring integument. Such proceedings some may affect to disregard as trivial; but they are not looked upon as such by the unfortunate individuals to whom they are applicable, and really constitute a most interesting and useful department of operative surgery.

Harelip.

Harelip, one of the most disagreeable of the congenital deficiencies, can be very perfectly remedied, by paring the edges of the fissure, and securing them in close and accurate apposition by two or more points of twisted suture. According to the principles already detailed, no further dressing is applied; and if the patient be otherwise in good health, and the parts protected from external injury, adhesion will seldom or never fail to occur. The most important part of the operation, as regards restoration of the lip's natural appearance, is complete removal, by the paring of the rounded margins where the membrane that covers the edge of the fissure joins the true prolabium. If this be not attended to, the operation is imperfect, for a most unseemly notch remains in the lip; in fact, the fissure is merely diminished, not obliterated. But when these rounded portions are completely removed, and the operation is in other respects well conducted, a mere line of cicatrization is all that remains of the deformity.

Club-foot.

Club-foot, a most inconvenient as well as unseemly malformation, is remedied in children by simple means; merely applying the necessary retentive apparatus, until the parts become fixed in the normal position in which that apparatus places them. Now, the cure is extended even to the adult; and very many varous feet, formerly regarded as irremediable, are restored to usefulness and symmetry, at the cost of but slight pain and inconvenience. The first part of the treatment is to sever the tendo Achillis; an operation simple in performance, and seldom if ever followed by any untoward results. A narrow knife or lancet-shaped needle is introduced obliquely through the integument, beneath the tendon, and at a little distance from it on one side; "by directing the edge against the resisting fibres, the foot being kept powerfully extended by an assistant, the object can be effected with scarcely a perceptible external wound, and with the escape of only a drop or two of blood." The foot is then placed in the desired position, and retained so by the suitable apparatus, for the necessary period; the foot becomes both "useful and ornamental;" and the space between the separated ends of the divided tendon is, after no long time, firmly and completely occupied by a new formation, of tendinous structure and capabilities, by means of which the functions of the muscles are ultimately restored.

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[1] The columnar slip includes the whole thickness of the lip, and in its application is not twisted. The mucous membrane, after exposure in its new situation, soon becomes cuticular in both appearance and function.

A similar operation has been for some time in practice in the veterinary profession. It was first performed on the human body by the continental surgeons. After dividing the tendon, they again brought the retracted ends together, and retained them in apposition until partial reunion took place, when, by gradual extension, the new formation was elongated to the extent necessary for the adjustment of the foot. This method, however, is both more tedious and more painful than the one already described; and by either, the repair is equally substantial and efficient. In some cases of the deformity, the bones are either so deficient in original development, or so firmly secured in their malposition, as to be irremediable even by such means. But, as already stated, there are very many cases, both of simple extension of the foot, and of that complicated with inversion, in which this little operation, well seconded by the care of the machinist, will be followed with success almost equal to the most sanguine hopes of both surgeon and patient.

We have thus briefly sketched the subjects which naturally occur to us, as the most prominent examples of the modern advancement of surgery. It were easy to swell the list. But our assigned limits have already been attained, if not exceeded; and enough has probably been said, both to convey a general idea of the improvement recently effected in this profession, and to encourage a hope that such progress will still continue, year after year, bringing the practice of this useful, enlightened, and noble art, closer to perfection. (C. D.)

SURINAM. See GUIANA.

SURNAME, that which is added to the proper name, for distinguishing persons and families. It signifies some name superadded to the proper name to distinguish the individual, as Artaxerxes *Longimanus*, Harold *Harefoot*, Malcolm *Canmore*. Surnames were introduced among all nations at an early period, and seem to have been formed at first by adding the name of the father to that of the son. This was the practice among the Hebrews, as appears from the Scriptures. Caleb is denominated the son of Jephunneh, and Joshua the son of Nun. That the same thing was customary among the Greeks, every one who has read the poems of Homer must remember. We have an instance of it in the very first line of the Iliad: Πηληϊάδεω ’Αχιλῆος, "Achilles the son of Peleus." This is perhaps the general origin of surnames, for it has been common among most nations.

The Romans generally had three names. The first, called *prænomen*, answered to our Christian name, and was intended to distinguish the individuals of the same family; the second, called *nomen*, corresponded to the word *clan* in Scotland, and was given to all those who were sprung from the same stock; the third, called *cognomen*, expressed the particular branch of the tribe or clan from which an individual was sprung. Thus, in Publius Cornelius Scipio, *Publius* corresponded to our names John, Robert, William; *Cornelius* was the name of the clan or tribe, as Campbell was formerly the name of all the duke of Argyle's clients, and Douglas the name of the retainers of the duke of Hamilton's progenitors. *Scipio* being added, conveyed this information, that Publius, who was of the tribe of the Cornelii, was of the family of the Scipios, one of the branches or families into which that tribe was divided. Respecting the three names which were common among the Romans, we may say that the first was a name and the other two were surnames.

Du Chesne observes, that surnames were unknown in France before the year 987, when the lords began to assume the names of their demesnes. Camden relates, that they were first assumed in England a little before the conquest, under King Edward the Confessor; but he adds, they were never fully established among the common people till the time of Edward II.: till then they varied with the father's name. Thus, if the father was called *Richard*, or *Roger*, the son was called *Richardson*, or *Hodgson*. The oldest surnames are those which we find in Domesday-Book, most of them taken from places, with the addition of *de*; as Godefridus *de* Mannevilla, Walterus *de* Vernon, Robert *d'* Oyly, &c.; others from their fathers, with *filius*, as Gulielmus *filius* Osberni; others from their offices, as Eudo *Dapifer*, Gulielmus *Camerarius*, Gislebertus *Cocus*. But the inferior people are merely noted by their Christian names.

Surnames seem to have been introduced into Scotland, in the time of William the Conqueror, by the English who accompanied Edgar Atheling when he fled into that kingdom. These had their proper surnames, as Moubray, Lovell, Lisle, using the particle *de* before them; which makes it probable that these surnames had been derived from the lands which their ancestors or they themselves had possessed. In Kenneth II.'s time, about the year 800, the great men had indeed begun to call their lands by their own names; but the ordinary distinctions then used were only personal, and did not descend to succeeding generations, such as those employed by the Hebrews and Greeks: for example, *John the son of William;* or the names of office, as Stewart; or accidental distinctions from complexion or station, Black, White, Long, Short; or the name of their trade, as Weaver, Tailor, Baxter, Brewster.

It was long before any surnames were used in Wales, except that of son, as Evan ap Rice, Evan the son of Rice; Evan ap Howel, Evan the son of Howel. But many of them have at length formed separate surnames, as the English and Scotish, by leaving out the *a* in *ap*, and joining the *p* to the father's name: thus Evan ap Rice becomes Evan Price; Evan ap Howel, Evan Powel.

When we come to inquire into the etymology of surnames, we must allow that many of them were originally significant of the qualities of mind, as Bold, Hardy, Meek; some of the qualities of body, as Strong, Low, Short; others expressive of the trade or employment followed by the persons to whom they were applied, as Baker, Smith, Wright, Butler, Page, Marshall. But the greatest number, at least of the ancient surnames, were borrowed from the names of places. Camden avers that there is not a village in Normandy but has given its name to some family in England. He mentions as examples, Percy, Devereux, Tankerville, Mortimer, Warren, &c. They were introduced with William the Conqueror. Several have been derived from places in the Netherlands, as Gaunt, Tournay, Grandison; and many from the names of towns and villages in England and Scotland, as Wentworth, Markham, Murray, Aberdeen. Many have been formed from the names of animals, as quadrupeds, birds, fishes; from vegetables, and parts of vegetables, as trees, shrubs, flowers, and fruits; from minerals of different kinds. Others are formed from such a variety of accidents that it is impossible to particularize them.

SURPLICE, the habit of the officiating clergy in the Church of England. By Can. 58, every minister saying the public prayers, or ministering the sacrament or other rites of the church, shall wear a decent and comely surplice with sleeves, to be provided at the charge of the parish. But by 1 Eliz. c. 2, and 13 and 14 Car. II., the garb prescribed by act of parliament, in the second year of King Edward VI. is enjoined; and this requires, that in the saying or singing of matins, and even songs, baptizing and burying, the minister in parish churches and chapels shall use a surplice. And in all cathedral churches and colleges, the archdeacon, dean, provosts, masters, prebendaries, and rey.

fellows, being graduates, may use in the choir, besides their surplices, such hoods as pertain to their several degrees; but in all other places every minister shall be at liberty to use a surplice or not. And hence, in marrying, churching of women, and other offices not specified in this rubric, and even in the administration of the holy communion, it seems that a surplice is not necessary. Indeed for the holy communion the rubric appoints a white alb plain, which differs from the surplice in being close-sleeved, with a vestment or cope.

daries x-

SURREY, an inland English county, on the banks of the Thames, by which, on its northern side, it is separated from Middlesex. On the west it is bounded by Berkshire and Hampshire, on the south by Sussex, and on the east by Kent. Its shape is an oblong, of moderate regularity, except on its northern side, where considerable indentations are formed by the curvatures of the Thames. Its length from east to west is about thirty-seven miles, and its breadth from north to south about twenty-five. The area is 758 square miles, or 485,120 statute acres.

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The population of this county at the four decennial periods of enumeration was found to be as follows; viz. in 1801 it amounted to 269,043, in 1811 to 323,851, in 1821 to 398,658, and in 1831 to 485,700.

At the last date the occupiers of land employing labourers were	1,873
Occupiers of land not employing labourers	727
Labourers employed in agriculture	16,761
Labourers employed in manufactures	2,065
Labourers in retail trade and handicraft	44,139
Capitalists, bankers, &c.	14,235
Labourers not agricultural	24,878
Males at and above twenty years	10,756
Male servants	6,232
Female servants	24,540

In the same year the number of families chiefly employed in agriculture was found to be 14,647; of those chiefly employed in trade, manufactures, and handicraft, 49,616; and of those not comprised in either of the preceding classes, 44,814. The number of inhabited houses was 80,070, occupied by 109,077 families; of uninhabited, 6102; and of those building, 1073.

The amount of the annual value of the real property of the county, as assessed for the purposes of the property-tax in 1813, was L.1,579,173.

ns and ges.

The towns and villages within this county, whose inhabitants exceed 3000, are, with their population in 1831, as follows. Such of them which are so in contact with the metropolis as to form suburbs to it, are here distinguished by an asterisk.

*Southwark	91,501	Farnham	5,858
*Lambeth	87,856	Battersea	5,540
*Newington	44,526	Streatham	5,068
*Bermondsey	29,741	Chertsey	4,795
Camberwell	28,231	Dorking	4,711
*Rotherhithe	12,875	Godalming	4,529
Croydon	12,447	Mitcham	4,387
Clapham	9,958	Egham	4,203
Kingston	7,257	Guildford	3,813
Richmond	7,243	Putney	3,811
Wandsworth	6,879	Ryegate	3,397

of the try.

The face of the country exhibits great varieties. On the north, by the banks of the Thames, from Lambeth to Egham, the richness of the highly improved country, the abundance of trees, the verdure of the meadows, the undulation of the hills, with the numerous elegant private houses, all display the most pleasing marks of taste, wealth, and comfort. The centre of the county is a range of chalk hills, much covered with thick underwood, intermixed with arable fields badly cultivated, and utterly destitute of water. The south part, at the foot of this range of hills, is a flat clayey country, nearly impassable in the winter, but covered with some of the best and largest oak trees that are to be found in the island. The north-western part exhibits a considerable tract of the most sterile black heaths, while on the south-west, near Farnham, is some of the most productive land in England.

Surrey.

Productions.

The productions of agriculture are various, and, at a distance from the capital, scarcely differ from those of other districts in similar circumstances. A greater proportion of clover and of sanfoin is cultivated on the hills, where there are no natural meadows, than in most other parts of the kingdom. Woad is also very extensively raised in the same districts. It is commonly sown along with turnips intended for feeding sheep, which will not touch woad. It is generally harvested before the corn-crops are ready for the sickle. Near London, the garden-ground extends over several thousand acres. The growing of plants, for the use of the druggists and perfumers, engages much attention; and those gardens supply peppermint, lavender, wormwood, chamomile, aniseed, liquorice, poppy, and other similar articles. Hops are extensively cultivated near Farnham, and are sold for higher prices than those of any other districts.

Minerals and fossils.

No minerals are now raised in the county; for though iron is known to exist, and was formerly worked with charcoal, the improvements in chemistry have fixed that operation to the coal-districts. The fossil riches are valuable, especially fullers' earth, which is of the best quality, and in abundance, and supplies the cloth manufacturers both in the west and north of England. Limestone is plentiful; and that, as well as chalk, is converted into lime, upon a great scale, for the use of the builders of the metropolis. The quarries of Merstham produce an excellent fire-stone; and the sand near Dorking and Ryegate is in great request for making glass, hour-glasses, and other purposes.

Manufactures.

The manufactures are various and extensive; but, being almost exclusively near the metropolis, may more properly be considered as belonging to London than to the county of Surrey. The principal of these are breweries and distilleries on a magnificent scale. The tanners, rope and sail-makers, glass-makers, starch and hair-powder makers, and the preparers of vinegar and raisin wines, carry on large trades. A few miles farther from London, chiefly on the banks of the river Wandle, the calico-printers and bleachers have large establishments.

Rivers, canals, and railroads.

All the rivers of this county empty themselves into the Thames. The only navigable river, besides that fine stream which bounds it, is the Wey, on which barges pass above Guildford into the Basingstoke Canal. The Mole is a beautiful small stream, celebrated for sinking into the ground, and at some few miles lower again emerging. The Wandle runs a short course, but is of great value, from the vast quantity of mill-machinery which it keeps in motion, and the employment which it thus affords to several thousand persons. It rises in one spring near Croydon, turns a large mill within a few yards of its source, and runs nine miles before it joins the Thames. The Medway rises in Surrey, but is a very small stream till it enters the county of Kent. The Loddon, a small river on the western border, is chiefly valuable for the supply of water which it affords to the Basingstoke Canal. That canal was one of the first executed in this part of the kingdom, having been finished in 1796. The Croydon Canal only reaches that town from the Thames; and the little success attending it has prevented its being carried farther, as was originally intended. The Surrey Canal runs parallel to the Thames; but, by avoiding the sinuosities of that river, and the whole of the metropolis, is expected to be beneficial to the inhabitants on the upper banks, by conveying coals and other heavy commodities to them, from ships, at a cheap rate. Its entrance, from the Thames below London Bridge, has a fine basin, capable of containing 100 sail of square-rigged vessels. Railroads have been constructed from Merstham to the Thames; but the project has not repaid those who have advanced the capital a sufficient interest to recommend any further attempts. Several railroads which will pass through the county have been projected, and acts of the legislature for some of them have been obtained: only one of them has yet made much progress, namely, the London and Southampton. Some obstacles long delayed that intended to proceed to Brighton, and the same is the case with the one projected from London to Dover.

Antiquities and interesting objects.

Among the Roman antiquities of this county are the Ermine Way, which traversed it, and the remains of which may still be traced near Dorking. The piles are still standing in the river Thames at Walton, which were placed there by the ancient Britons, to impede the passage of Julius Cæsar. The vestiges of the encampments of the Romans may be distinctly traced at Bottlehill, at Waltonhill, and some other spots. Among the antiquities of later date, are the Palace of Lambeth, belonging to the see of Canterbury; that of Farnham, belonging to the see of Winchester; the remains of the Abbey at Croydon, the Castle of Guildford, Waverley Abbey, and some other Saxon edifices. The meadow of Runnymead, St Anne's Hill, the seat of the late Mr Fox, the park of Richmond, and the terrace there, with the palace and gardens of Kew, are all objects that excite a high degree of interest.

Capital.

It is difficult to determine which of the towns is the capital of the county. The principal prison is in the borough of Southwark, and the quarter-sessions are held there; but the lent assizes are held at Kingston-on-Thames, and the summer assizes alternately at Croydon and at Guildford.

Titles and representation.

The titles derived from this county are those of the Duke of Richmond, the Earls of Surrey, Guildford, and Onslow, and Baron Abinger. The county is formed into the eastern and western division to elect two members for each. The election for the east division is held at Croydon; and the other polling places are Ryegate, Camberwell, and Kingston. The western election is held at Guildford; and the other polling places are Dorking and Chertsey. The boroughs of Gatton and Haselmere, which formerly returned two members each, have been disfranchised; and Ryegate, which chose two, now elects but one member. Lambeth has been erected into a borough, and returns two members; as do the ancient boroughs of Southwark and Guildford.

Chief seats.

The number of seats belonging to noblemen and gentlemen in this county is so great as to forbid the noticing of even all those which in any other county would be deemed highly worthy of notice. The most remarkable are, her majesty's palace of Kew; Claremont, king of Belgium; Clandon Place, earl of Onslow; Pepper Harrow, Lord Middleton; Oatlands, Lord Francis Egerton; Painshill, Lord Carhampton; Ockham Park, earl of Lovelace; Addington Palace, archbishop of Canterbury; Rooksnist, C. H. Turner, Esq.; Nonsuch Park, S. Farmer, Esq.; Gatton, Lord Monson; Nork House, Lord Arden; Betchworth, Right Honourable H. Goulbourne; Norbury Park, Joseph Dennison, Esq.

See Manning and Bray's History of Surrey; Salmon's Antiquities of Surrey; Stevenson's View of the Agriculture of Surrey; Lyson's Environs of London.

SURROOL, a town of Bengal, district of Birbhoom, where the East India Company have a factory for white cottons. Long. 87. 42. E. Lat. 23. 39. N.

SURSOLID, or SURDESOLID, in *Arithmetic*, the fifth power of a number, or the fourth multiplication of any number, considered as a root.

SURSUTTY, a river of Hindustan, which rises in the mountains on the north-east boundary of the province of Delhi, and running south-west, is lost in the sands of Ajmeer. A town and fortress of the same name is situated on the western bank of this river, and now belongs to an independent chief. Long. 75. 27. E. Lat. 29. 13. N.

END OF VOLUME TWENTIETH.

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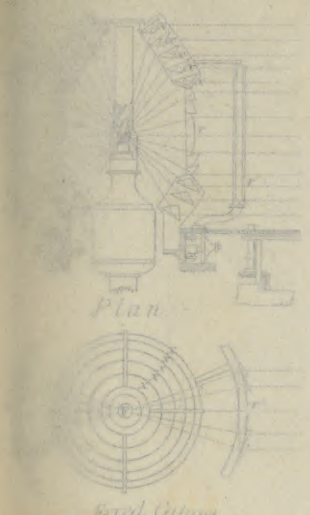
SEA LIGHTS

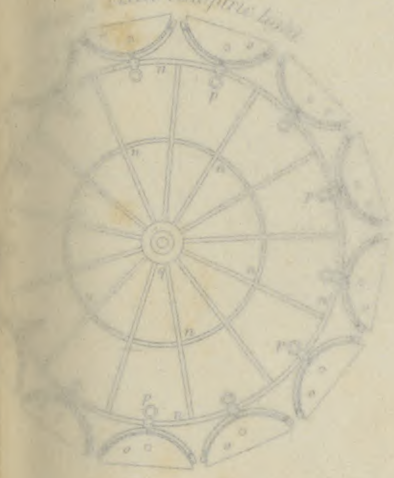
PLATE CCCCXLI.

Fig 1.

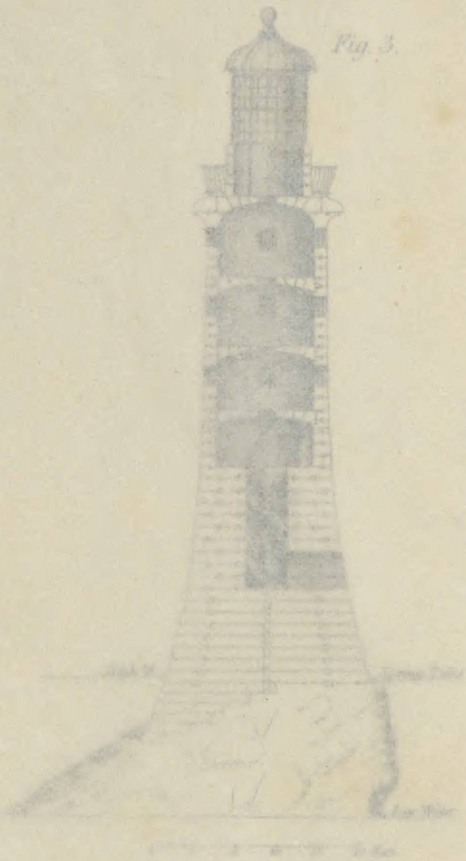
[illegible] dioptric light



Fixed Catoptric light



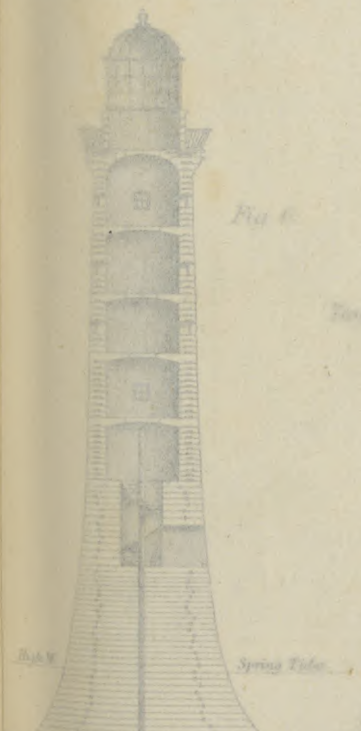
Section of Eddystone Lighthouse



[illegible]

10 5 0 10 20 30 40 50 60 70 80 90 100 Feet.

Section of Bell-Rock Lighthouse



10 5 0 10 20 30 Feet.

[illegible]

ndrews, Delt.

Geo. Aikman, Sculpt.

Surrey.

&c. Railways have been constructed from Merstham to the Thames; but the project has not repaid those who have advanced the capital a sufficient interest to recommend any further attempts. Several railroads which will pass through the county have been projected, and acts of the legislature for some of them have been obtained; only one of them has proceeded, that projected between London and Southampton. [illegible] that intended to proceed to Brighton; and the same is the case with the one proposed from London to Dover.

Antiquities and remarkable objects.

Among the Roman antiquities of this county are the [illegible], which [illegible], and the remains of which may still be traced near Dorking. The piles are still standing in the river Thames at Walton, which were placed there by the Britons to impede the passage of Julius Cæsar. The vestiges of the encampments of the Romans [illegible] at [illegible]hill, at Walonhill, and [illegible]. Among the antiquities of later date are the palace of Lambeth, belonging to the see of Canterbury; that of Farnham, belonging to the see of Winchester; the [illegible] of the [illegible] of [illegible], the Castle of Guildford, [illegible], and some other Saxon edifices. The [illegible] of [illegible], St Anne's Hill, the seat of the late Mr Fox; the park of Richmond, and the terrace there, with the palace and gardens of Kew, are all objects that excite a high degree of interest.

Capital.

It is difficult to determine which of the towns is the capital of the county. The principal place is the borough of Southwark, and the quarter-sessions are held there; but the lent assizes are held at Kingston-upon-Thames, and the summer assizes alternately at Croydon and at Guildford.

Titles and representation.

The titles derived from this county are those of the Duke of [illegible], and Earls of Surrey, Guildford, and Onslow, and Baron [illegible]. The county is formed into the eastern and western divisions to elect two members for each. The election for the eastern division is held at Croydon; and the other polling places are Reygate, Camberwell, and Kingston. The western election is held at Guildford; and the other polling places are Dorking and Chertsey. The boroughs of Gatton and Haslemere, which formerly returned two members each, have been disfranchised; and Reygate, which chose two, now elects but one member. Lambeth has been created into a borough, and returns two members; as do the ancient boroughs of Southwark and Guildford.

The number of seats belonging to noblemen and gentlemen in this county is so great as to forbid the enumeration of even all those which in any other county would be esteemed highly worthy of notice. The most remarkable are his majesty's palace of Kew; Claremont, king of [illegible]; Clandon Place, earl of Onslow; Pepper Harrow, Lord Midleton; Oatlands, Lord Francis Egerton; [illegible], Lord Carhampton; Ockham Park, earl of Lovelace; Addington Palace, archbishop of Canterbury; Rooksnest, C. H. Turner, Esq.; Nonsuch Park, S. Farmer, Esq.; [illegible], Lord Monson; Nork House, Lord Arden; Betchworth, Right Honourable H. Goulbourne; Norbury Park, [illegible], Esq.

See Manning and Bray's History of Surrey; [illegible] Antiquities of Surrey; Stevenson's View of the Agriculture of Surrey; Lyson's Environs of London.

SURHOOL, a town of Bengal, district of [illegible], where the East India Company have a factory for [illegible] cottons. Long. 87. 12. E. Lat. 23. 39. N.

SURSOLID, or SURSOLIDAL, in *Arithmetic*, the fifth power of a number, or the fourth multiplication of any number, considered as a root.

SURSUTTY, a river of Hindostan, which rises in the mountains on the north-east boundary of the province of Delhi, and running south-west, is lost in the sands of Ajmeer. A town and fortress of the same name is situated on the western bank of this river, and now belongs to an independent chief. Long. 75. 27. E. Lat. 29. 28. N.

END OF VOLUME TWENTIETH.

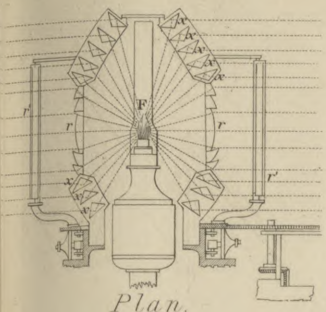
[illegible]

SEA-LIGHTS.

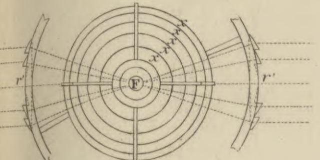
PLATE CCCCXLI.

Fig. 1.

Section of Cata dioptric light.



Plan.



4.

Plan of Fixed Catoptric light.

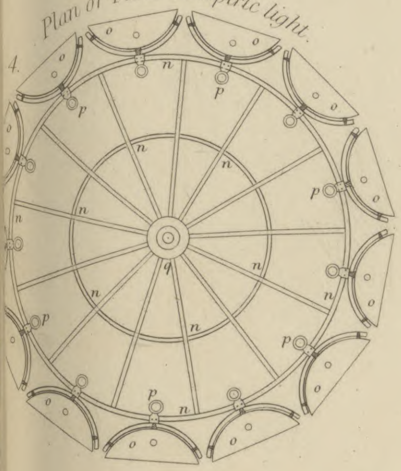


Fig. 2.

Section of Revolving Catoptric light.

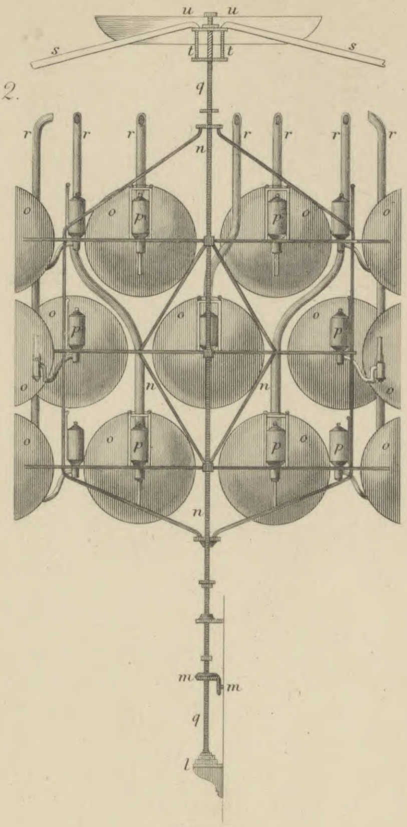
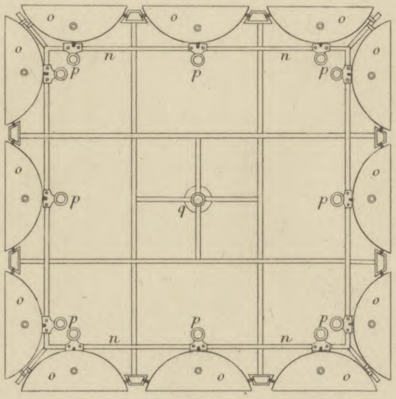


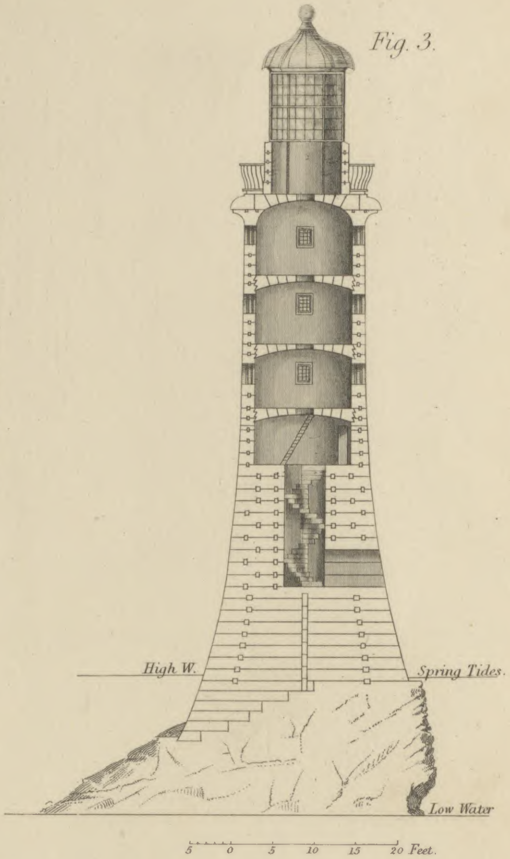
Fig. 5.

Plan of Revolving Catoptric light.



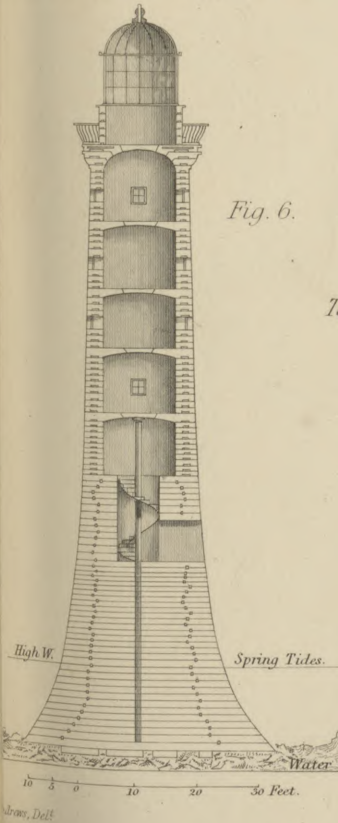
Section of Eddystone Lighthouse.

Fig. 3.

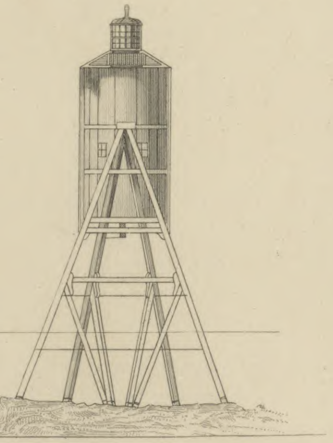


Section of Bell-Rock Lighthouse.

Fig. 6.

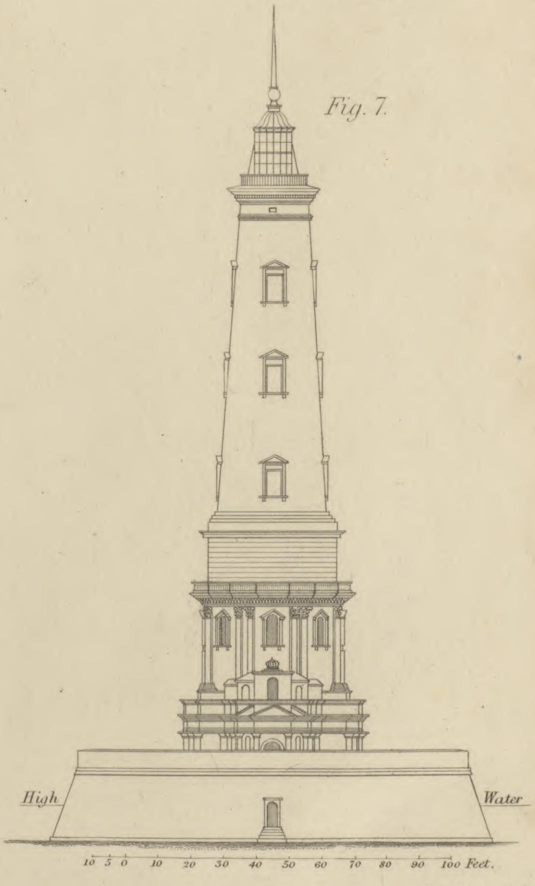


Temporary Wooden Barrack.



Elevation of Corduan Lighthouse.

Fig. 7.

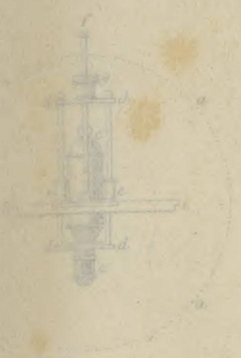


drews, Del^t.

Geo. Aikman, Sculp^t.

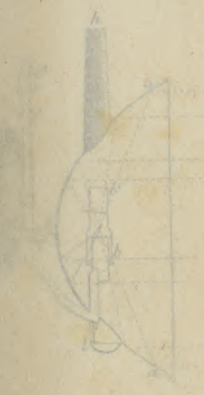
[illegible] and Lamp.
[illegible] apparatus.
Back view.

Fig. 9.



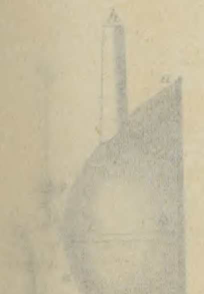
Reflector and Lamp
apparatus. — Section.

Fig. 8.

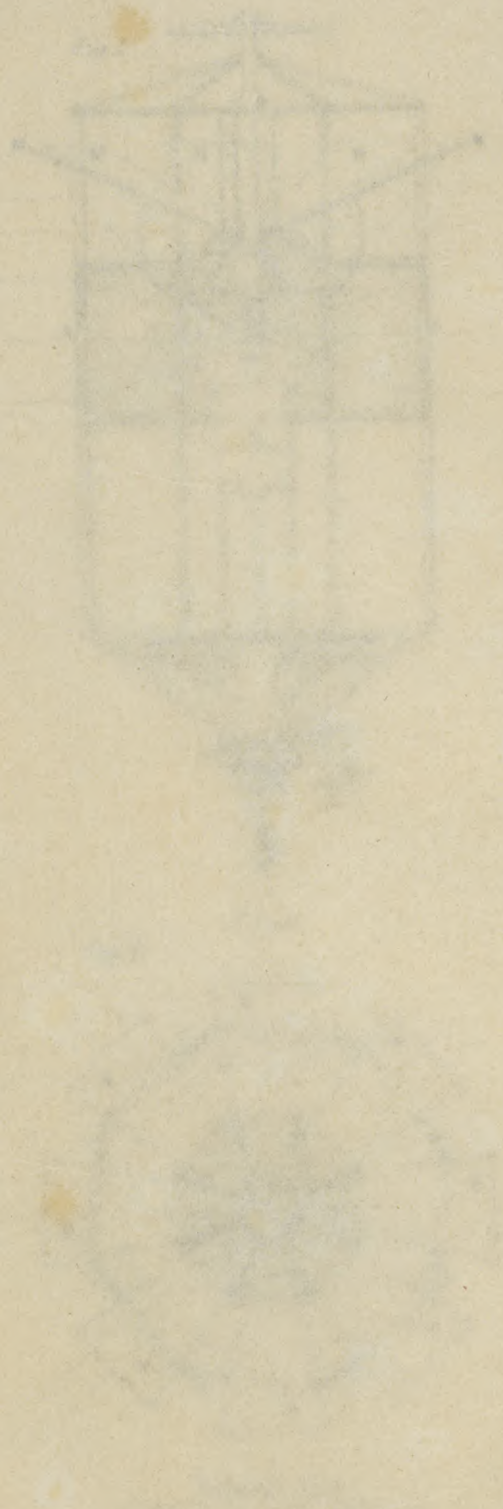


[illegible] and Lamp
Side view.

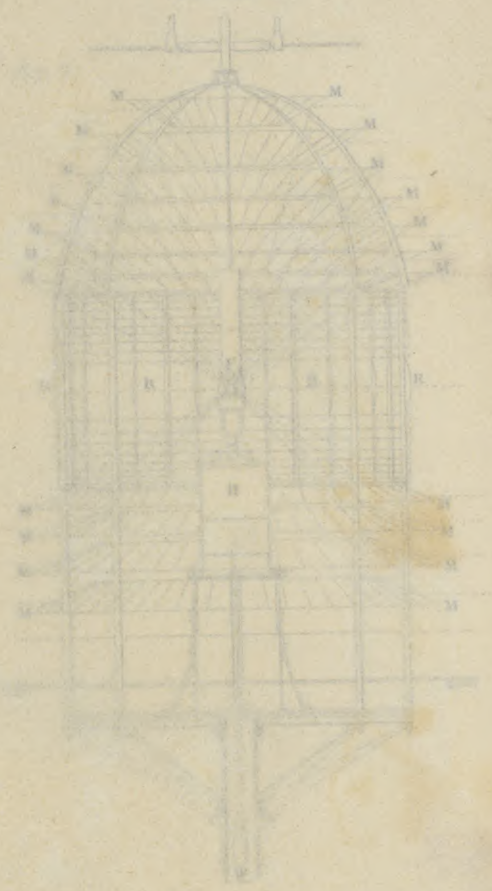
Fig. 7.



Revolving dioptric light of first order
Section.

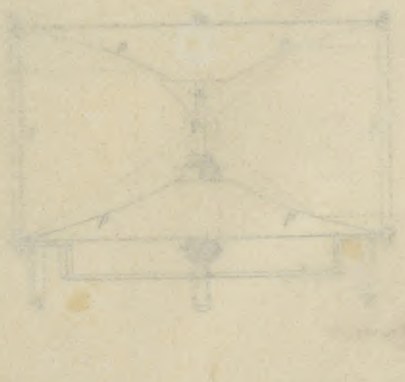


Fixed dioptric light of first order with mirrors
Section.



Plan.

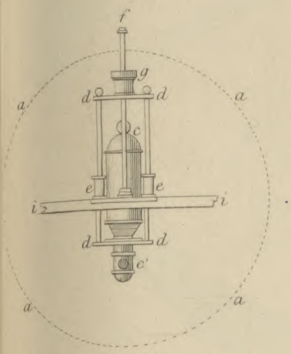
[illegible] [illegible]'s Reflector



SEA-LIGHTS.

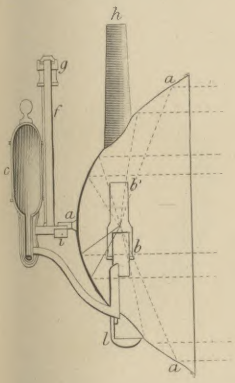
Reflector and Lamp
with sliding apparatus.
Back view.

Fig. 9.



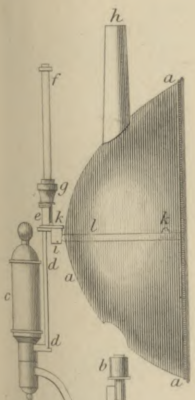
arabolic Reflector and Lamp
th sliding apparatus. — Section.

Fig. 8.



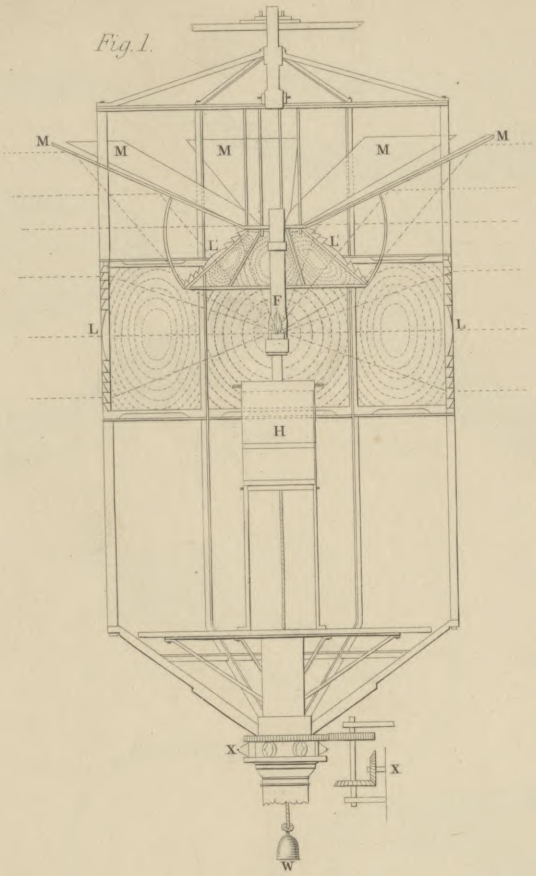
Reflector and Lamp.
Side view.

Fig. 7.



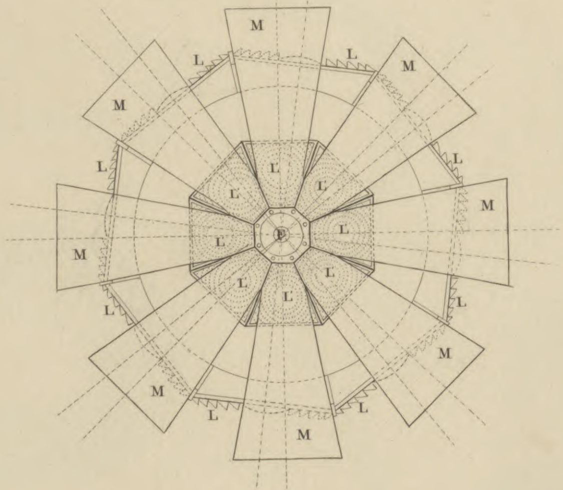
Revolving dioptric light of first order.
Section.

Fig. 1.



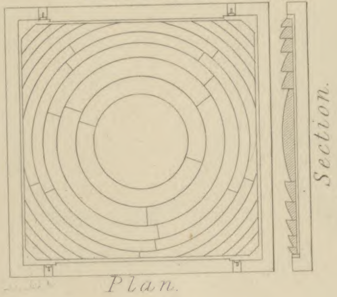
Plan.

Fig. 2.



Annular Lens.

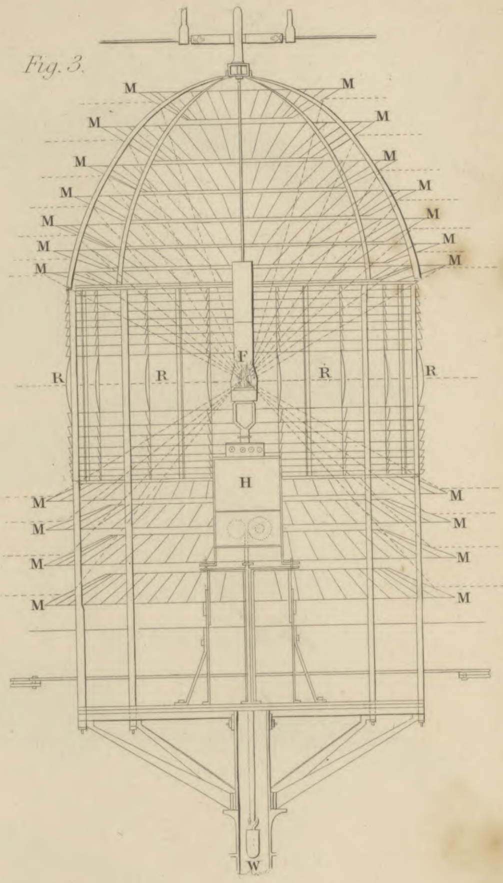
Fig. 6.



Plan.

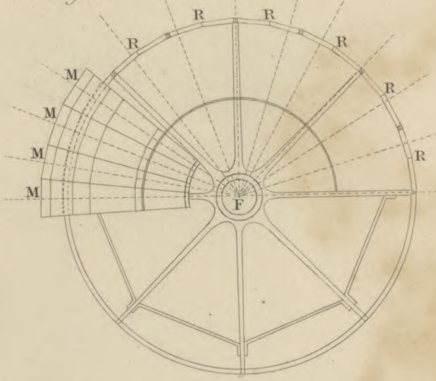
Fixed dioptric light of first order with mirrors.
Section.

Fig. 3.



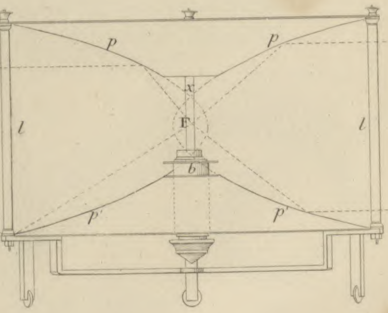
Plan.

Fig. 4.



Bordier Marcet's Reflector.

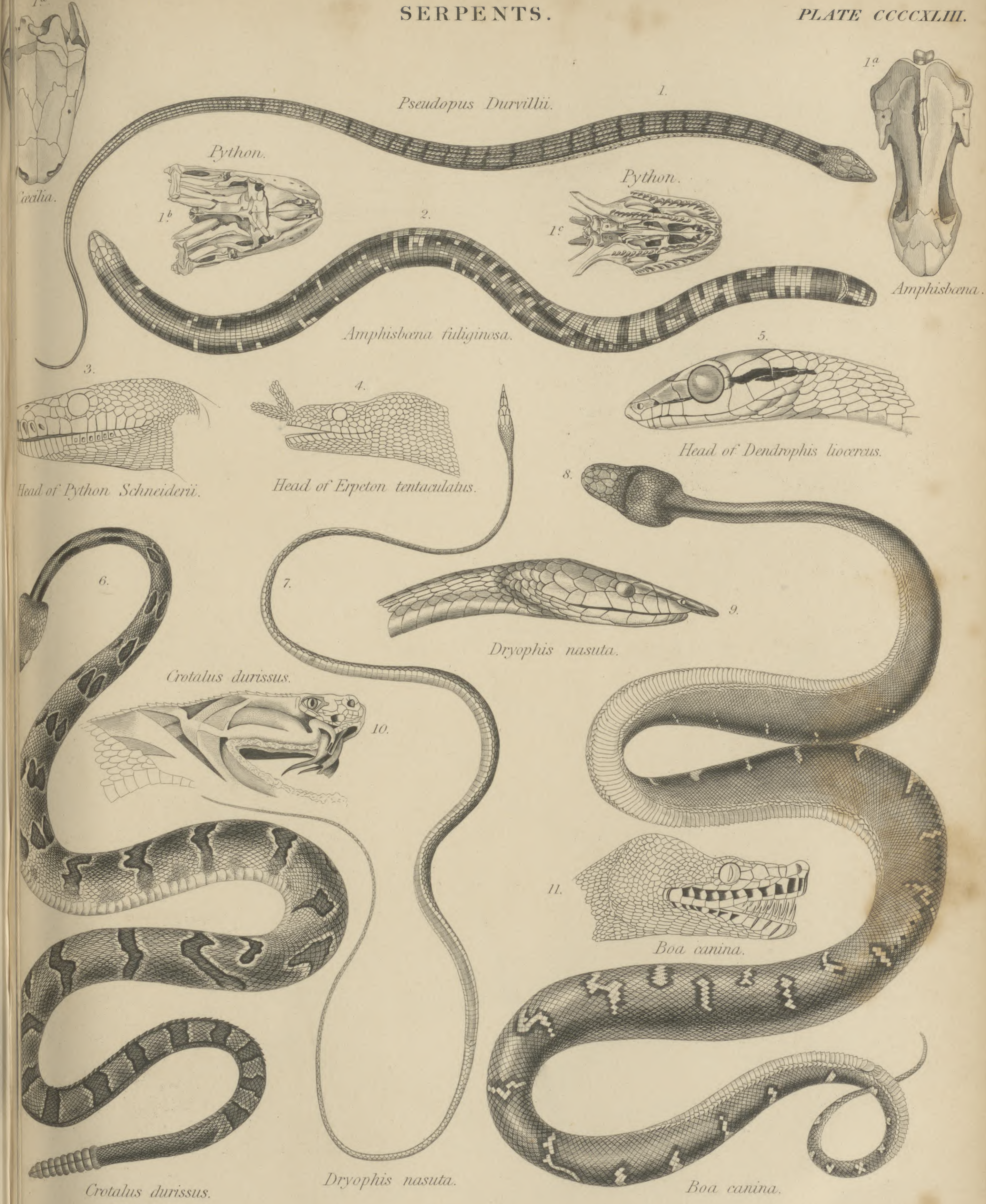
Fig. 5.



James Andrews, Delt.

Geo. Aikman, Sculpt.

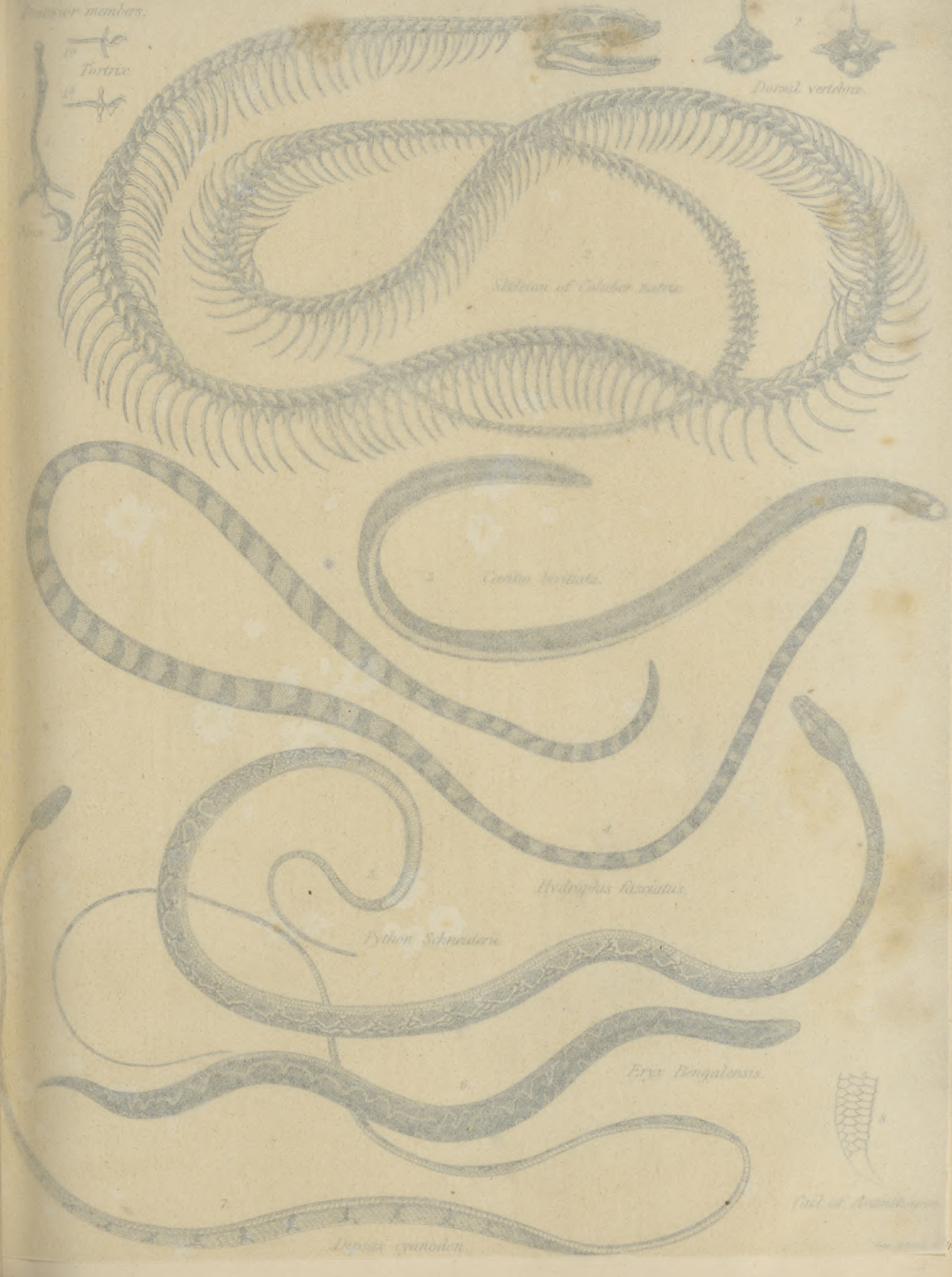
SERPENTS. PLATE CCCCXLIII.



Geo. Aikman Sculp.t

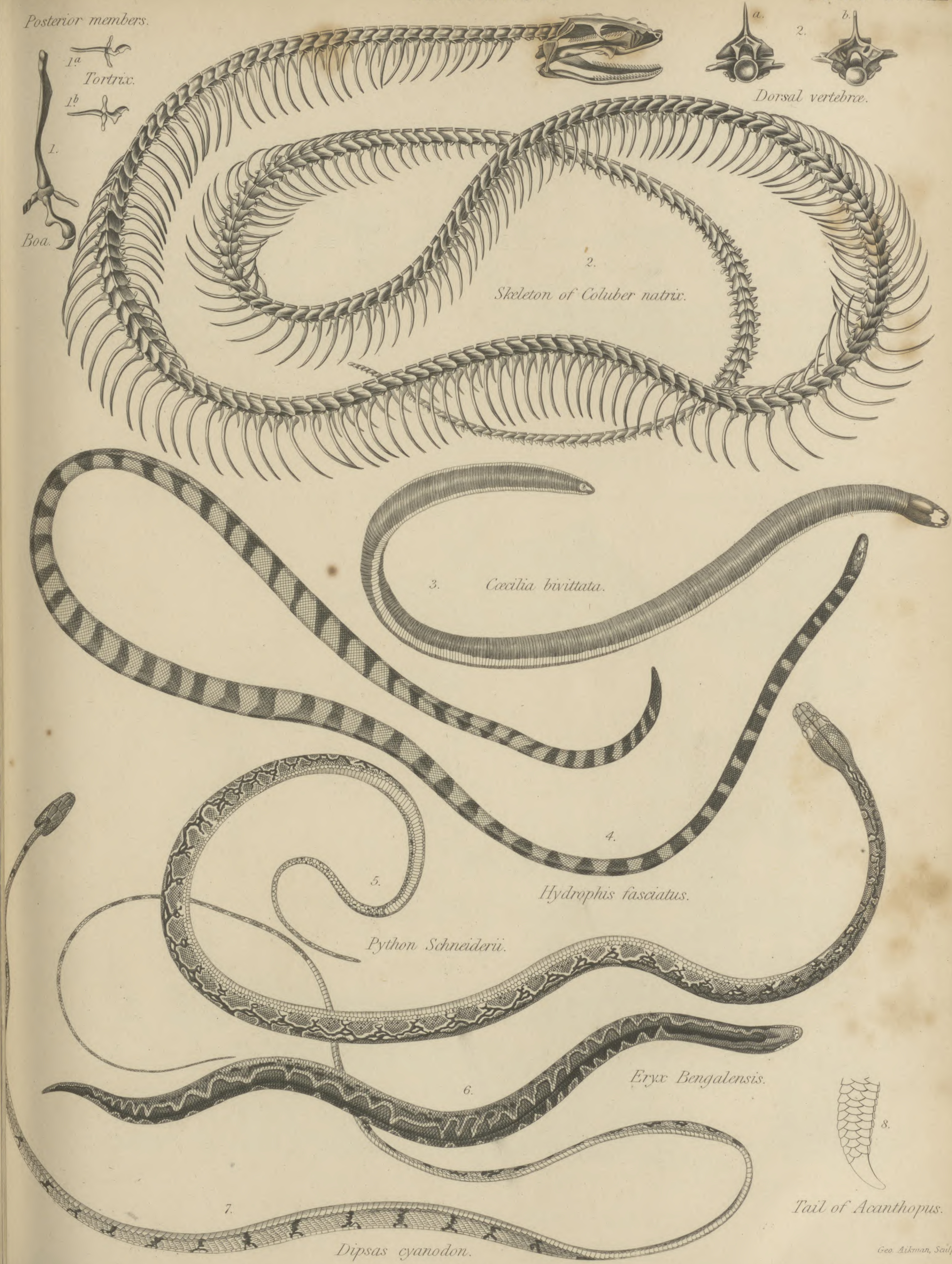
SERPENTS.

PLATE CCCCXIV.

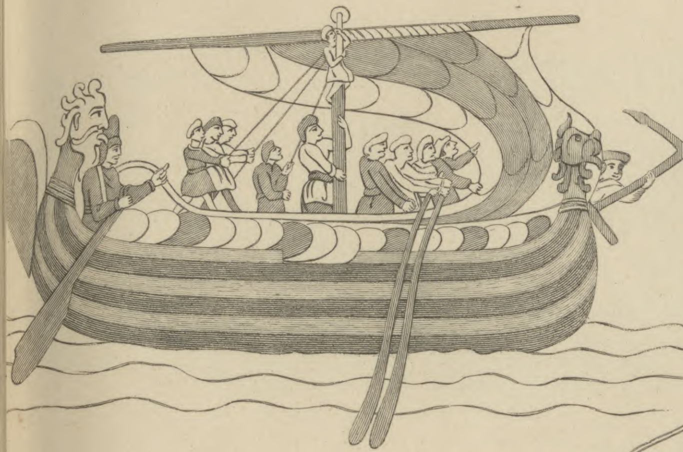


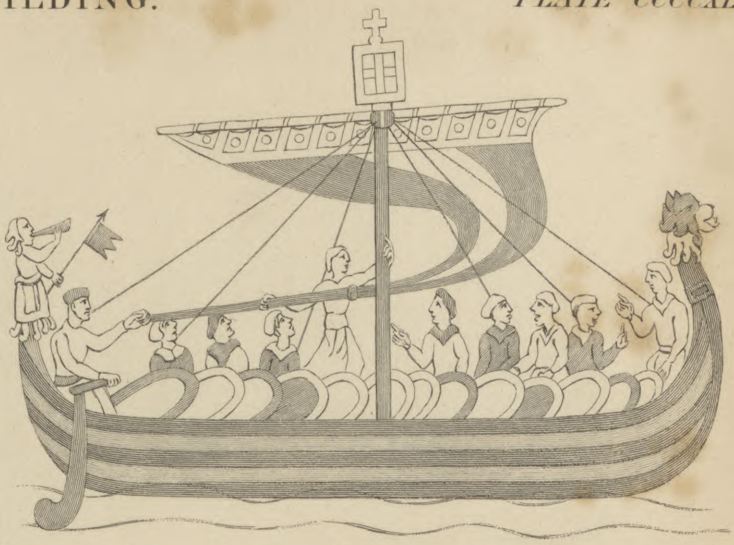
SERPENTS.

PLATE CCCCXLIV.



Geo. Aikman, Sculp^t.

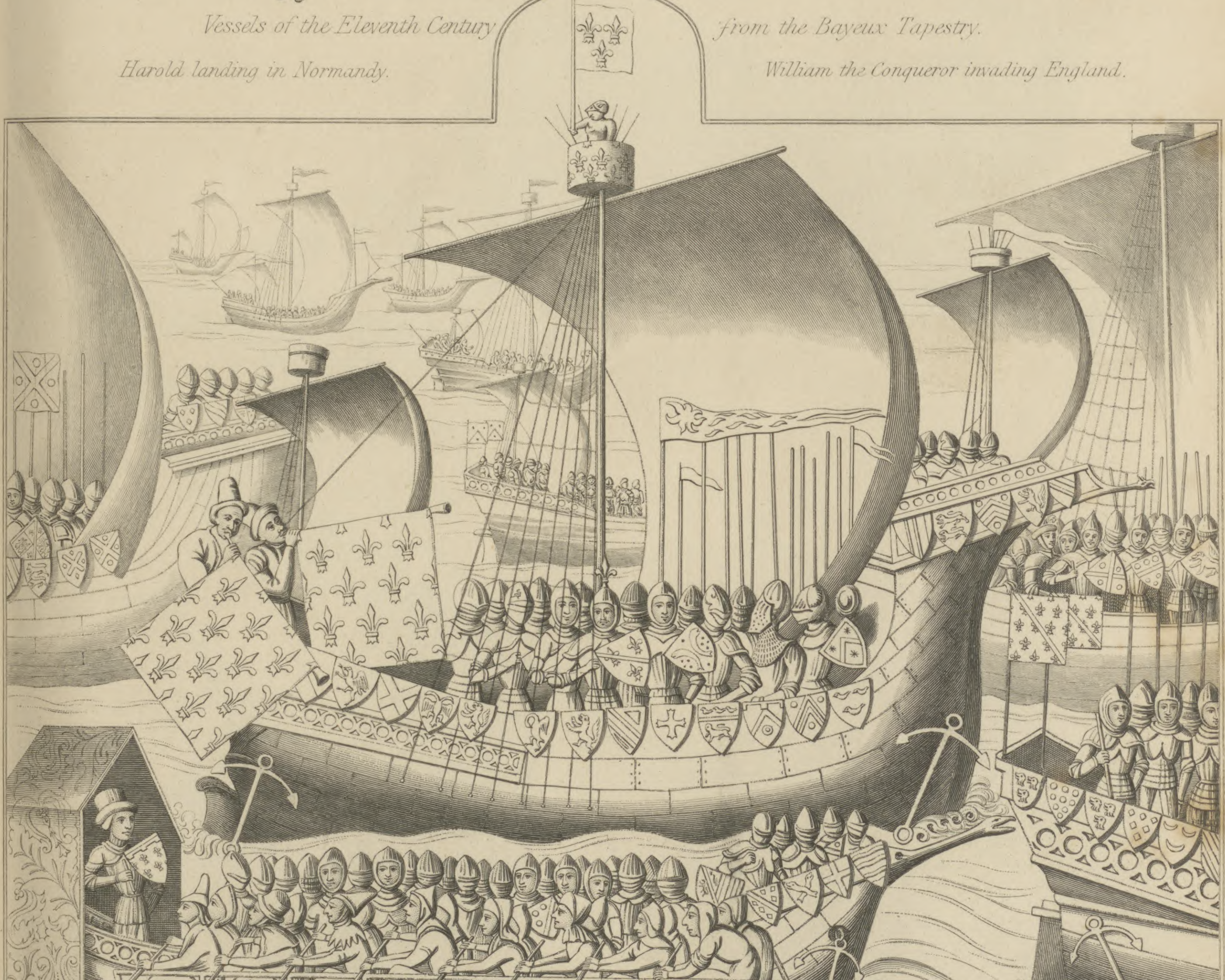




Vessels of the Eleventh Century from the Bayeux Tapestry.

Harold landing in Normandy.

William the Conqueror invading England.



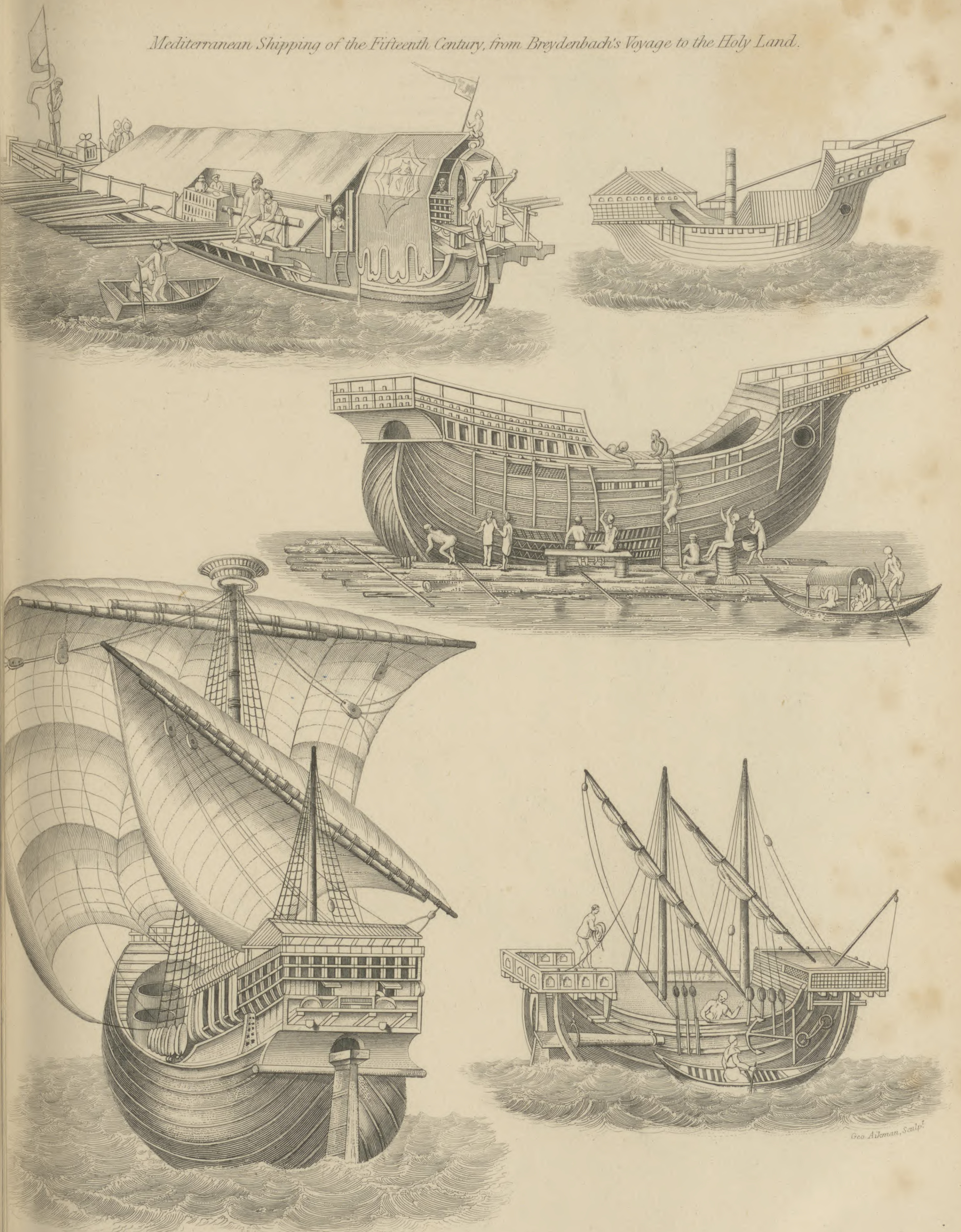
Geo. Aikman, Sculp^t

Norman Shipping of the Fourteenth Century,_ from Froissart.

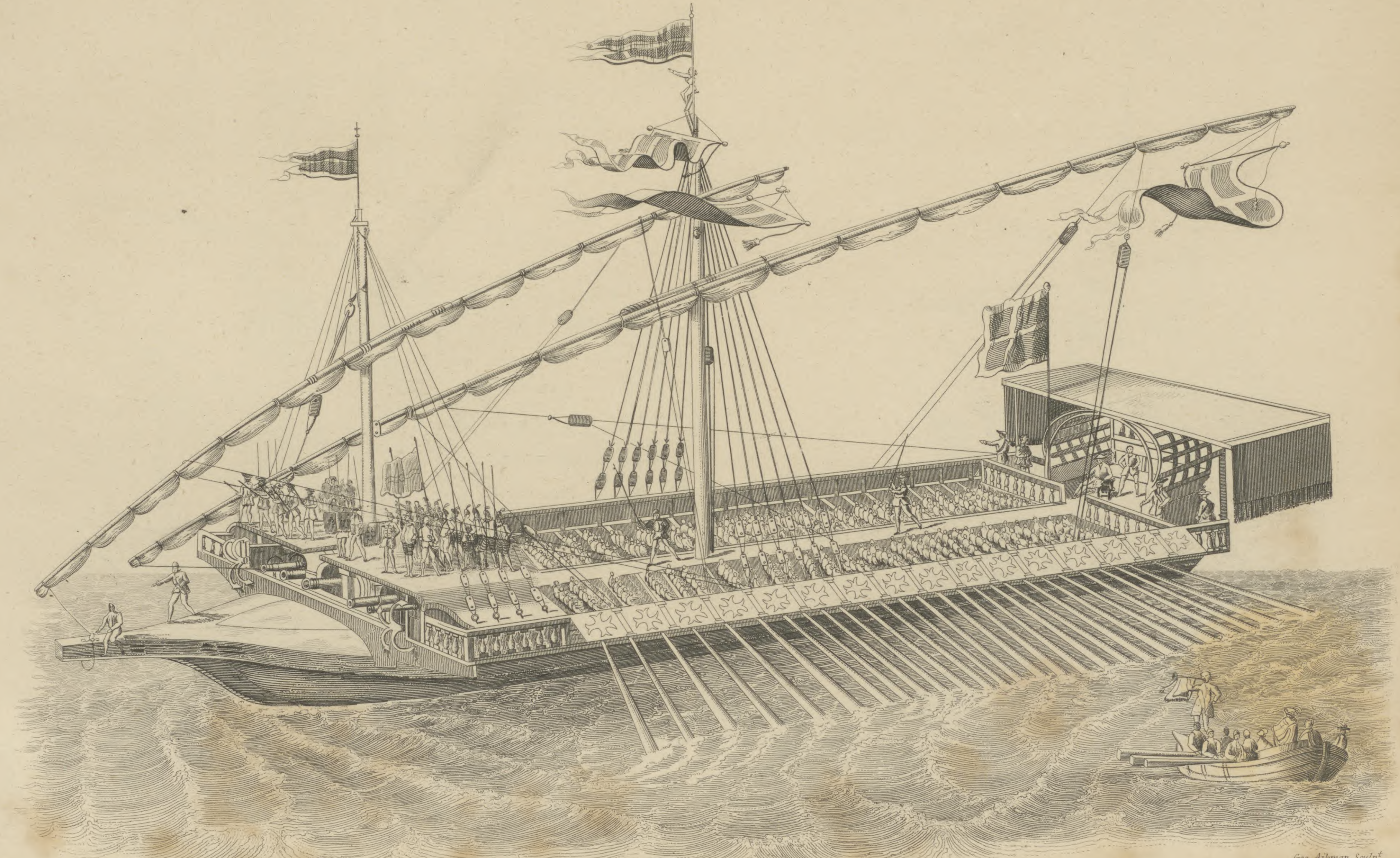
SHIP-BUILDING.

PLATE CCCCXLVI.

Mediterranean Shipping of the Fifteenth Century, from Breydenbach's Voyage to the Holy Land.

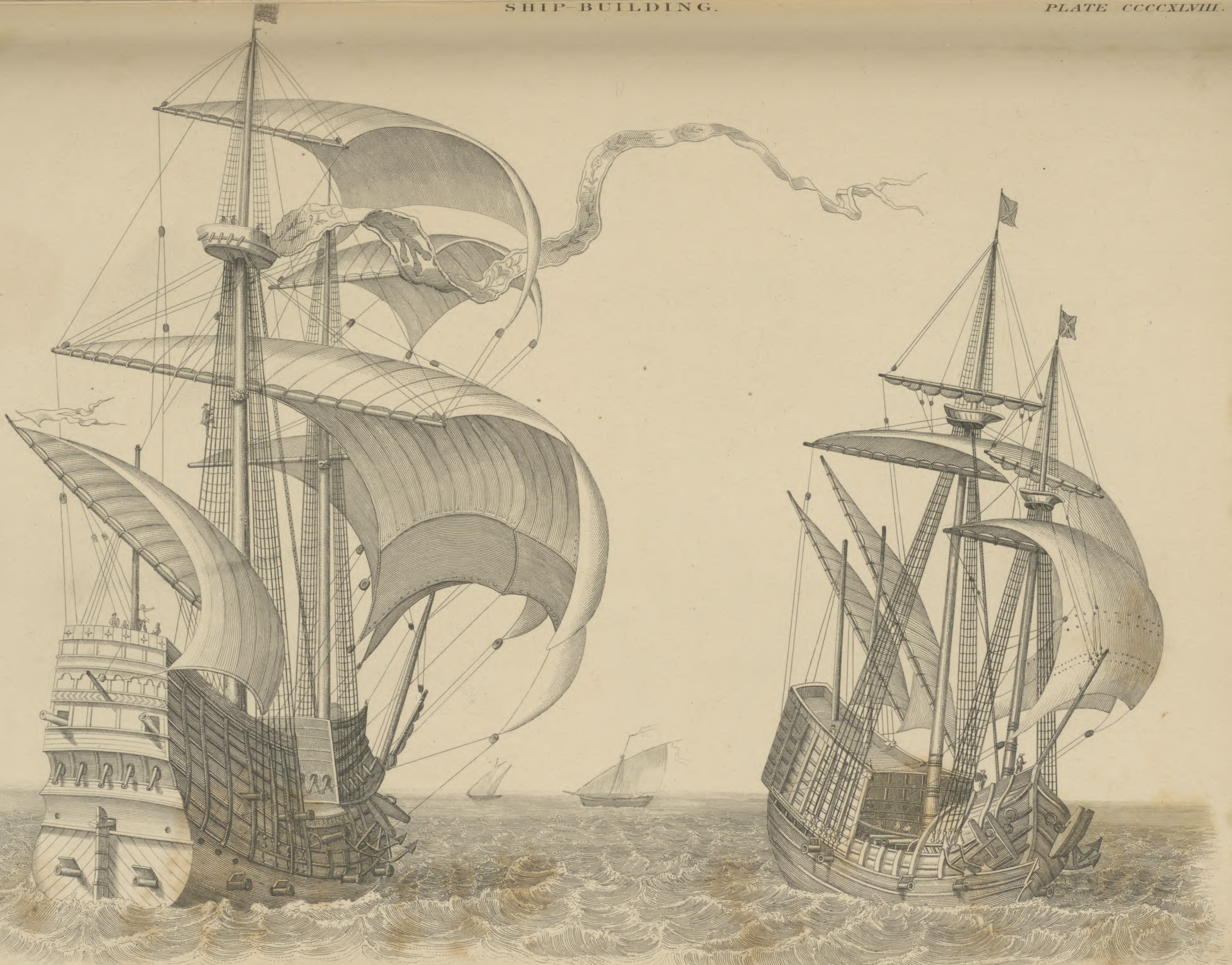


Geo. Aikman, Sculpt.



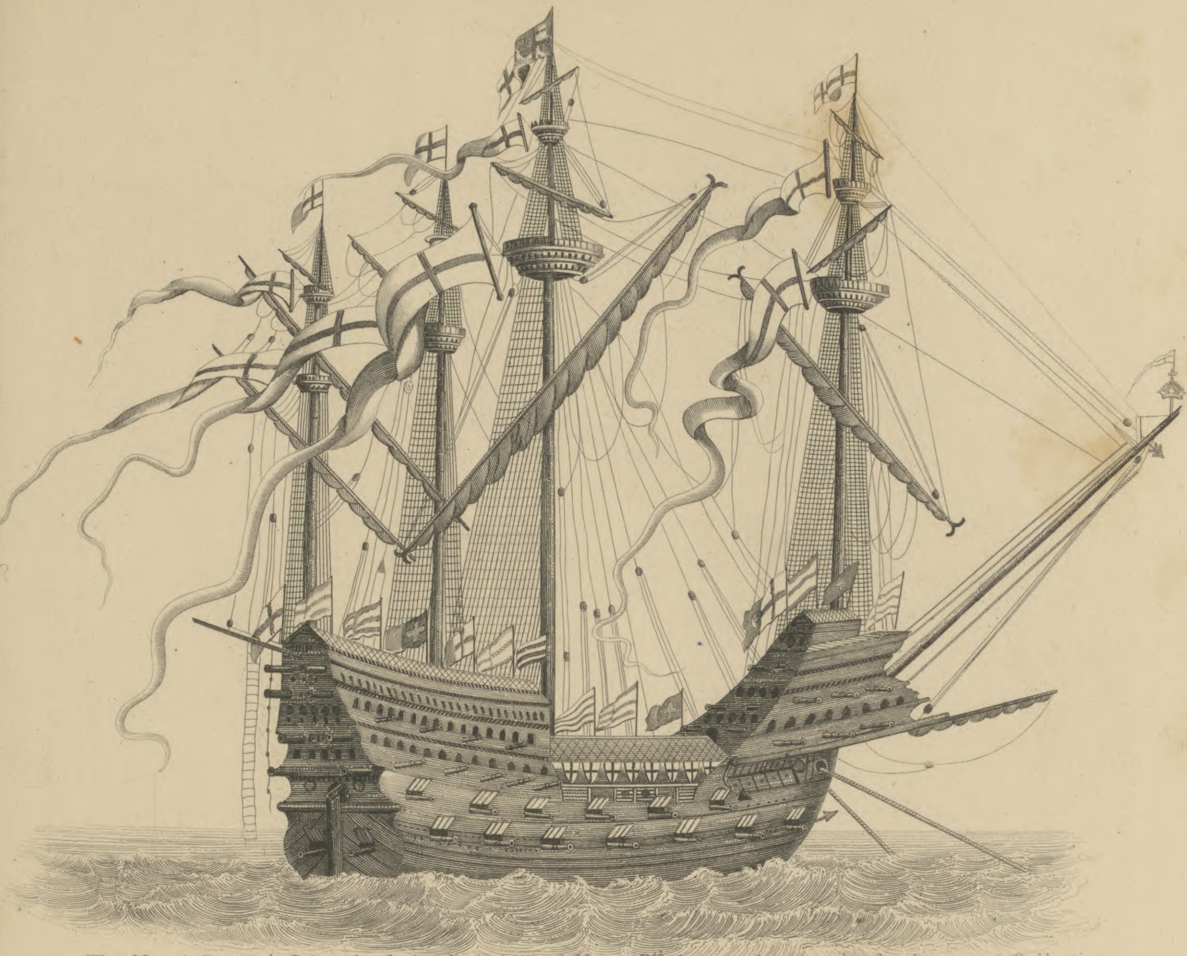
Geo. Aikman, Sculpt.

Galley of the Seventeenth Century, from Van Yk.

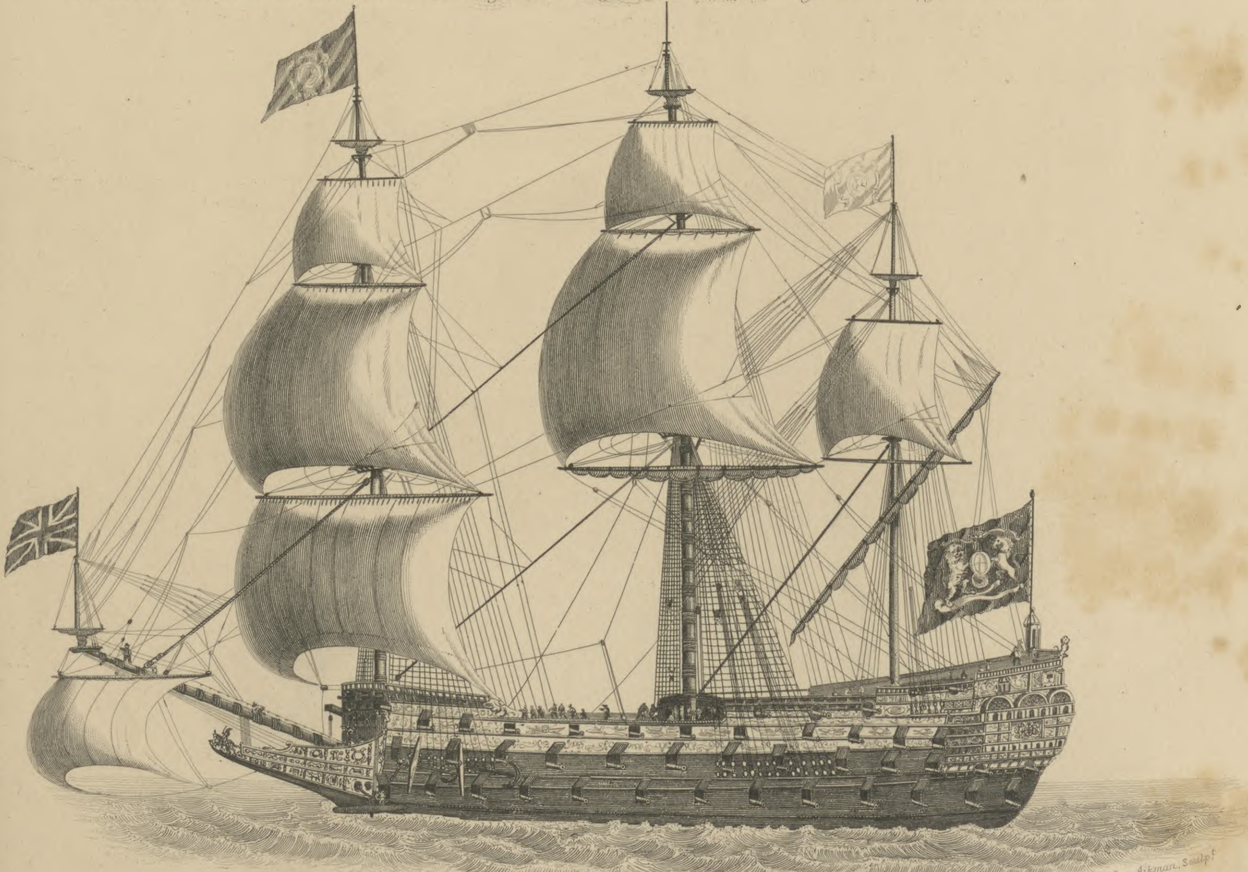


Carracks, Galleons, or "Tall Shippes," of the Seventeenth Century, from Van Yk.

Geo. Aikman, Sculpt.



The Henri Grace à Dieu, built in the reign of Henry 7th from a drawing in the Pepysian Collection.



Geo. Aikman, Sculpt.

The Sovereign of the Seas._built 1637. From a Painting by Vandevelde.

SHIP-BUILDI

DRAUGHT OF HER MAJESTY'S F

Dimensions.		
Length of Gun Deck	176 ft	4 ins.
Length of Keel for Tonnage	145 ..	$7\frac{5}{8}$.
Breadth extreme	47 ..	$10\frac{1}{2}$
Depth in Hold	14 ..	4
Burthen in Tons, 1775 No.		

Main Deck

Quarter Deck

& Fore cast

STERN.

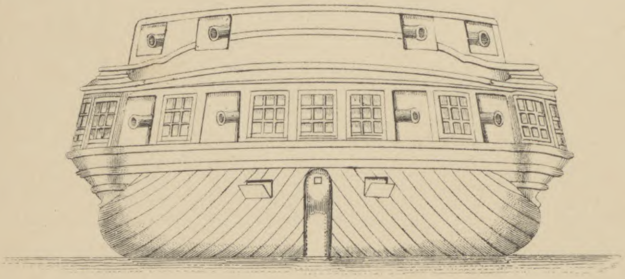


Fig. 25.

BODY PLAN.

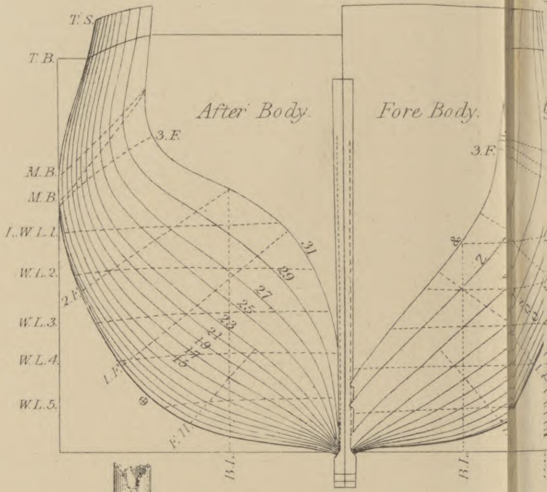


Fig. 24.

SHEER PL

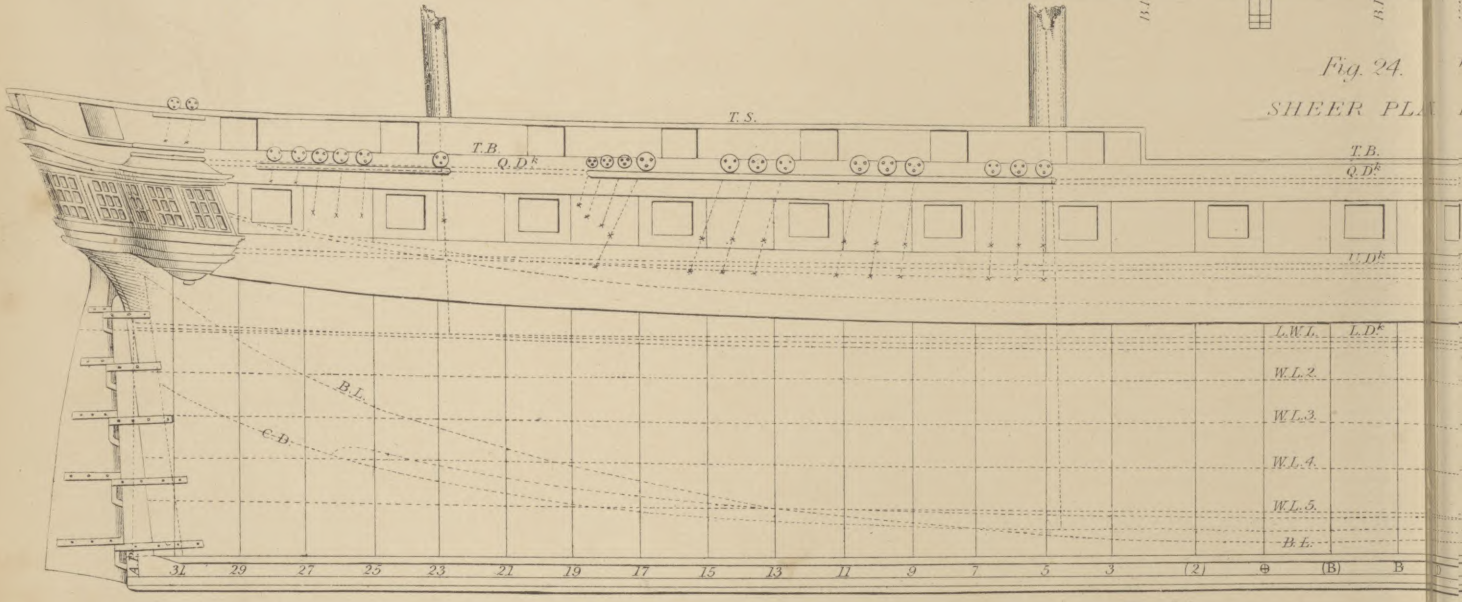
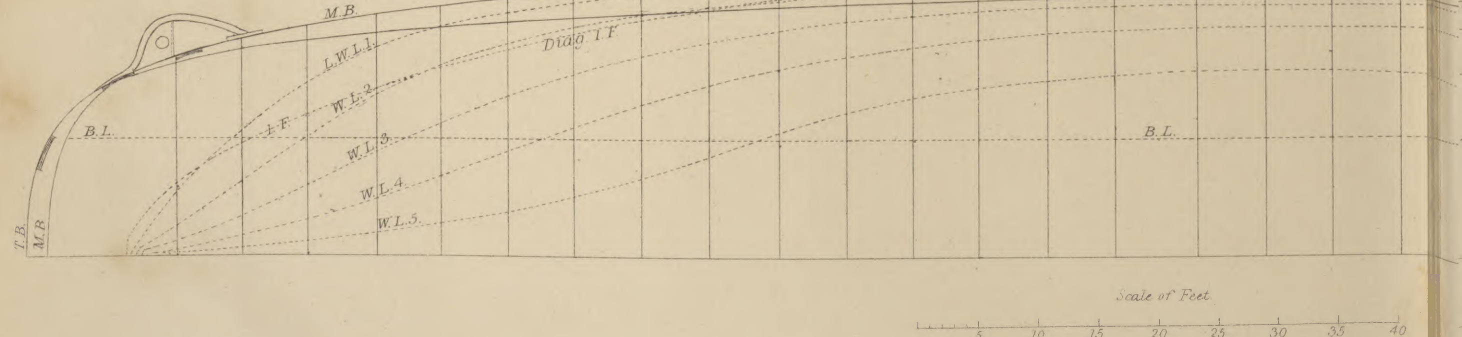


Fig. 26.

HALF BREADTH PLAN.

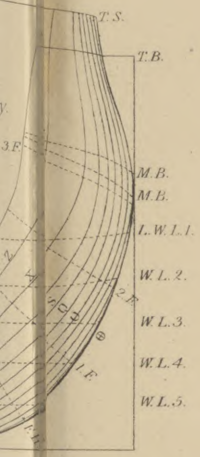


Scale of Feet.

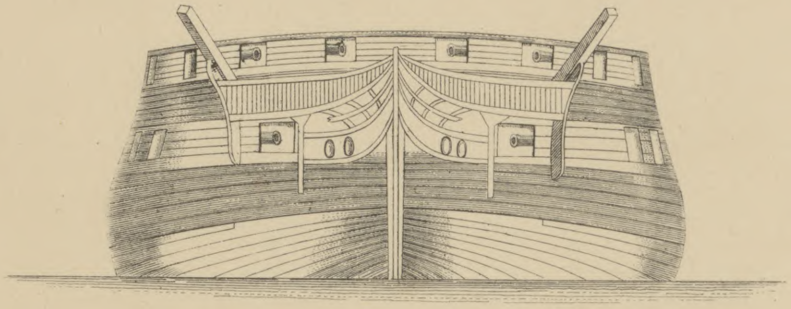
FR ATE VINDICTIVE.

rmament.

Deck Nº 8 inch. 65 Cwt. 9 ft. 0 ins. in Length
 .. 32 prs. 56 .. 9 .. 6 . ..
Deck
castle .. 32 prs. 45 .. 8 .. 6 .

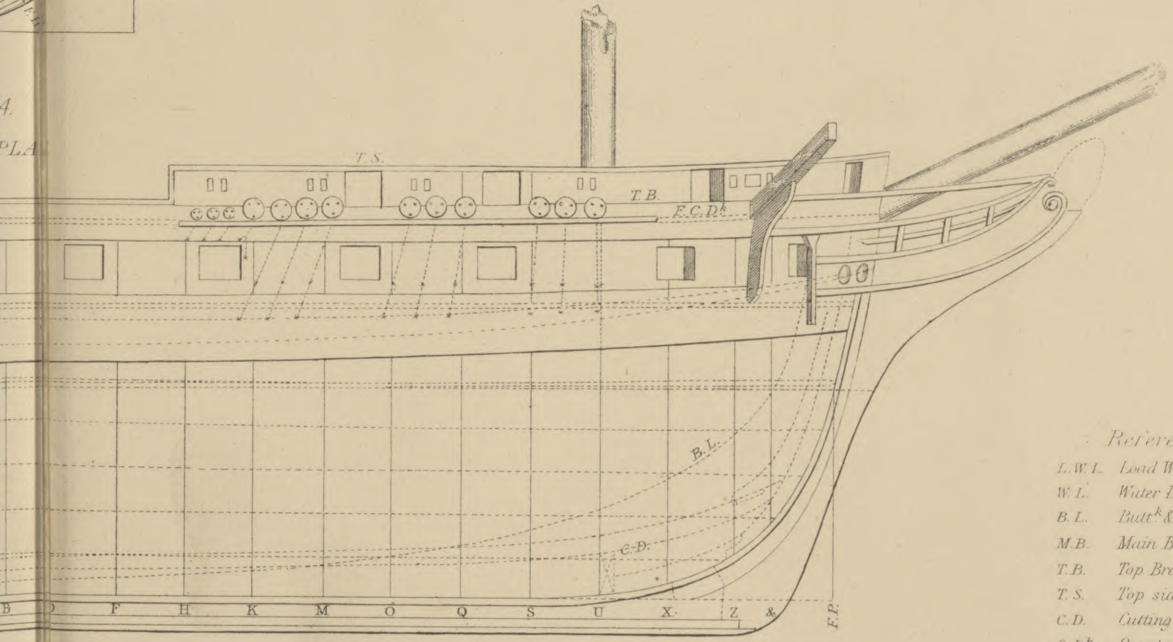


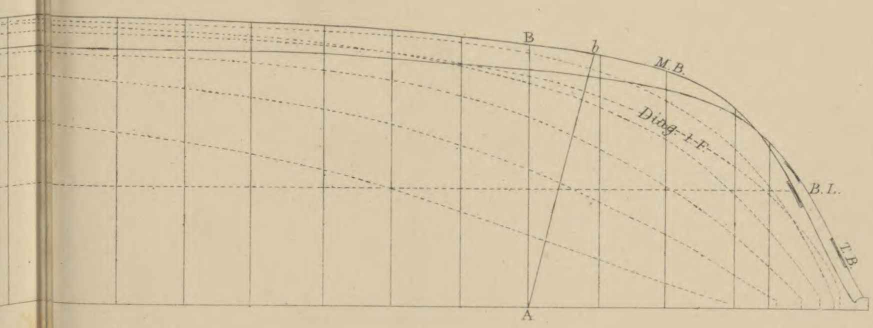
B O W.



4.

PLA





References.

L.W.L.	Load Water Line.
W.L.	Water Lines.
B.L.	Buttk. & Bow Lines.
M.B.	Main Breadth.
T.B.	Top Breadth.
T.S.	Top side.
C.D.	Cutting down.
Q.Dk.	Quarter Deck.
F.C.Dk.	Fore castle Dº.
U.Dk.	Upper Dº.
L.Dk.	Lower Dº.
F.P.	Fore Perpendicular.
A.P.	After Dº.
F.H.	Floor Head.
1.F.	1st. Futtock Dº.
2.F.	2nd. Futtk. Dº.
3.F.	3rd. Futtk. Dº.

40

Geo. Aikman Sculpt.

LAYING OFF

Fig. 28.

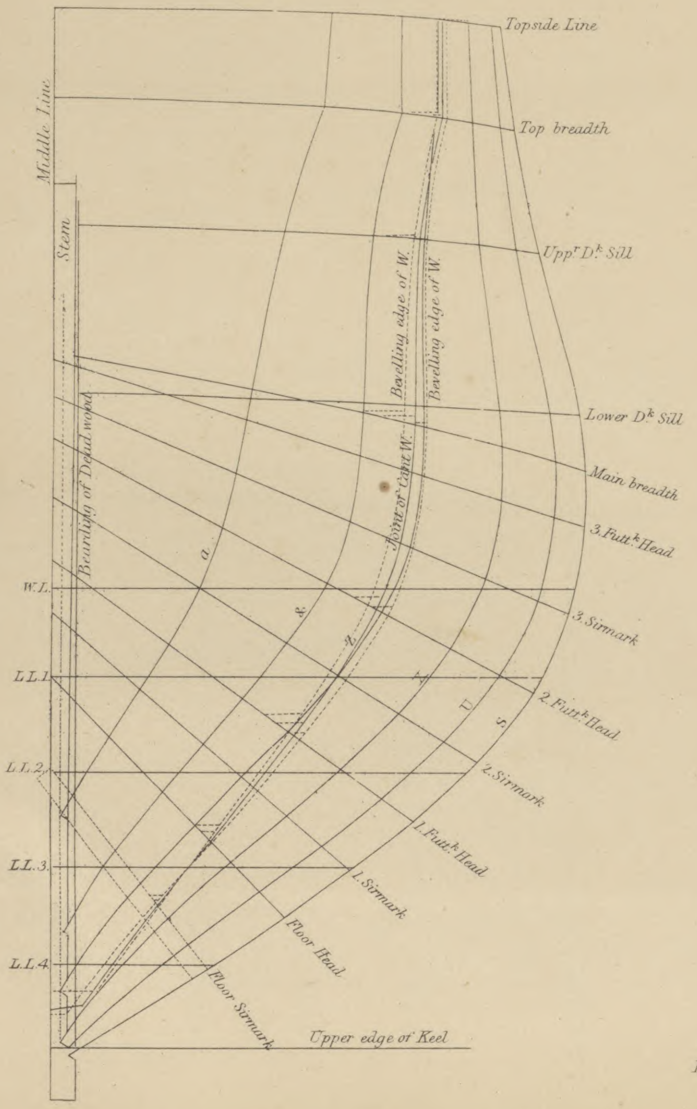
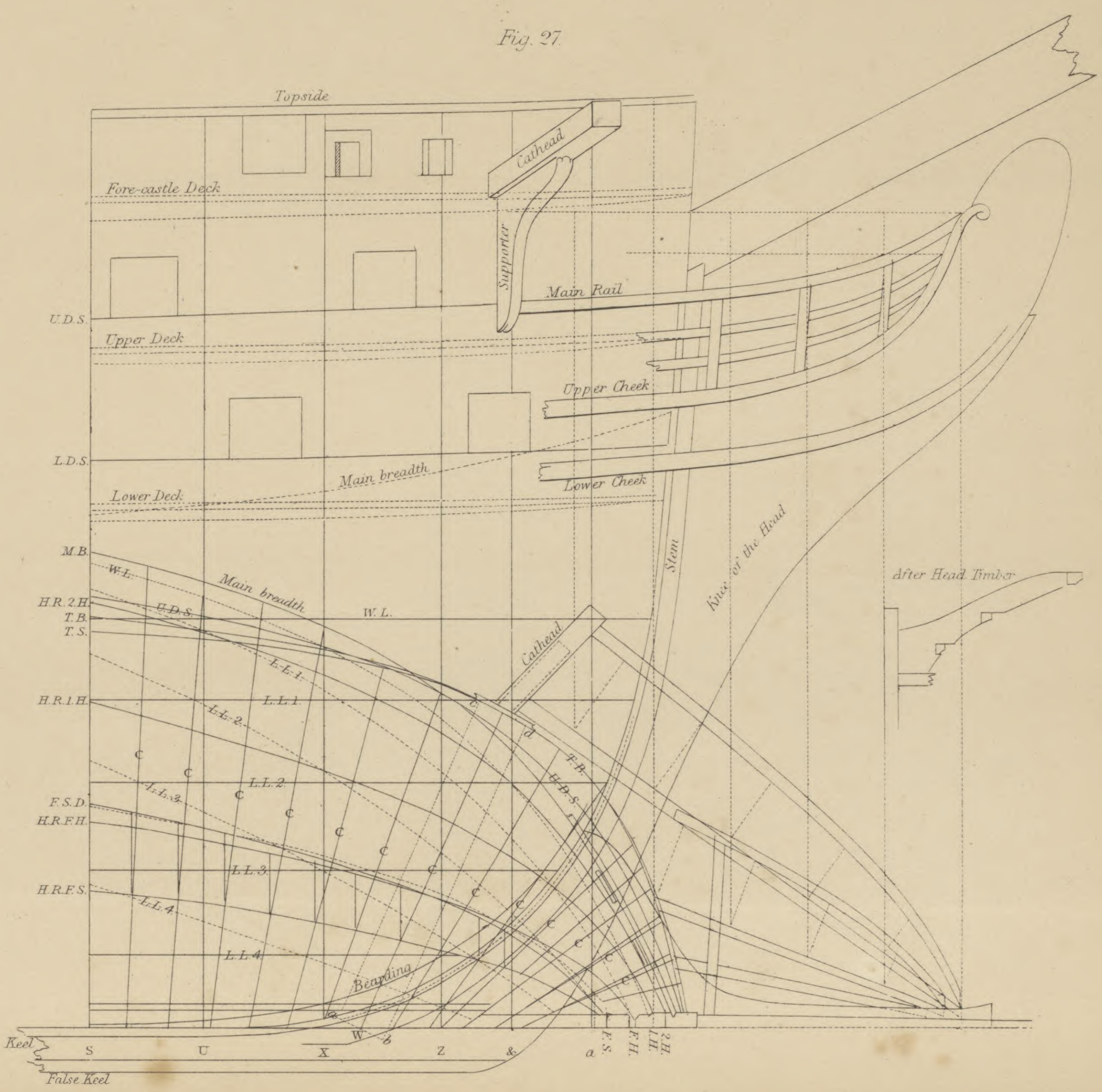


Fig. 27.



LAYING OFF.

Fig. 30.

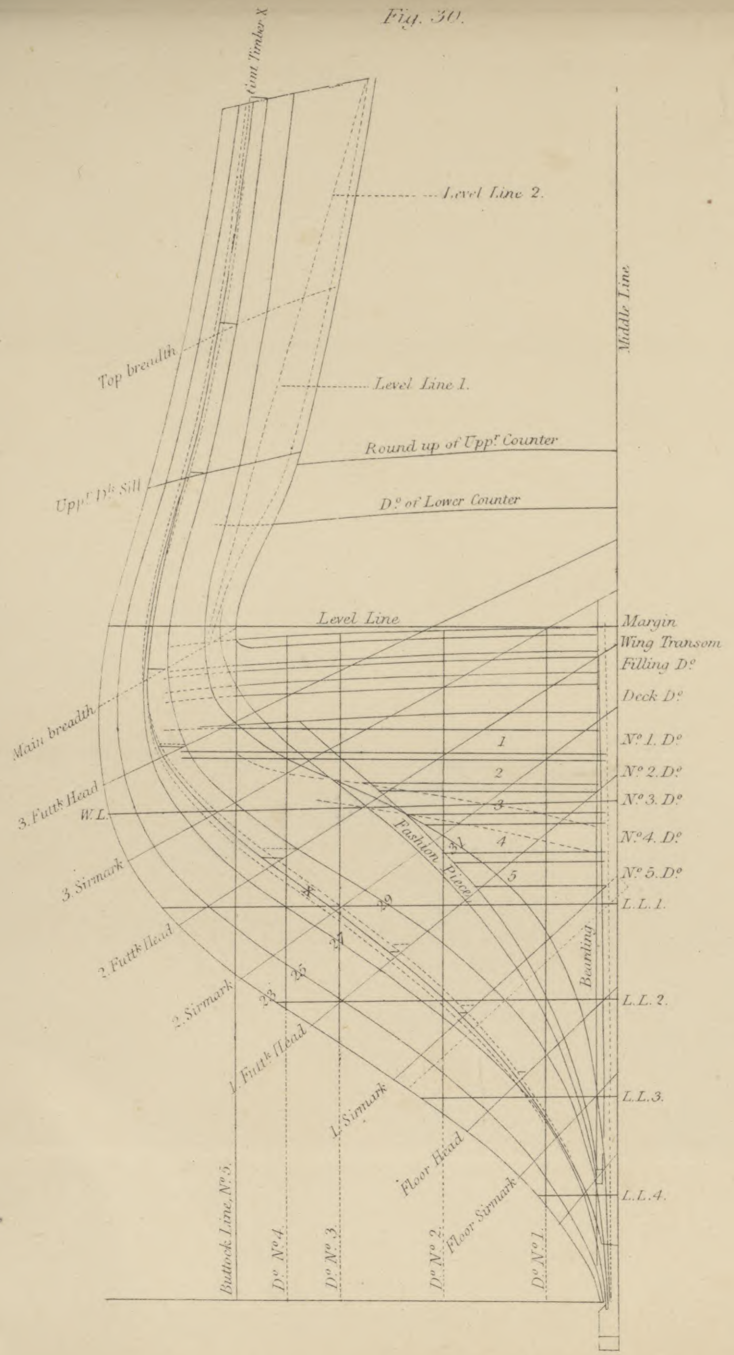
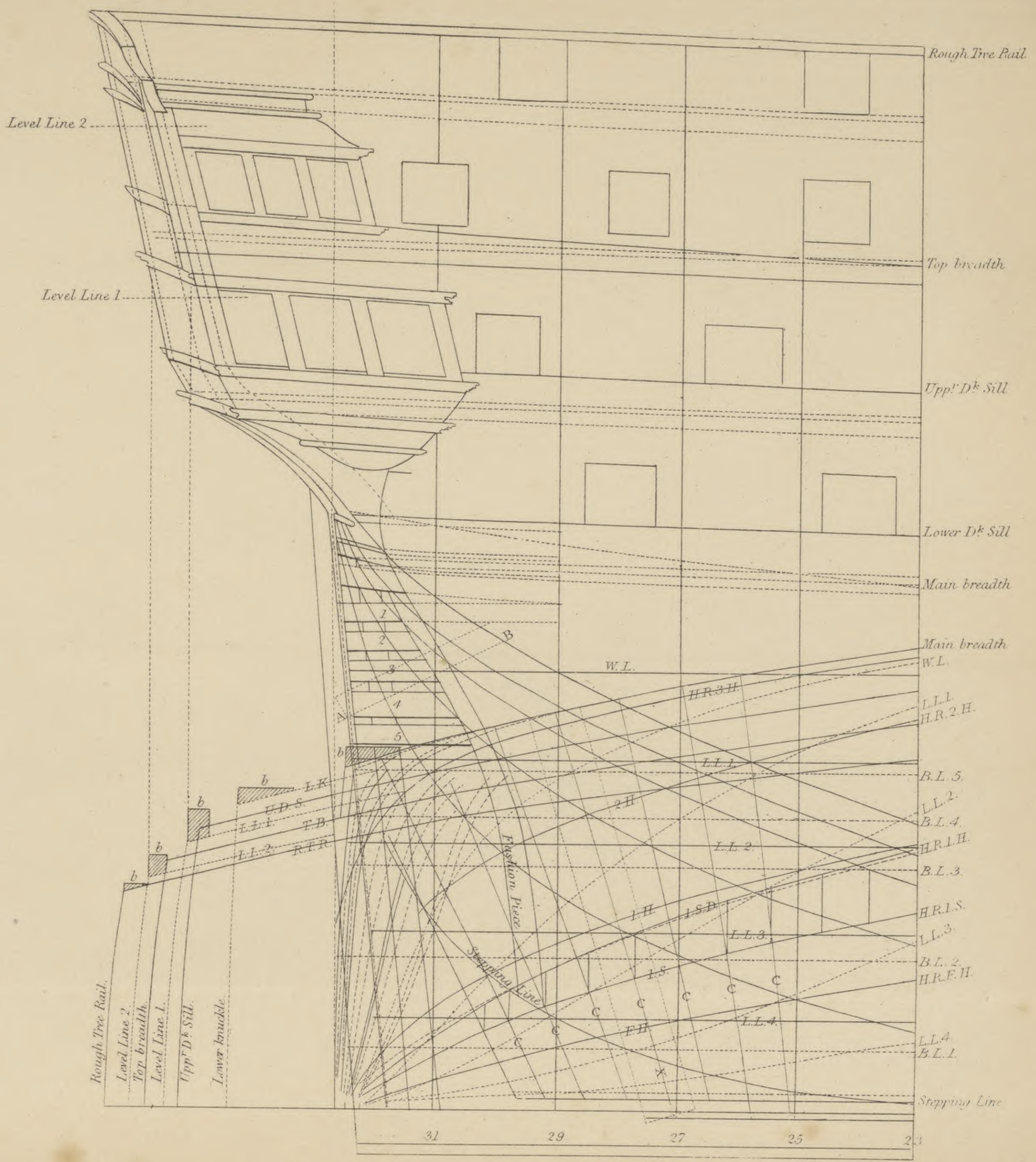


Fig. 29.



Geo. Aikman Sculpt

[illegible]

Fig. 32.

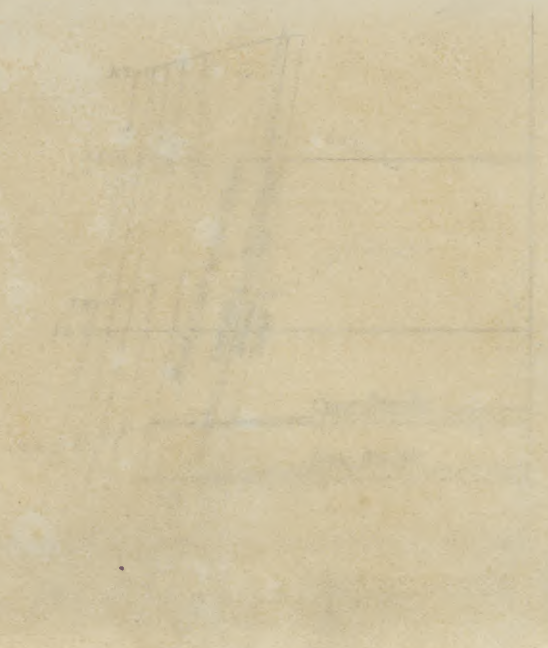
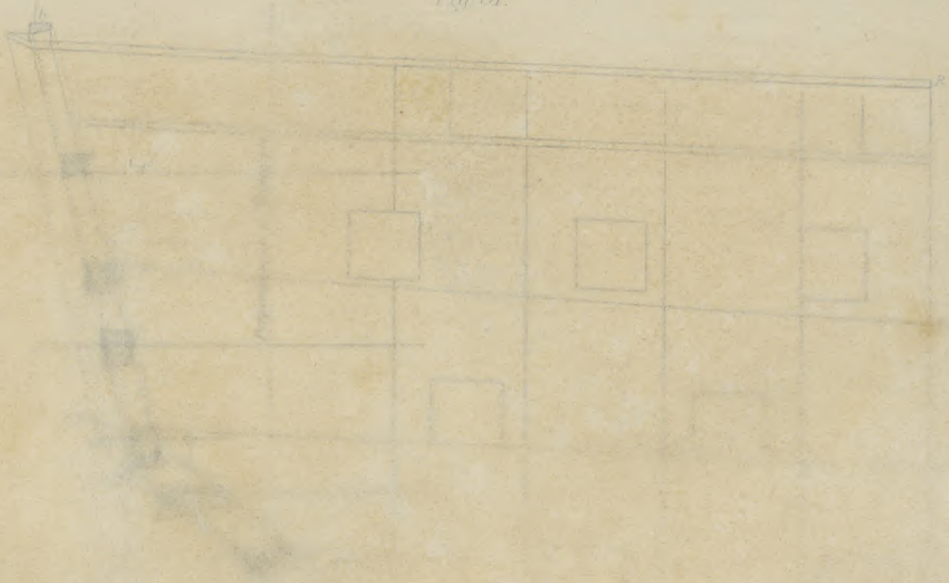


Fig. 31.



LAYING OFF.

Fig. 33.

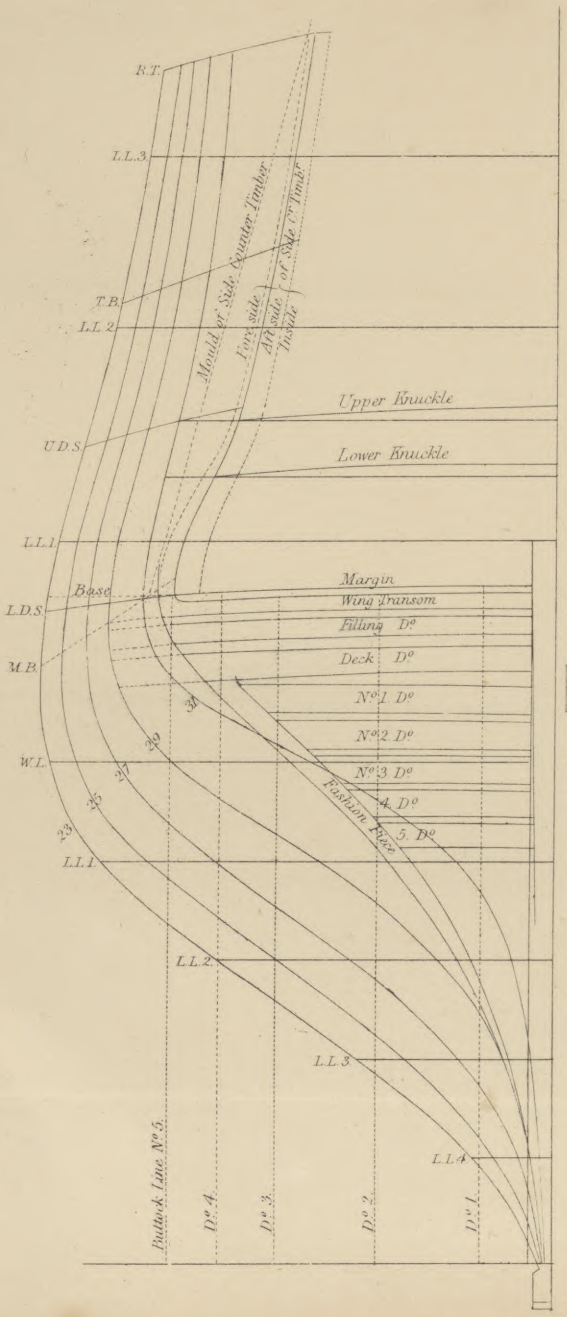
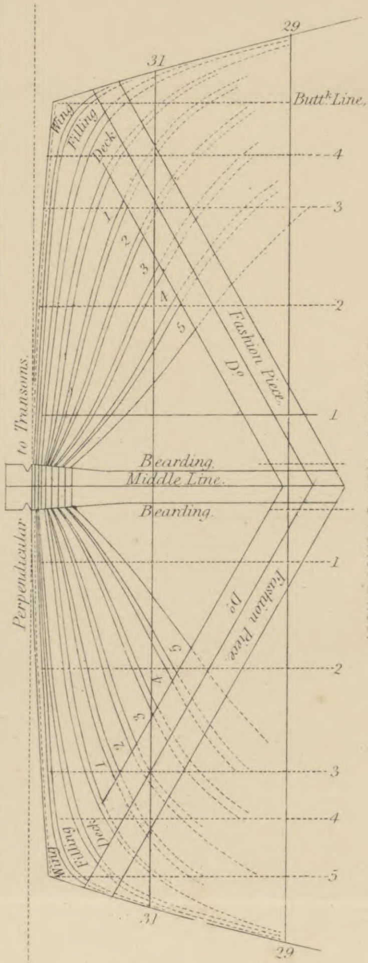
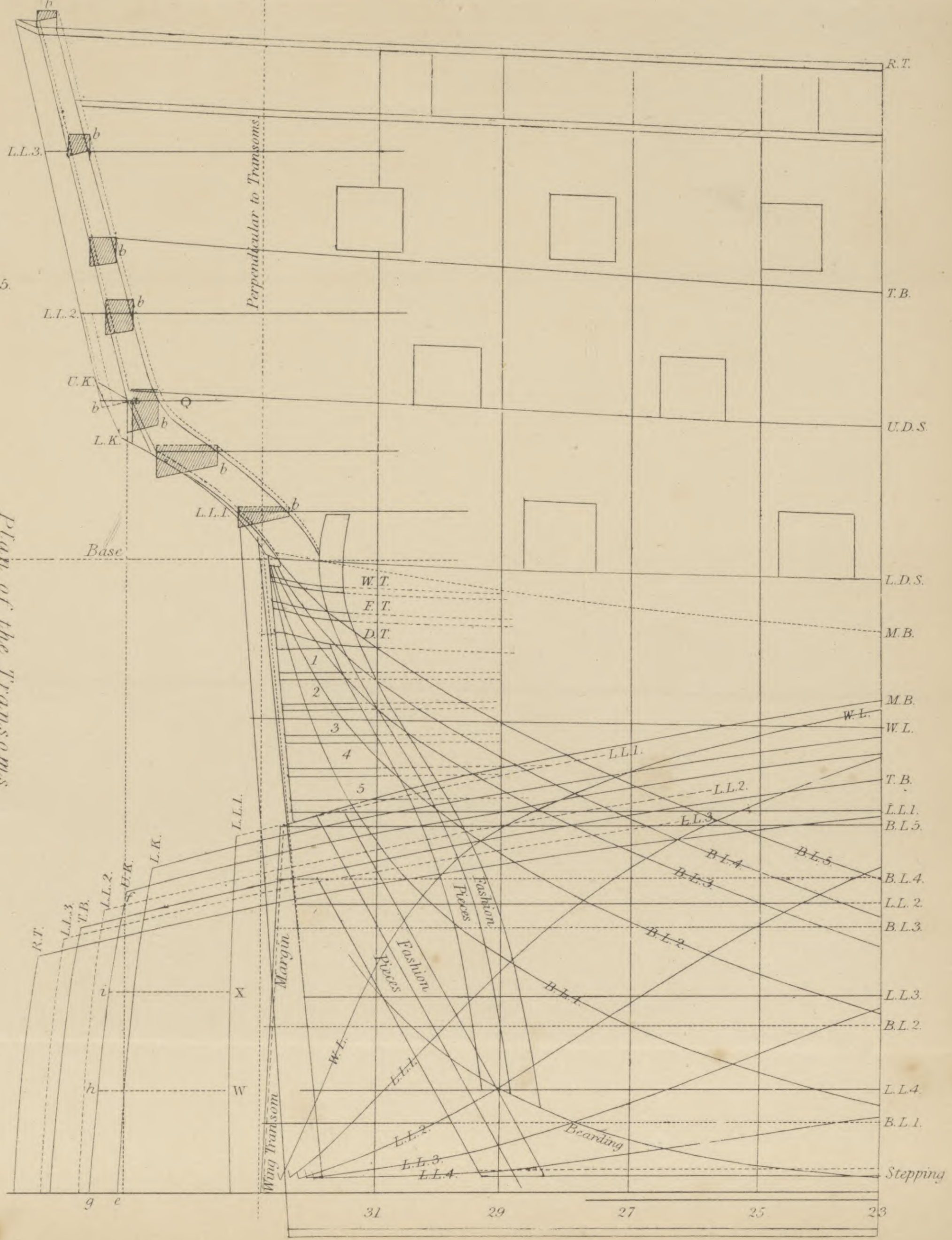


Fig. 32.



Plan of the Transoms.

Fig. 31.

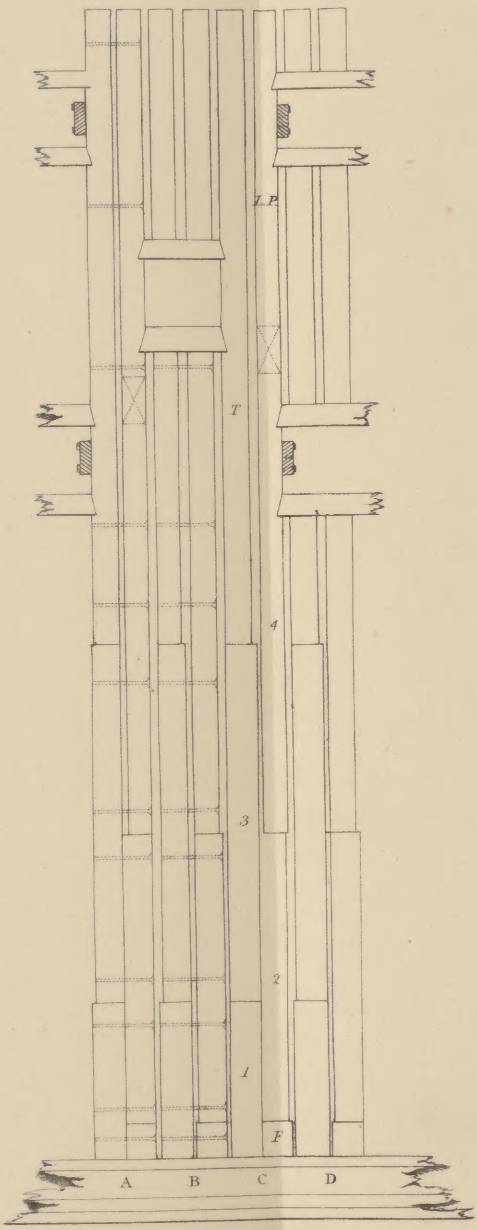


Geo. Aikman Sculp^t.

SHIP-BUILD N

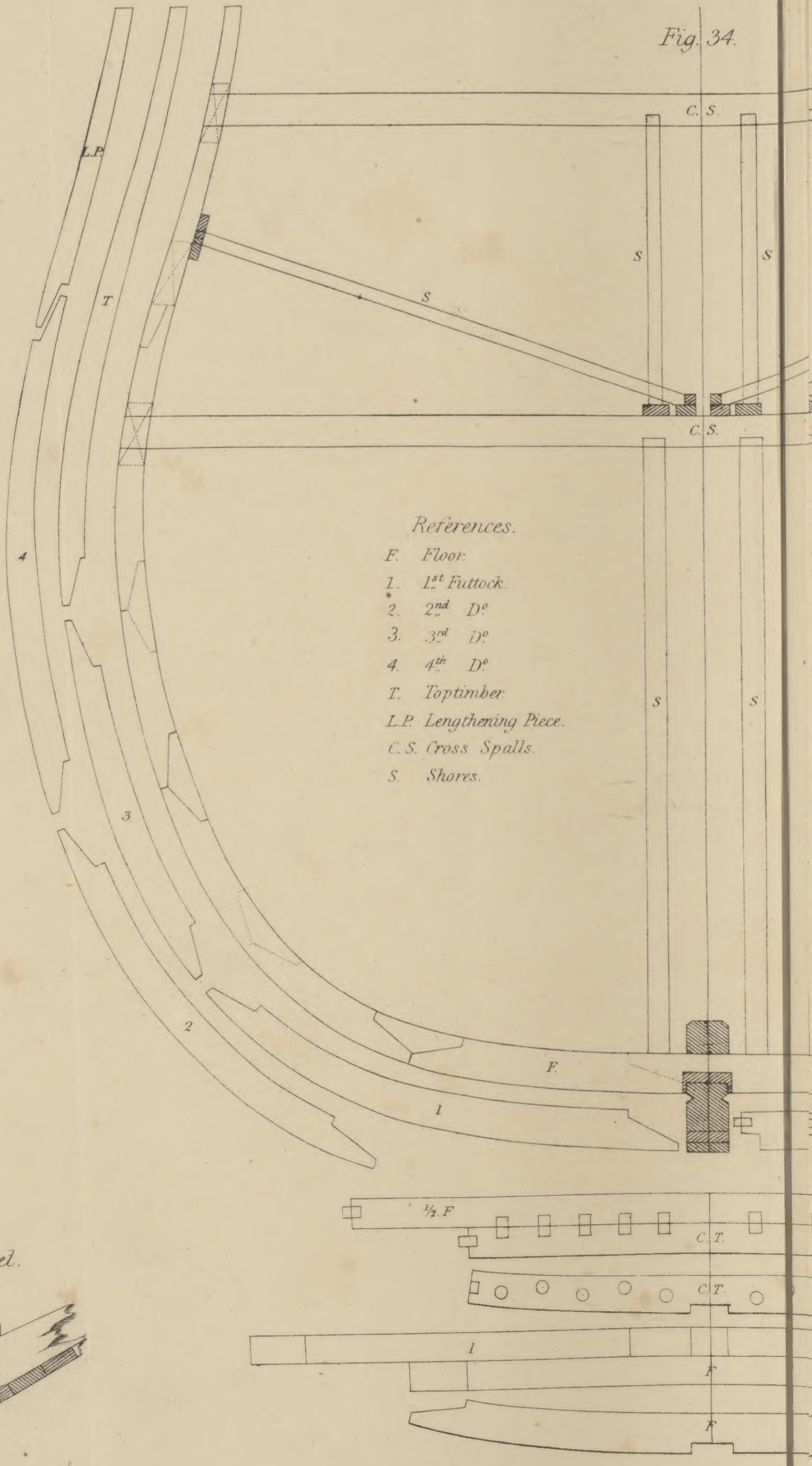
Midship Sections, showing Plans

Fig. 35.



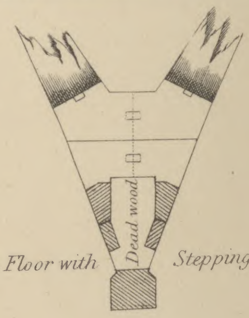
Old Plan.

Fig. 34.



References.

F. Floor.
1. 1st Futtock.
2. 2nd Do.
3. 3rd Do.
4. 4th Do.
T. Toptimber.
L.P. Lengthening Piece.
C.S. Cross Spalls.
S. Shores.



Made Floor with Stepping Pieces.

Fig. 37.

Lang's Safety Keel.

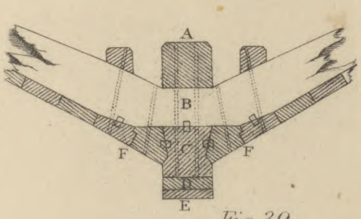


Fig. 39.

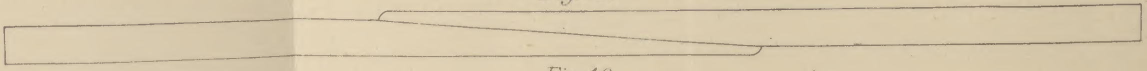
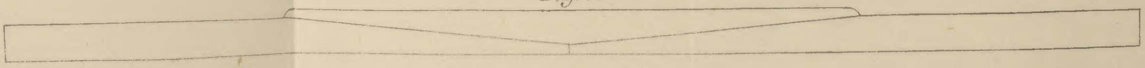
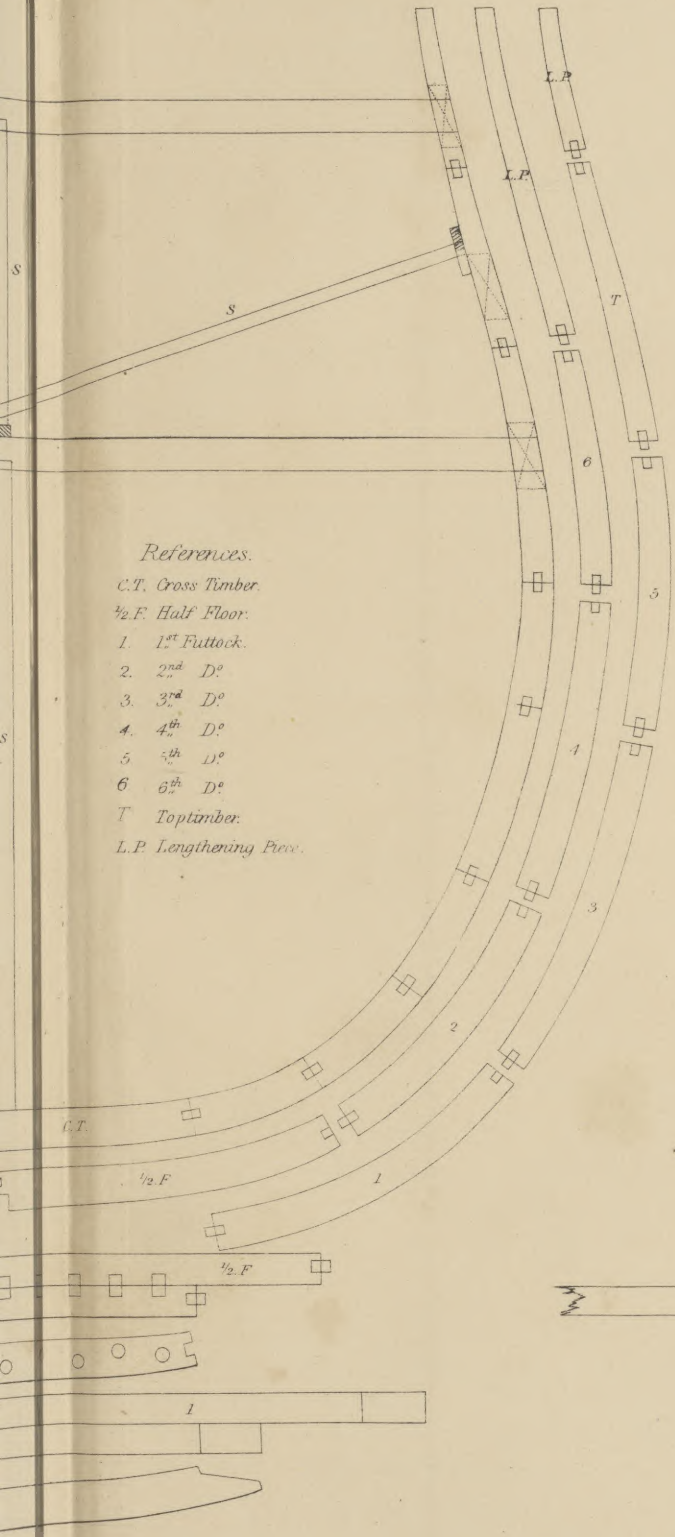


Fig. 40.



ns & Timbering Ships.

Modern Plan.



References.

C.T. Cross Timber.
½.F. Half Floor.
1. 1st Futtock.
2. 2nd Do.
3. 3rd Do.
4. 4th Do.
5. 5th Do.
6. 6th Do.
T. Toptimber.
L.P. Lengthening Piece.

Fig. 36.

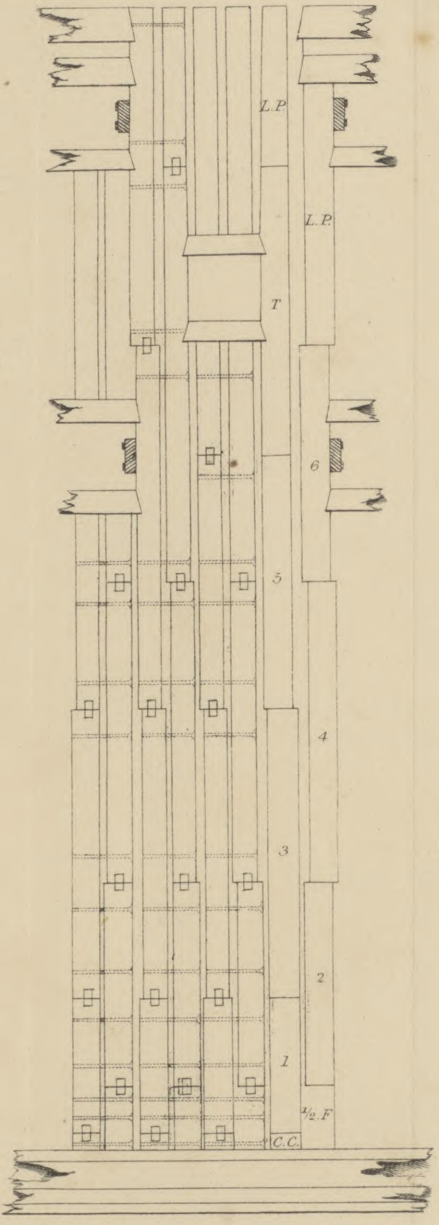
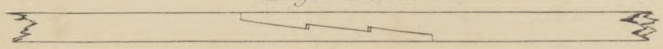
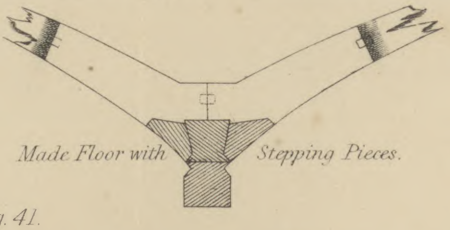


Fig. 38.

Edye's Beam.





Made Floor with Stepping Pieces.

Fig. 41.

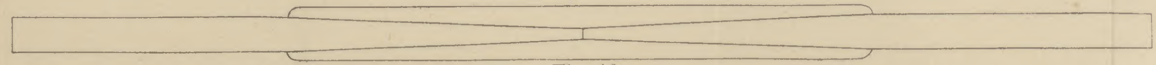
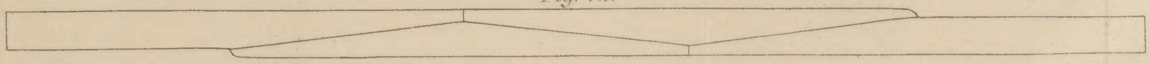
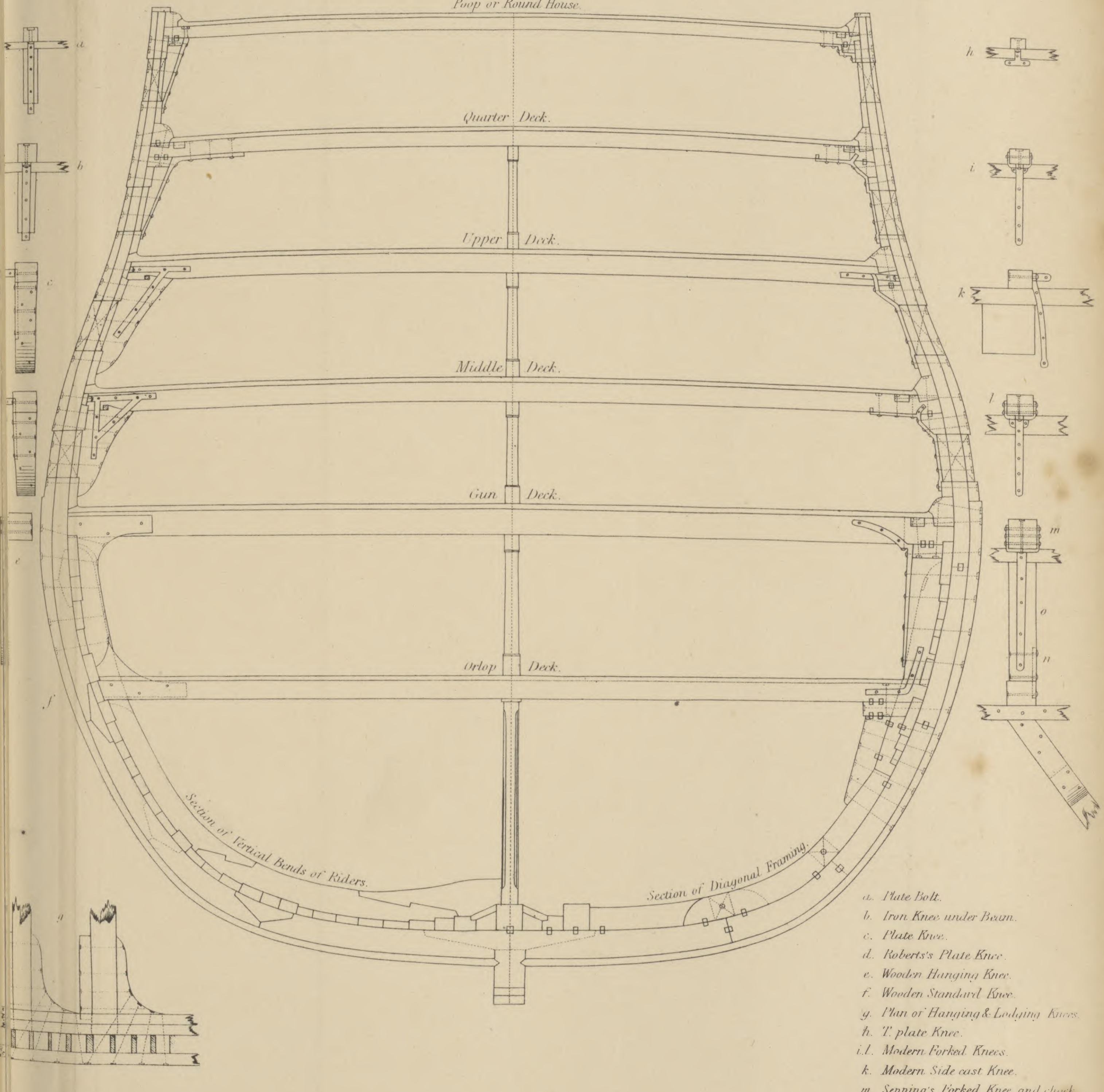


Fig. 42.

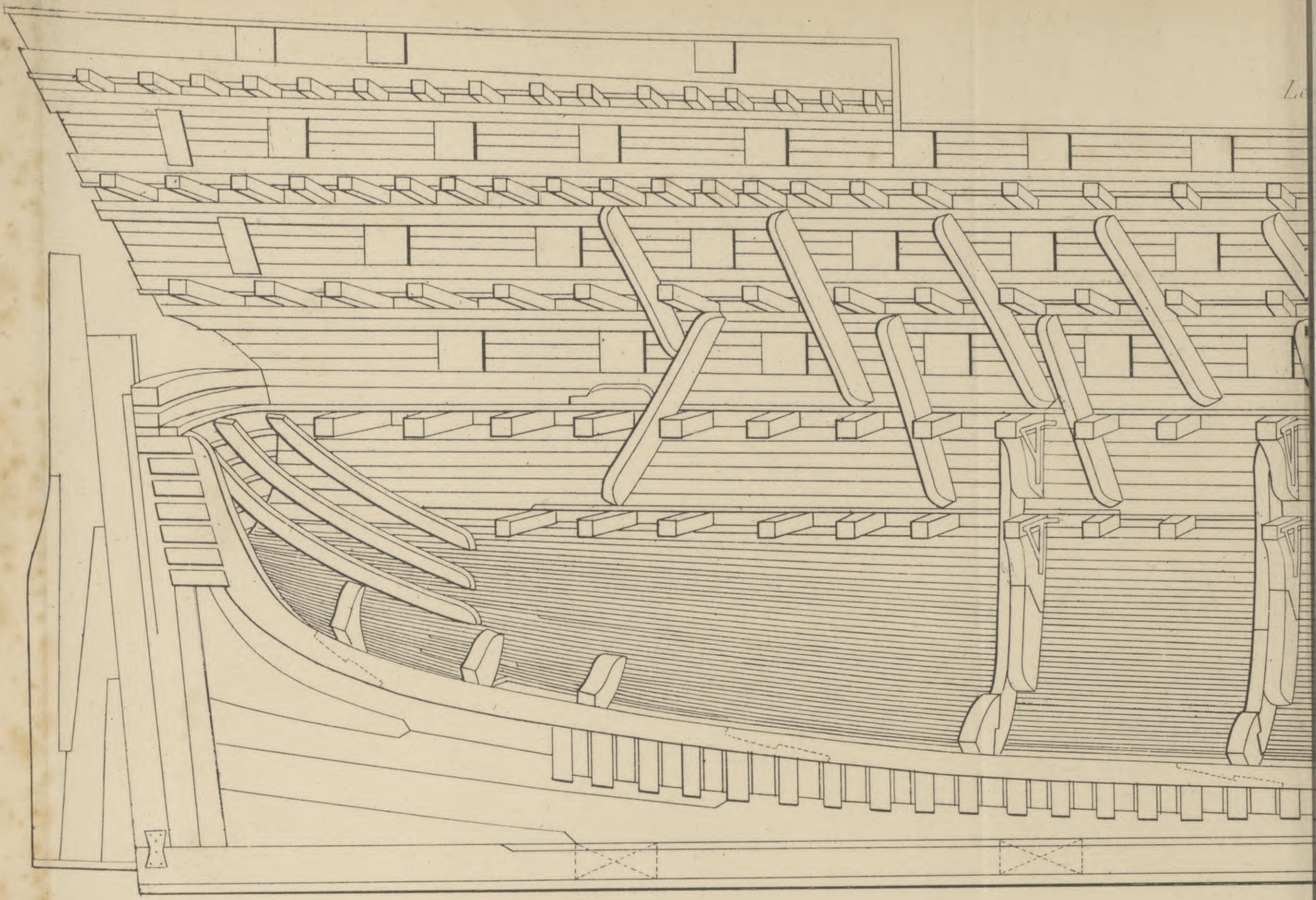


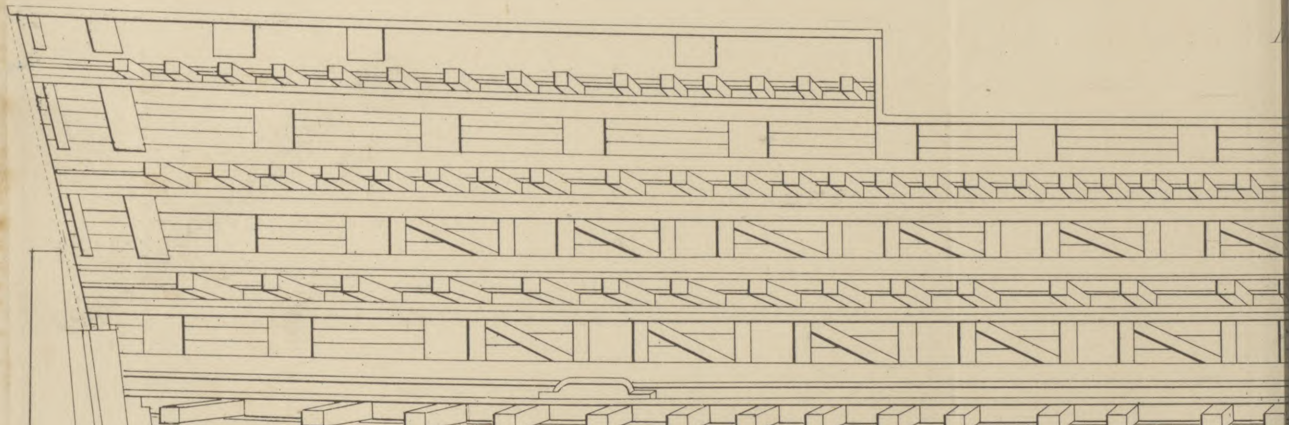
Section of a First Rate Ship of War, showing the various Plans which have been adopted for securing the Beam ends to the side; together with those at present in use.



- *a. Plate Bolt.*
- *b. Iron Knee under Beam.*
- *c. Plate Knee.*
- *d. Roberts's Plate Knee.*
- *e. Wooden Hanging Knee.*
- *f. Wooden Standard Knee.*
- *g. Plan of Hanging & Lodging Knees.*
- *h. T. plate Knee.*
- *i.l. Modern Forked Knees.*
- *k. Modern Side cast Knee.*
- *m. Sepping's Forked Knee and chock.*
- *n. Side Plate.*

Geo. Aikman, Sculpt.

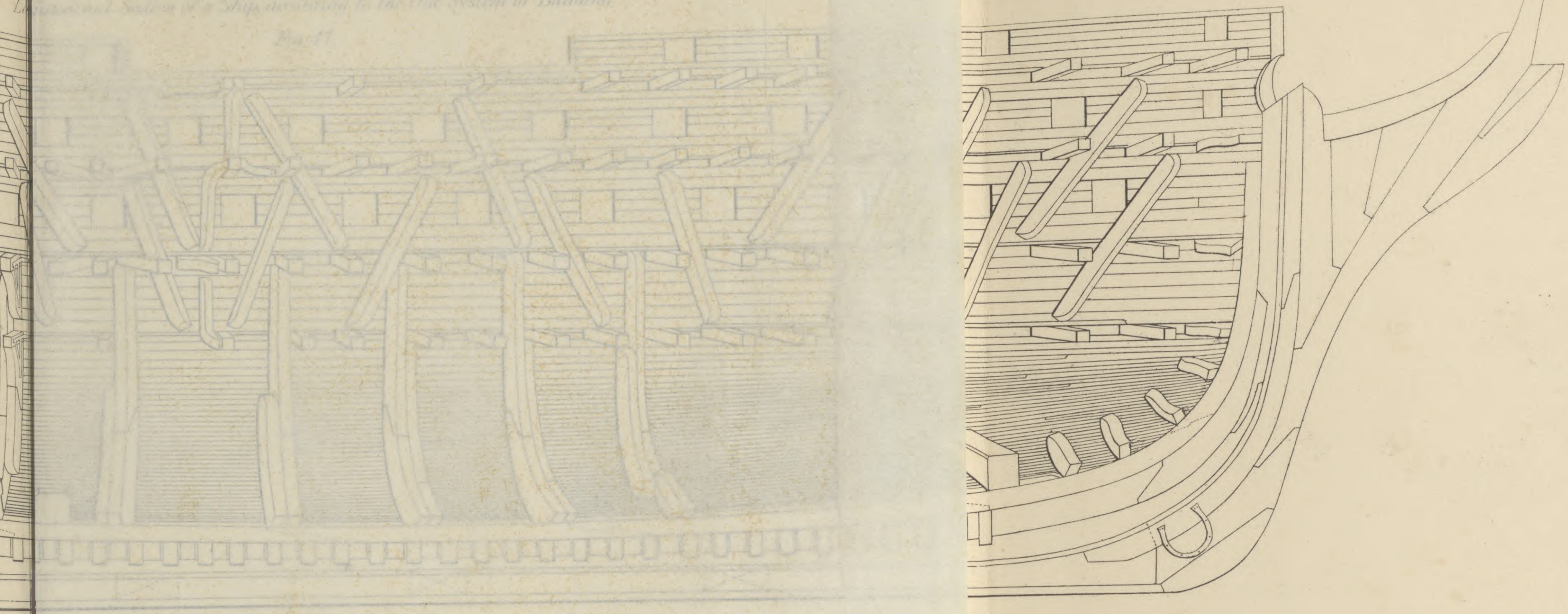

La



SHIP-BUILDING.

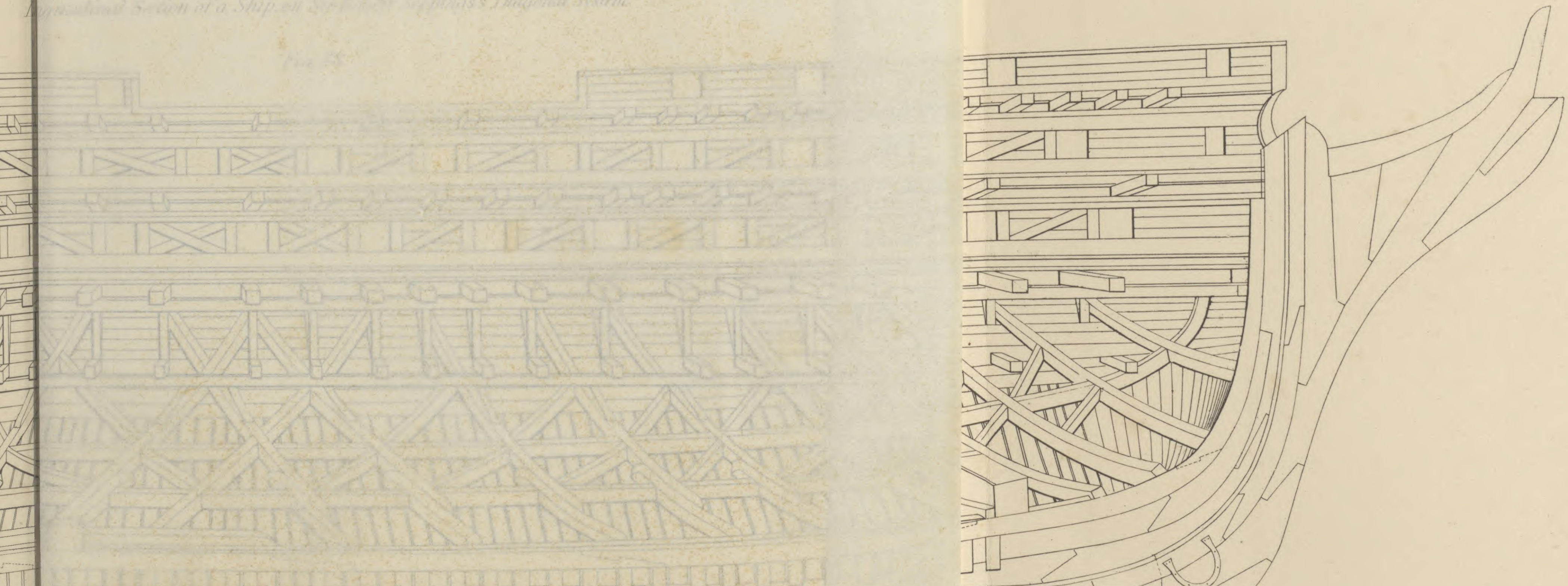
Longitudinal Section of a Ship according to the Old System of Building.

Fig. 1.



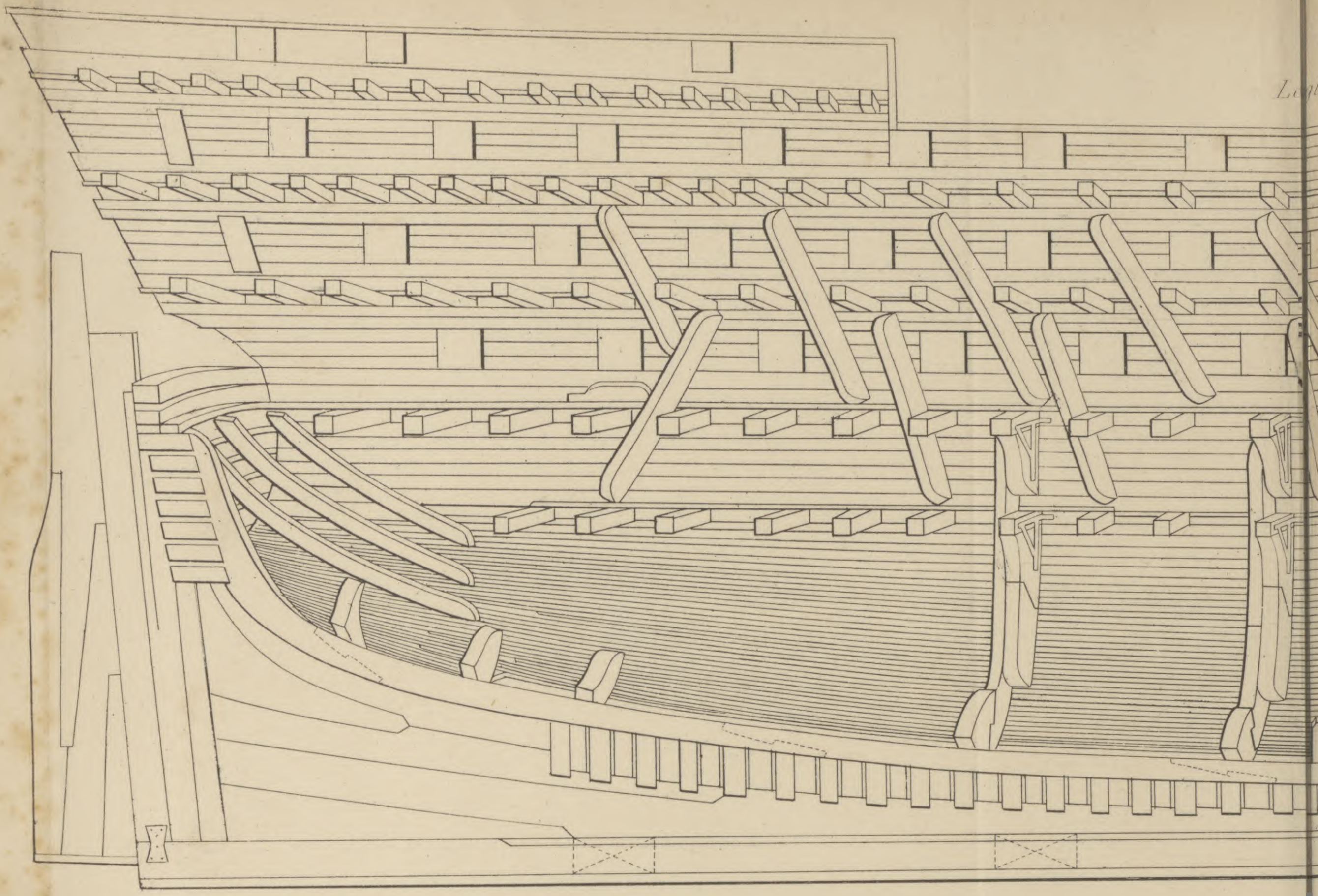
Longitudinal Section of a Ship on Sir Robert Seppings's Diagonal System.

Fig. 2.

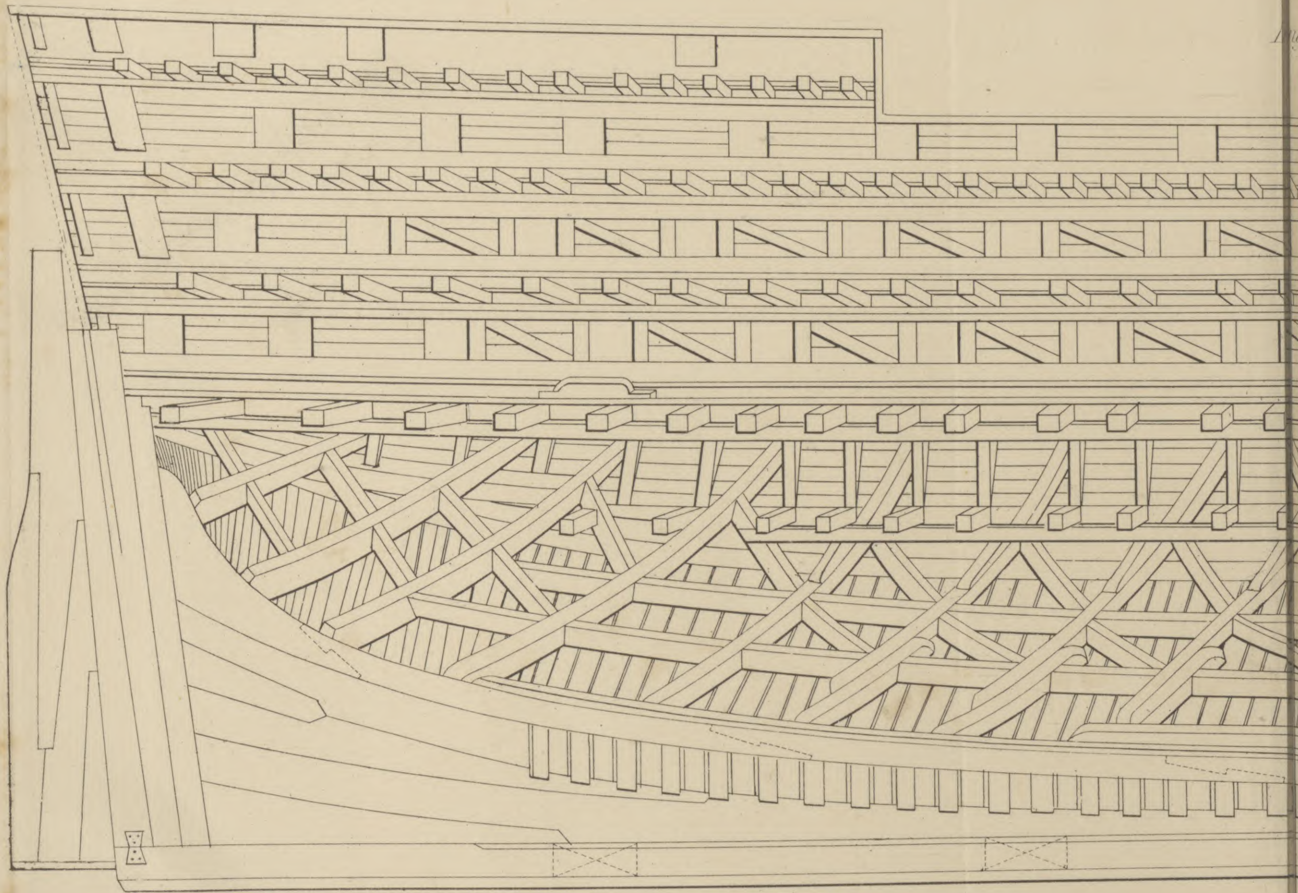


Geo. Aikman, Sculp^t

Longitu



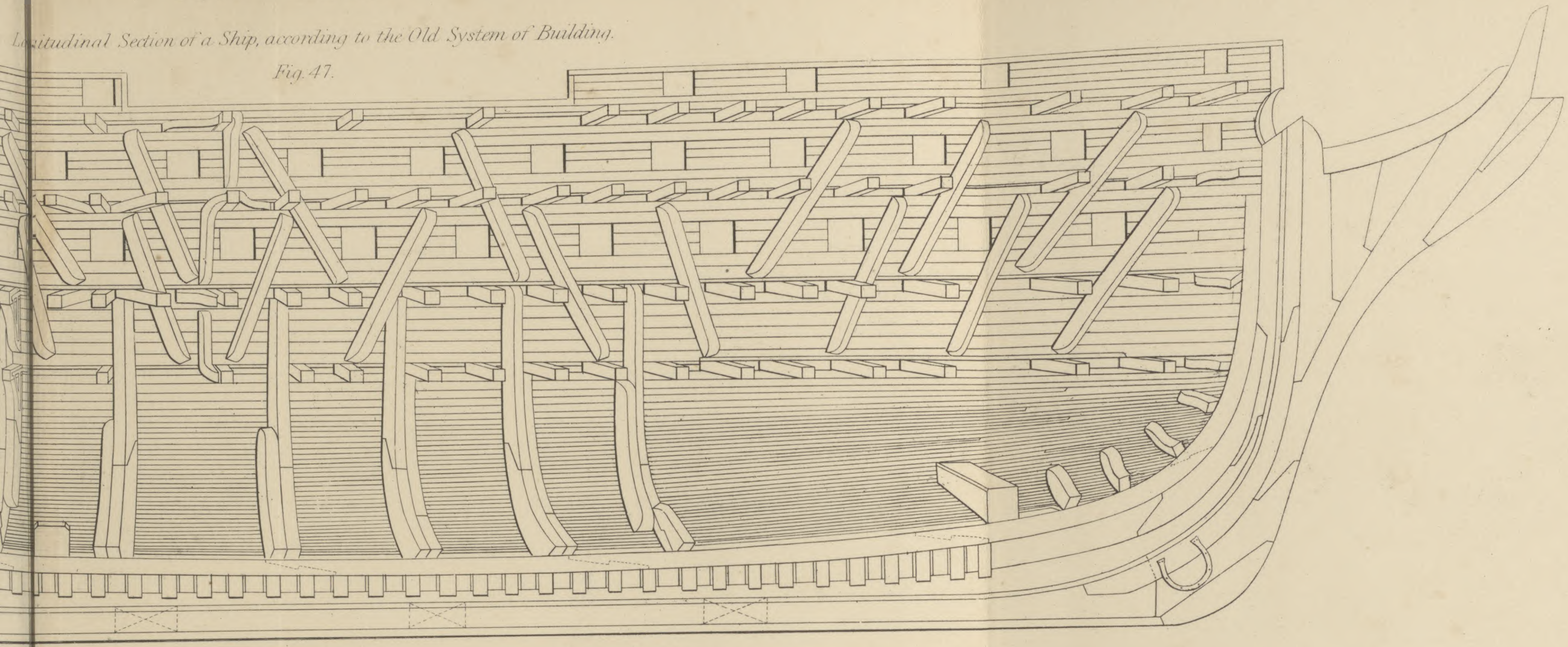
Longi



SHIP-BUILDING.

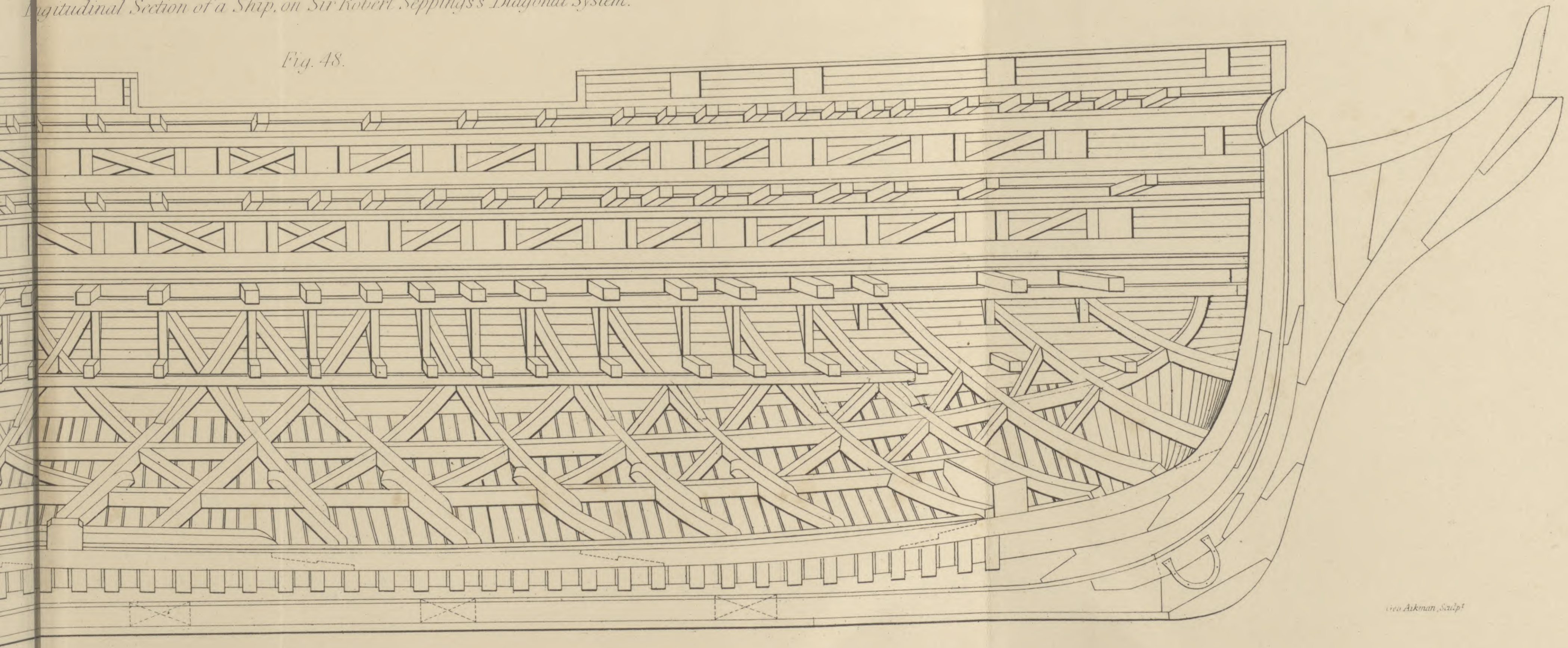
Litudinal Section of a Ship, according to the Old System of Building.

Fig. 47.



ngitudinal Section of a Ship, on Sir Robert Seppings's Diagonal System.

Fig. 48.



Geo Aikman, Sculpt.

Fig. 49.

Modern Disposition of the Timbers of an English Line of Battle Ship; with a Plan of the Modern System of Diagonal Trussing with Iron Plates.

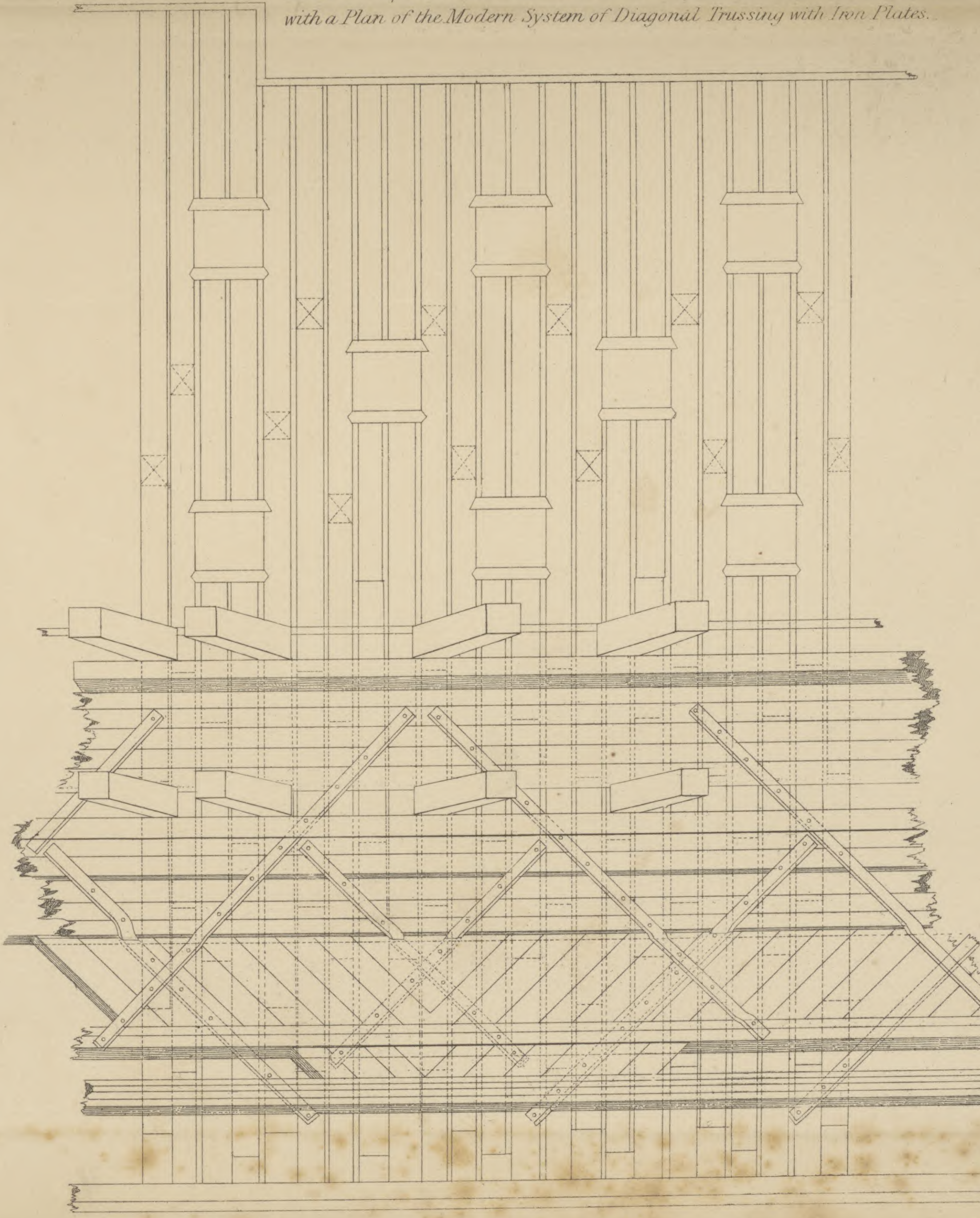
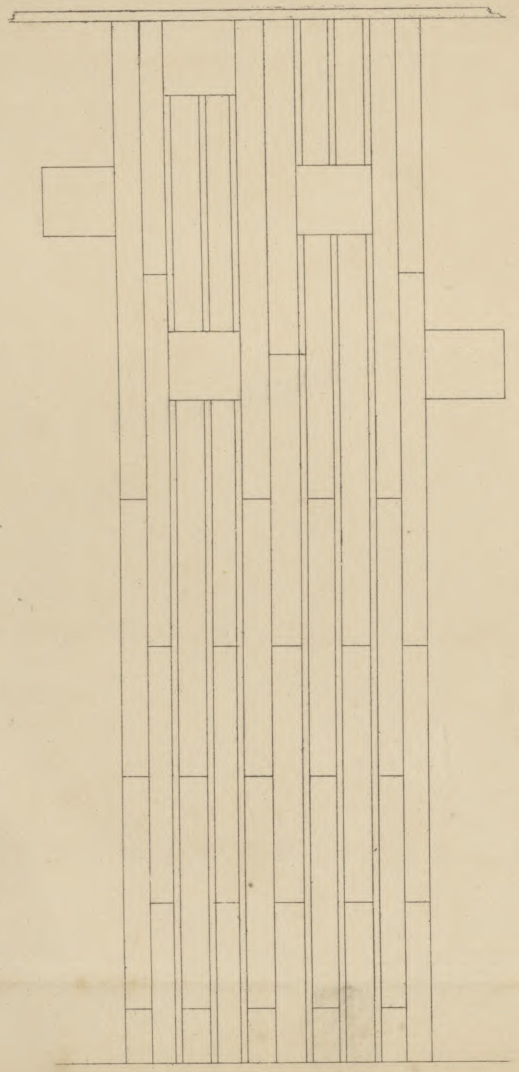


Fig. 50.

Disposition of the Timbers of a French Line of Battle Ship.



Geo. Aikman, Sculpt.

SHIPBU

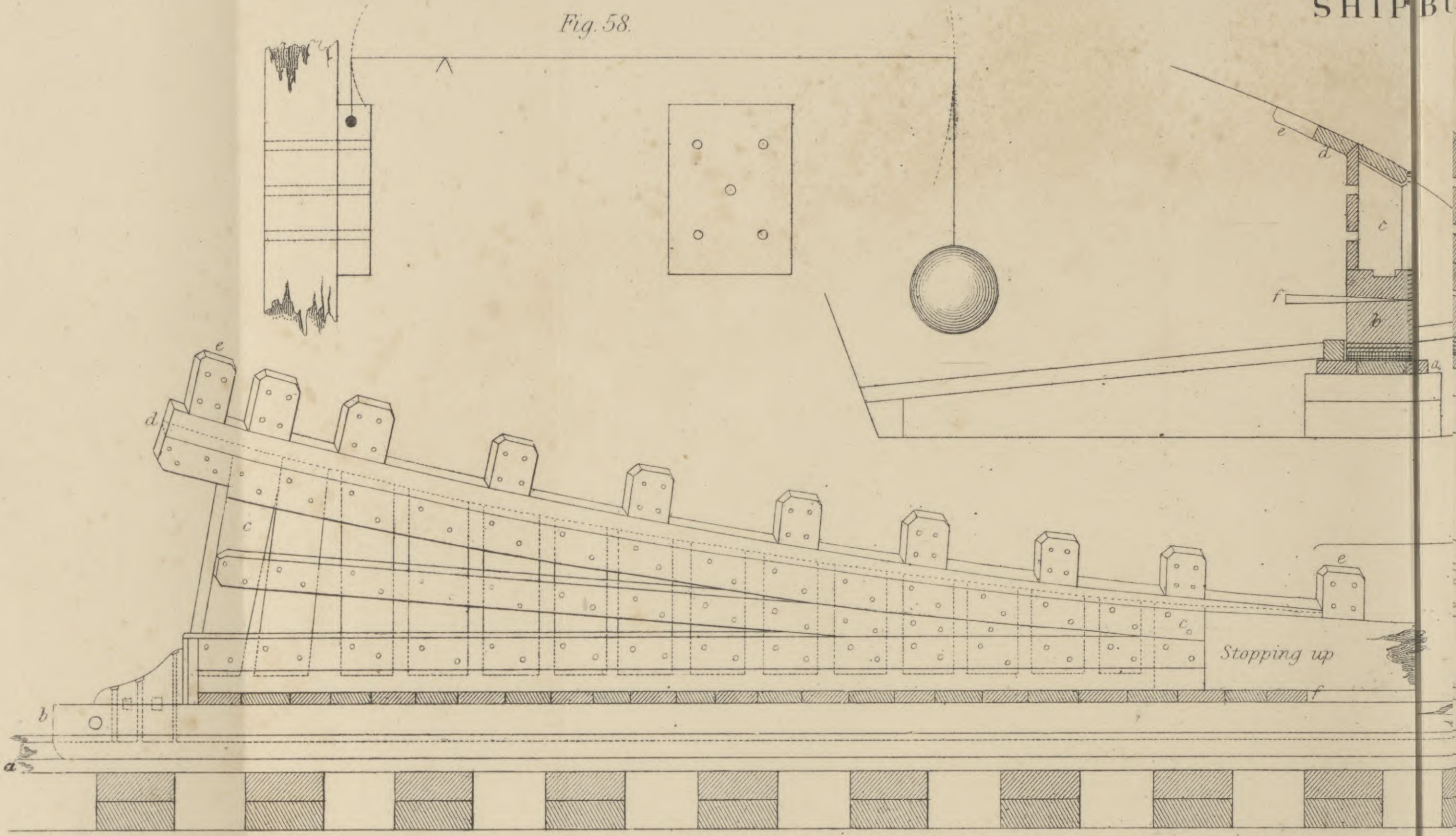


Fig. 58.

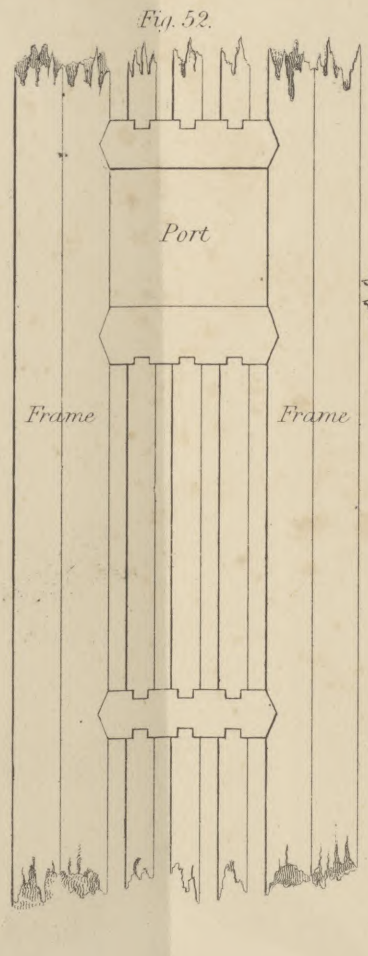


Fig. 52.

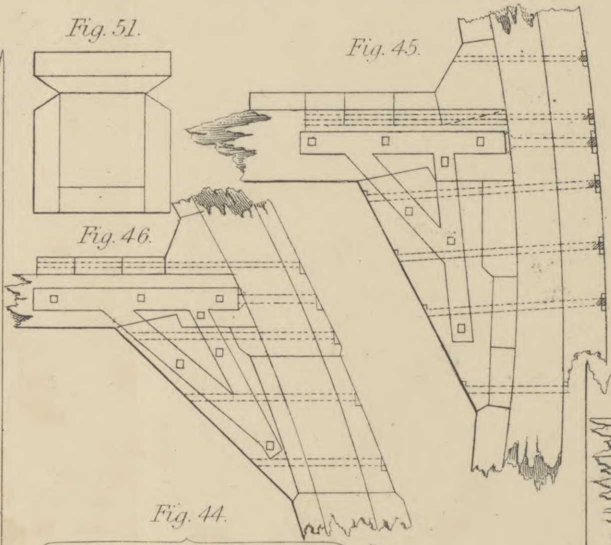


Fig. 51.

Fig. 45.

Fig. 46.

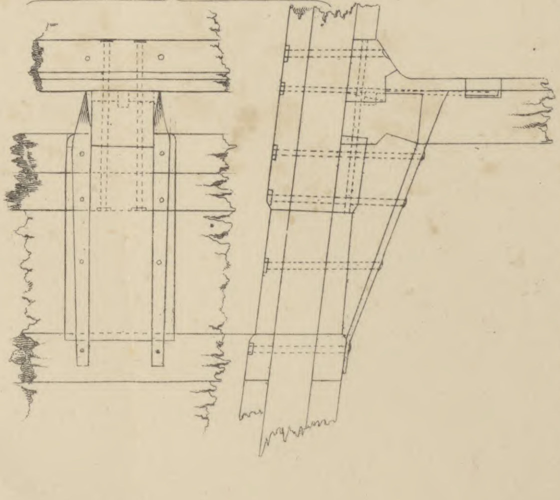
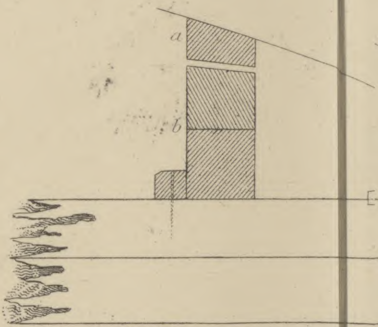
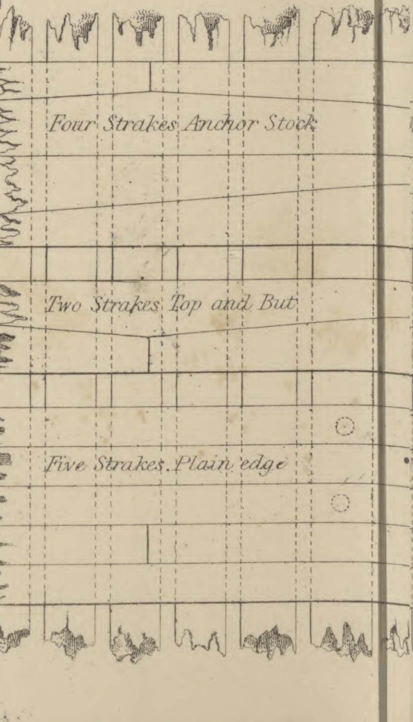


Fig. 44.





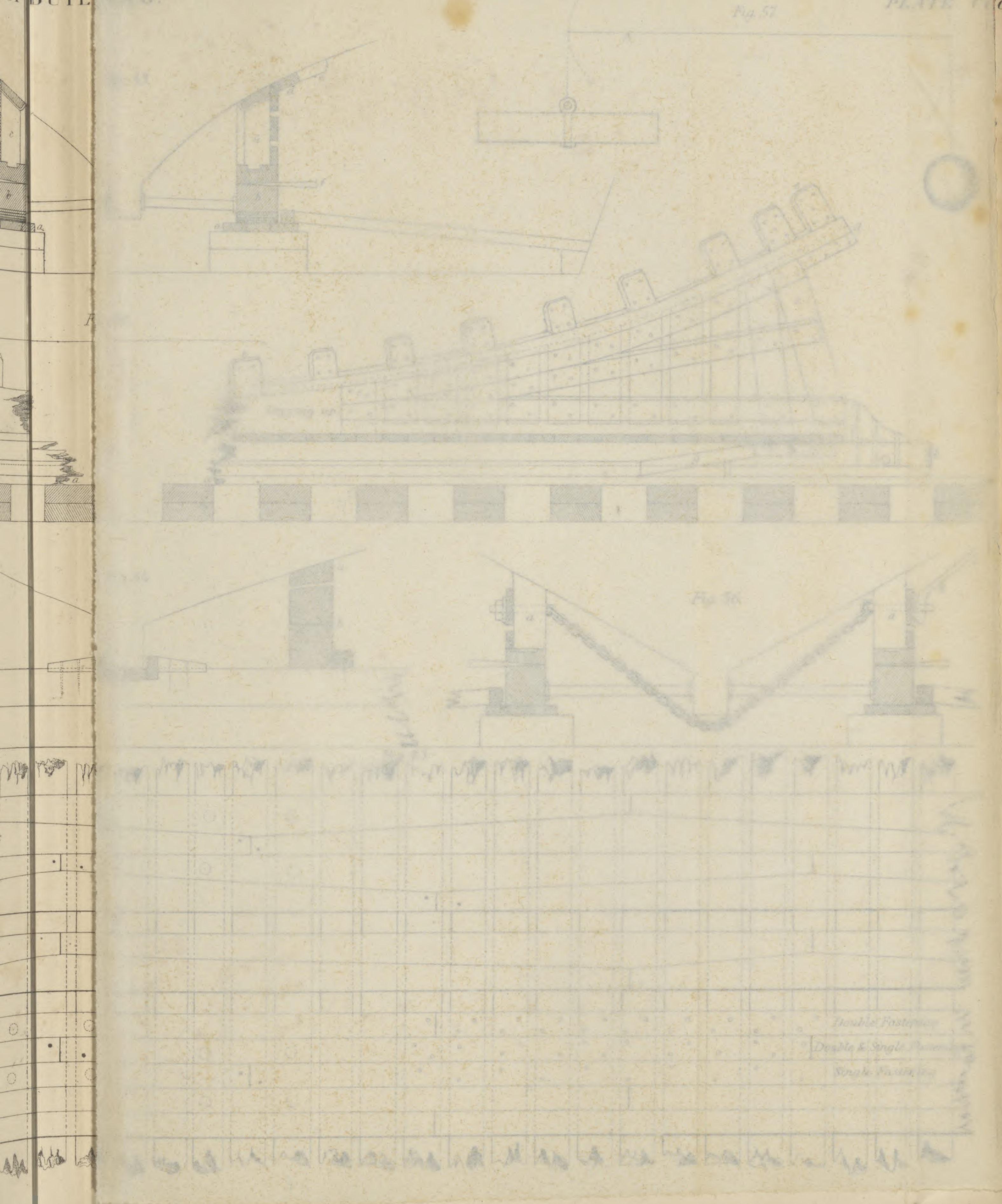
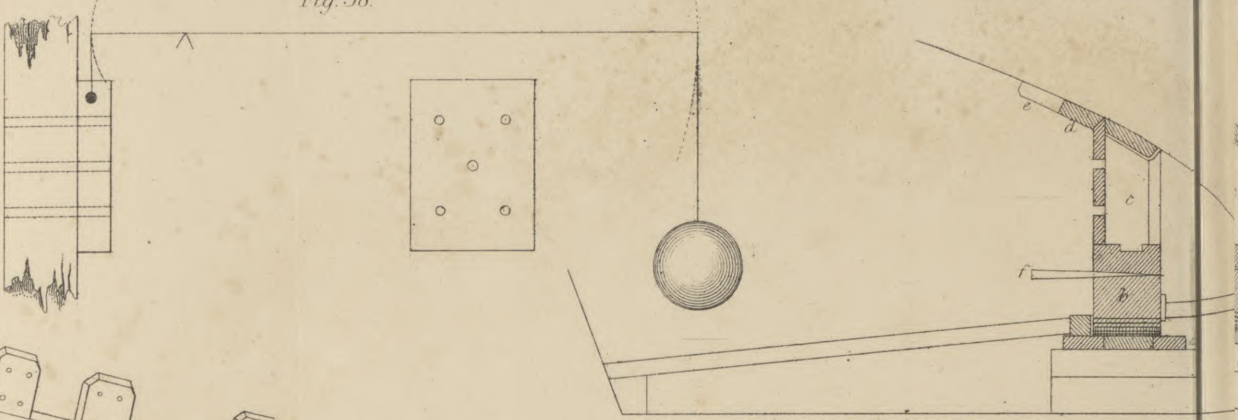


Fig. 57
Fig. 56
a
a
Double Fastening
Double & Single Fastening
Single Fastening

Fig. 58.



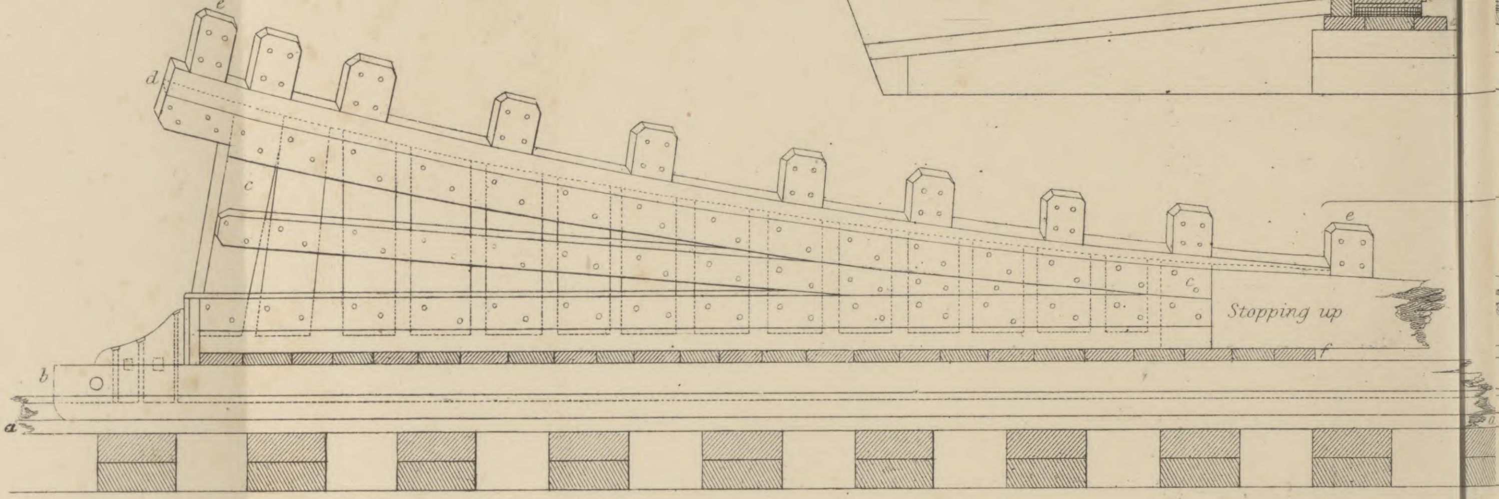
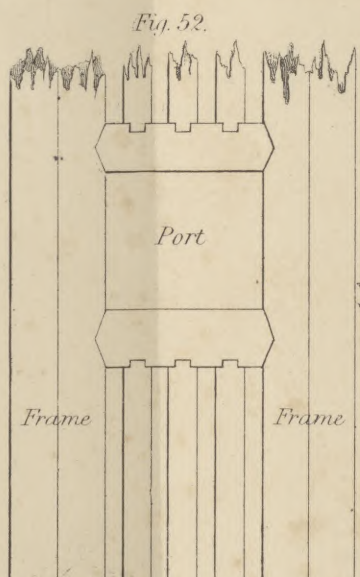


Fig. 52.



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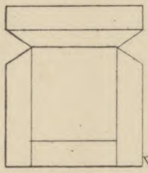


Fig. 45.

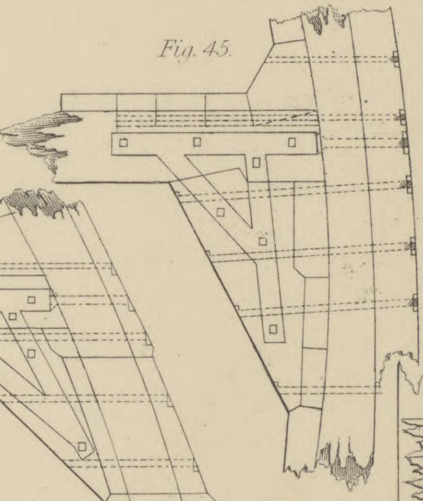
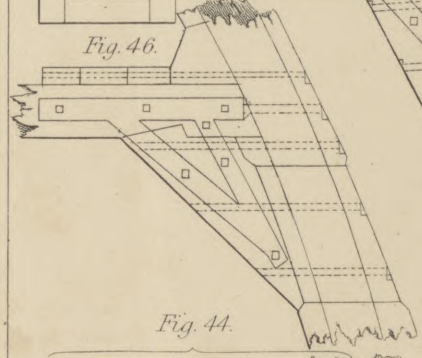


Fig. 46.



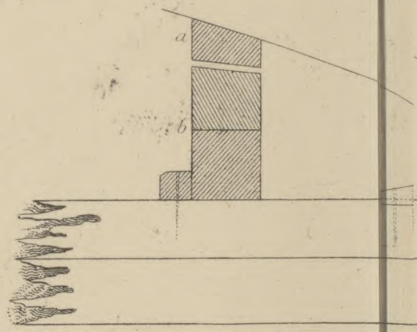
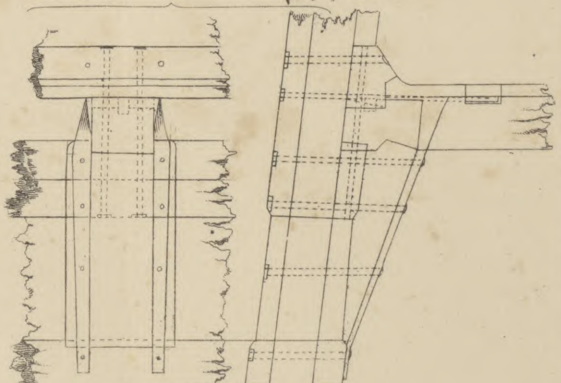
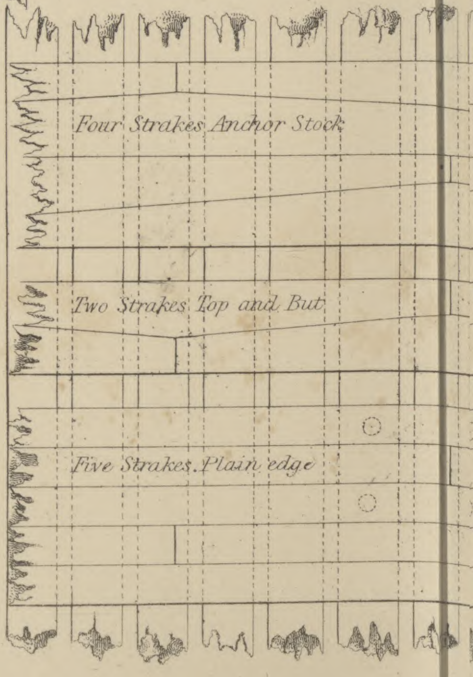


Fig. 44.





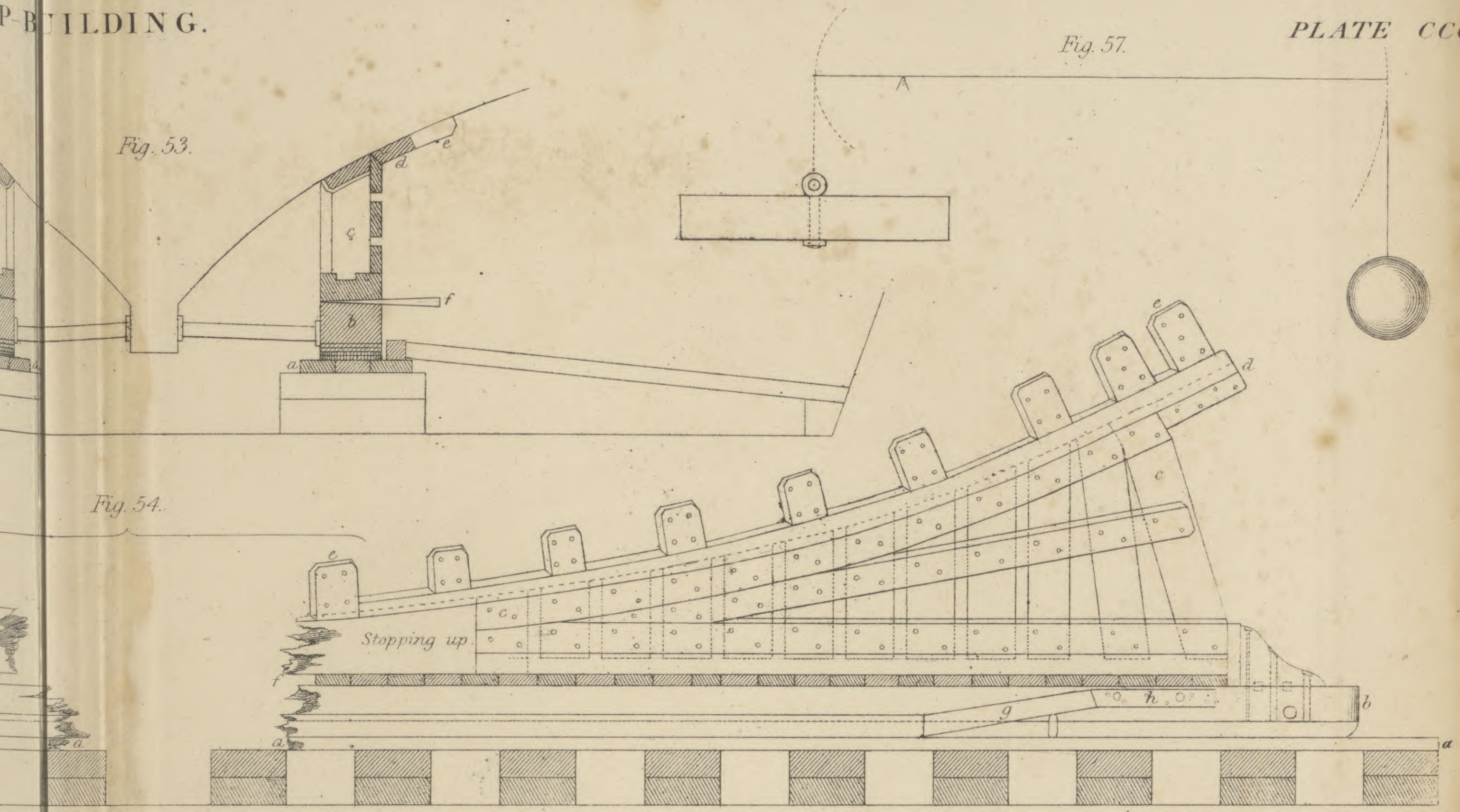
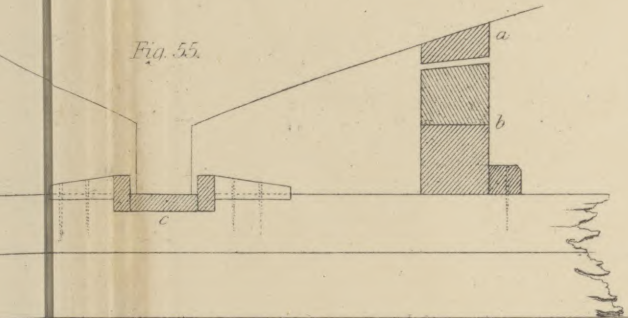


Fig. 53.

Fig. 54.

Fig. 57.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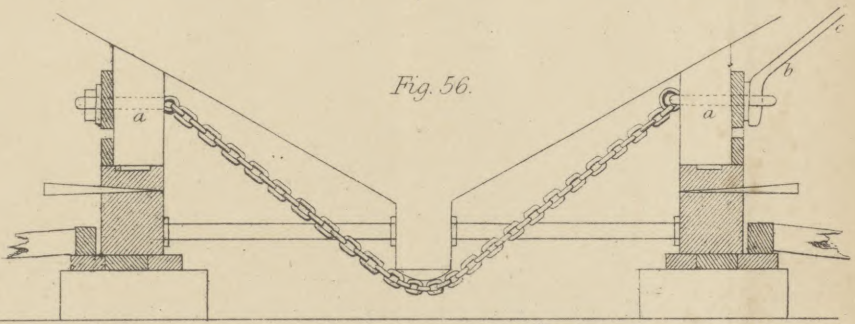
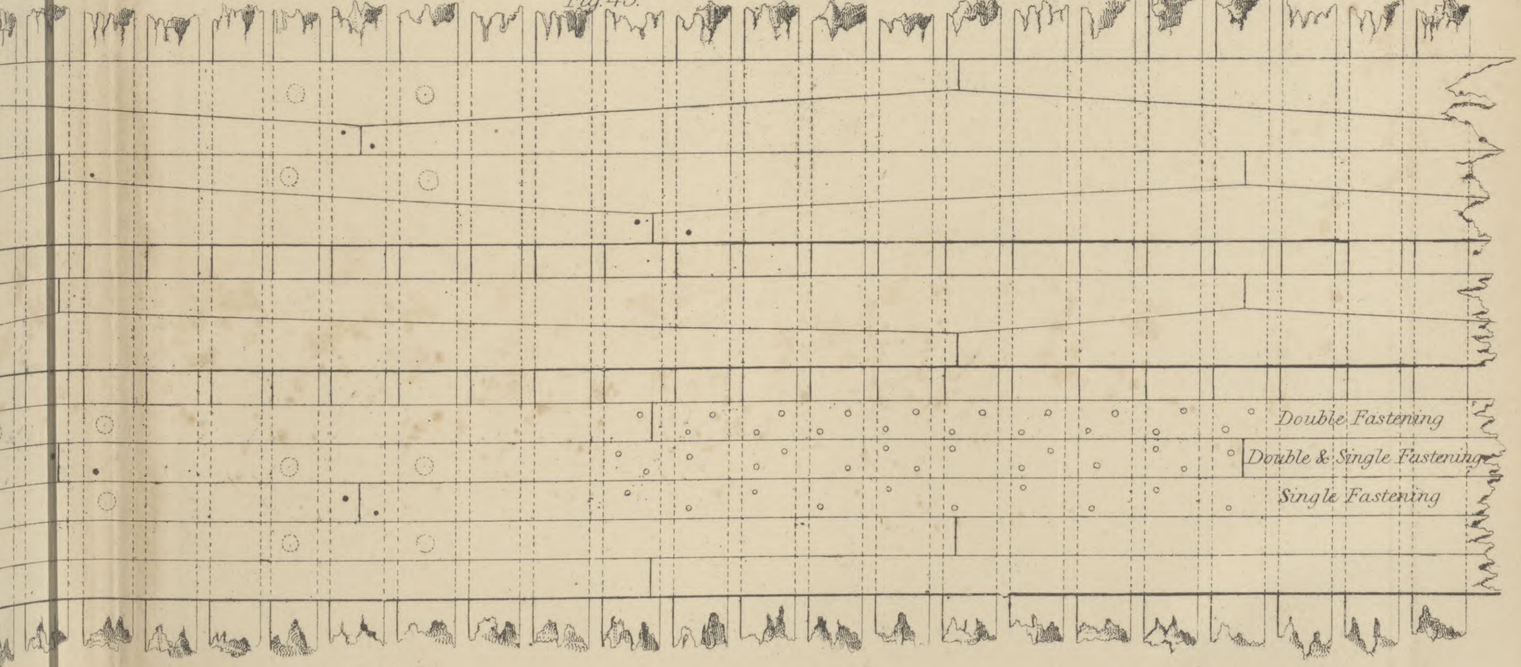


Fig. 56.

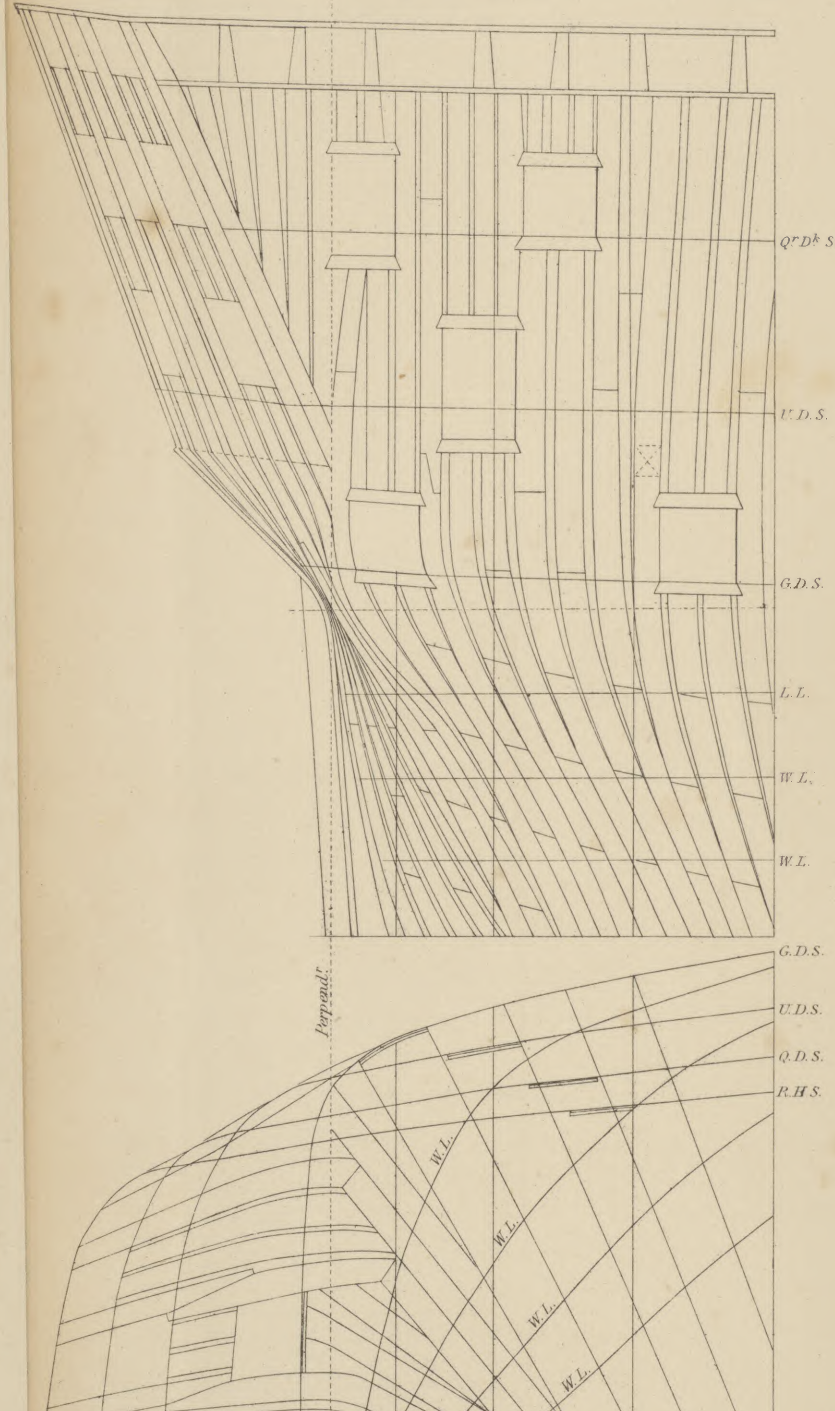
Fig. 43.



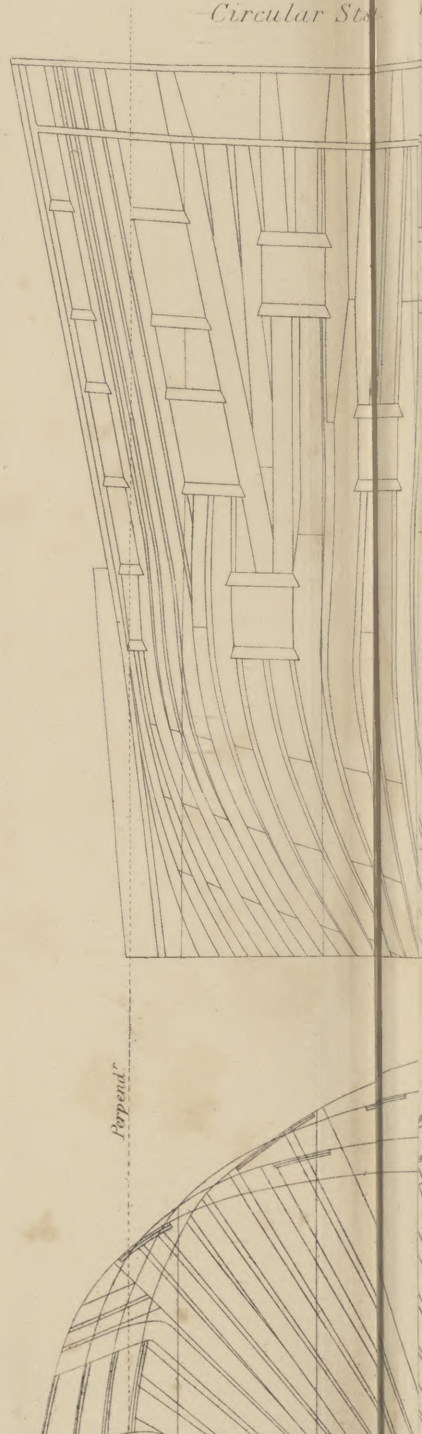
SHIP-BUILI NG

Methods of Timbering Square, Cir lar &

Modern Elliptical Stern.

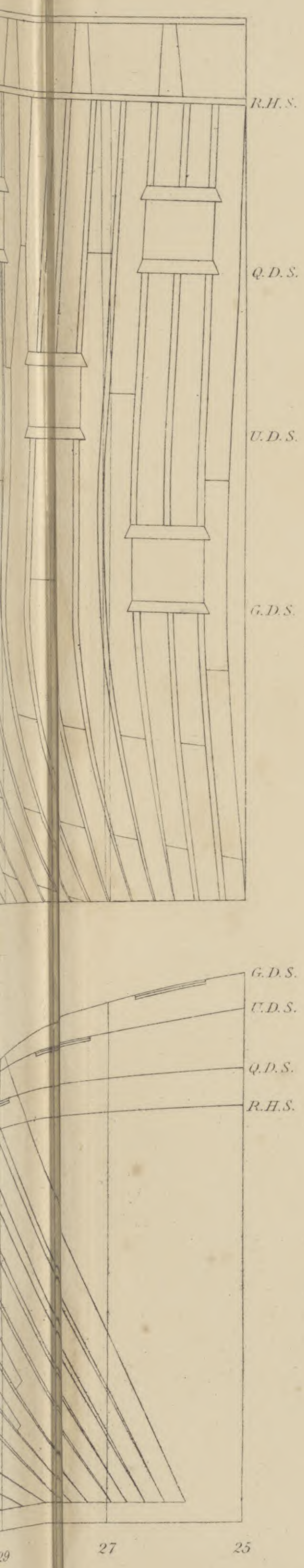


Circular St

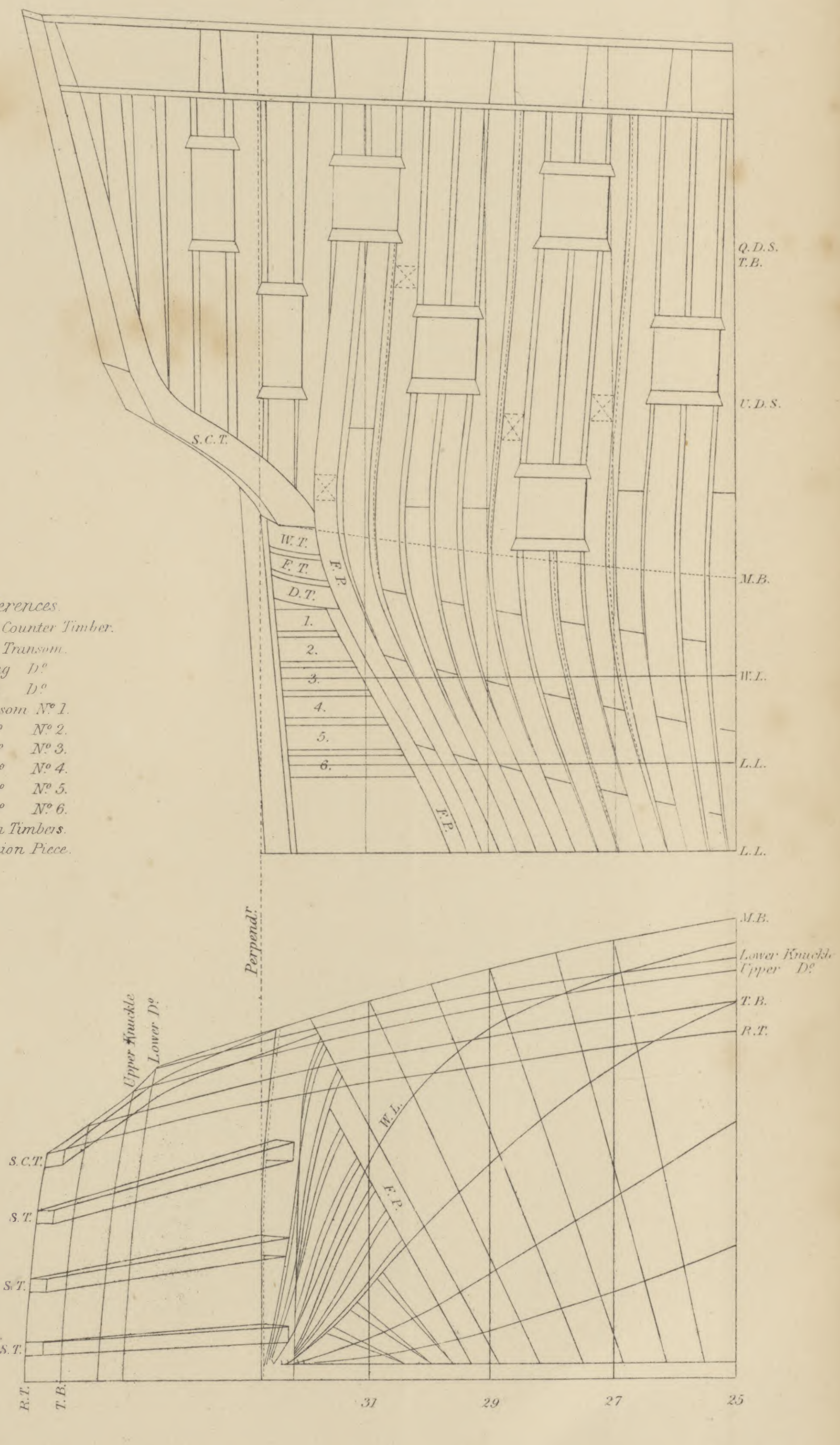


Cir ar & Elliptical Sterns.

r Ste



Square Stern.



References.

S.C.T.	Side Counter Timber.
W.T.	Wing Transom.
F.T.	Filling D^o.
D.T.	Deck D^o.
1.	Transom N^o. 1.
2.	D^o. N^o. 2.
3.	D^o. N^o. 3.
4.	D^o. N^o. 4.
5.	D^o. N^o. 5.
6.	D^o. N^o. 6.
S.T.	Stern Timbers.
F.P.	Fashion Piece.

Geo. Aikma

GROUSE SHOOTING.

RED DEER.

SHOOTING.

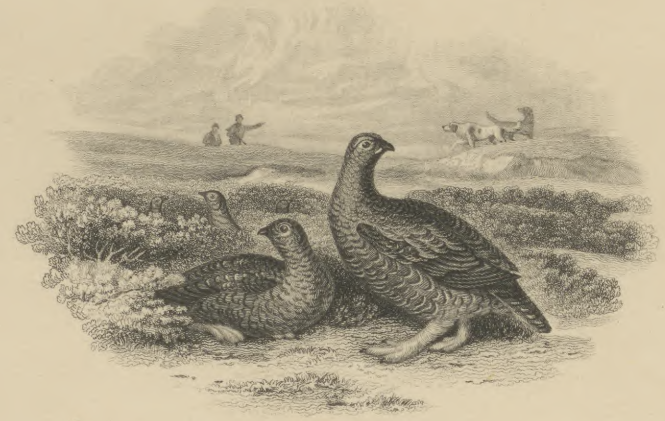
GROUSE SHOOTING.

RED DEER.

SHOOTING.

PTARMIGAN.

PARTRIDGES.

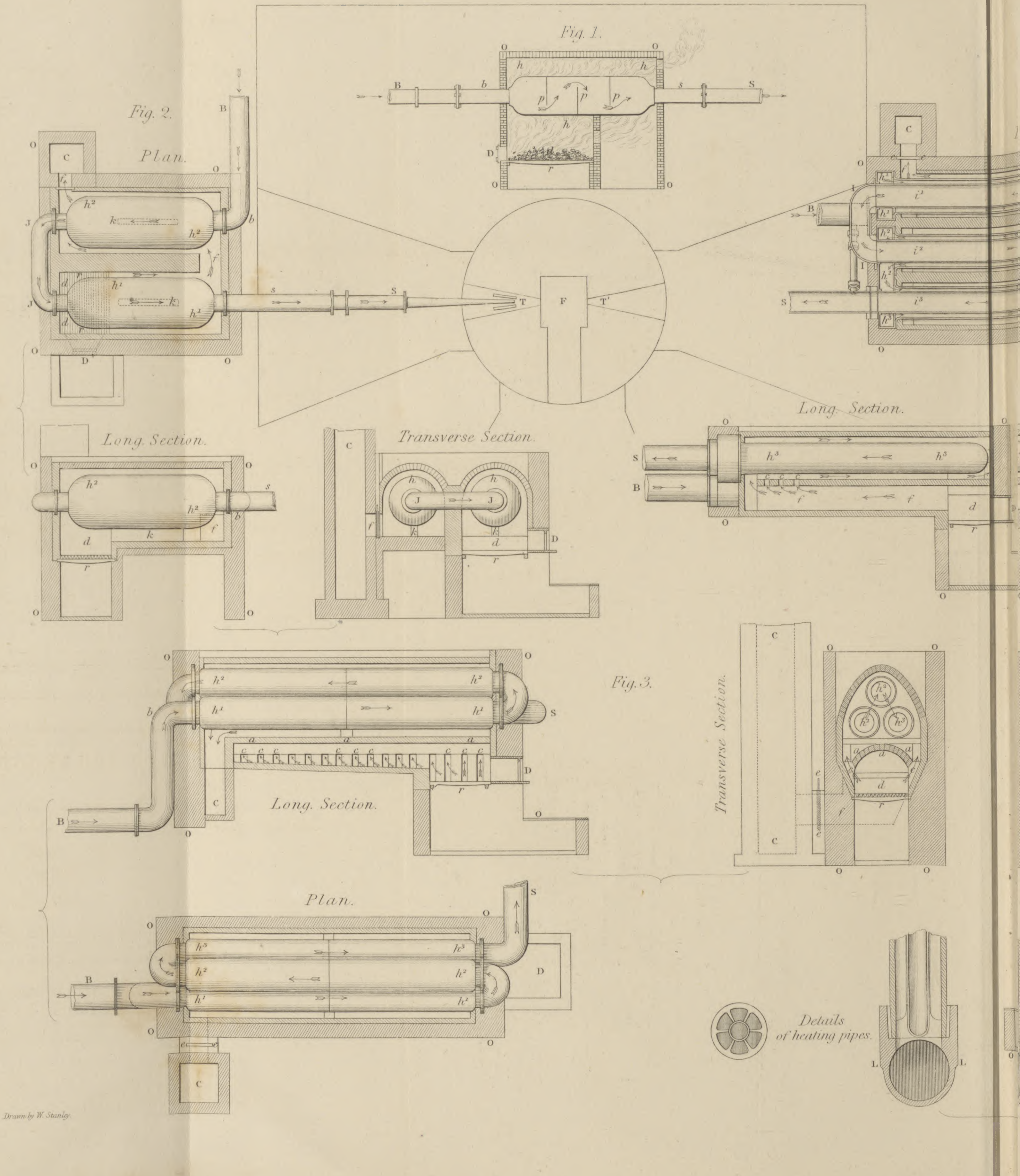


RED GROUSE.

PHEASANTS.

SMELTIN

SMELTING IRO BY

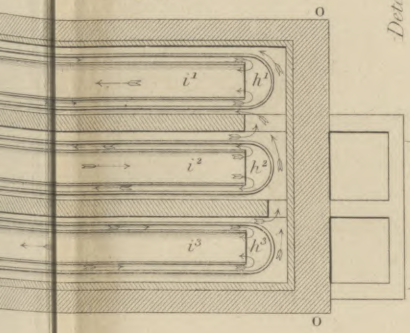


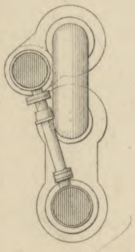
Drawn by W. Stanley.

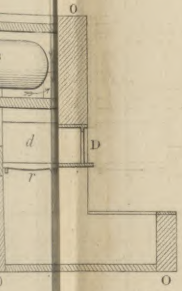
G IRON BY HOT BLAST.

Fig. 4.

Plan.




Detail of heating pipes.



Transverse Section.

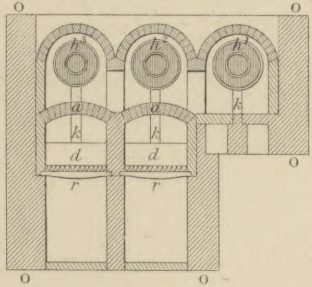
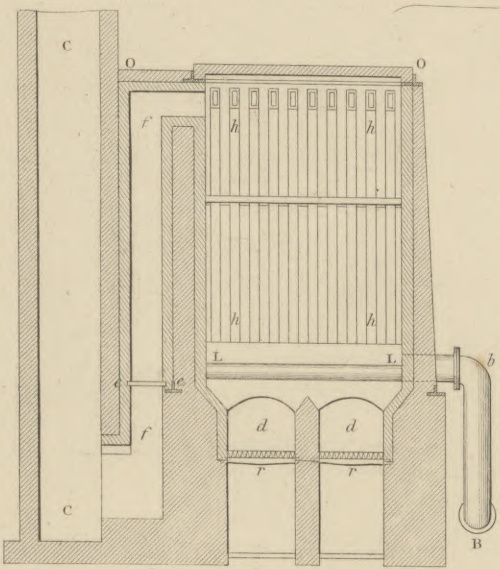
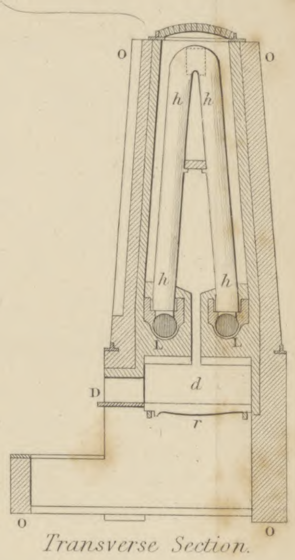


Fig. 6.

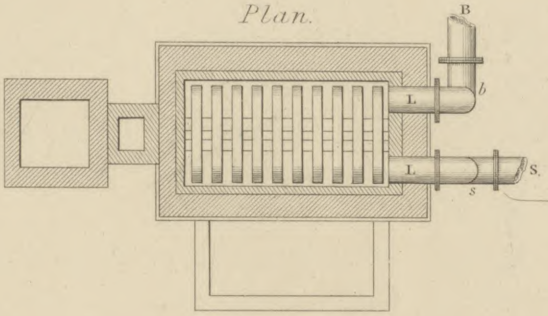


Long. Section.

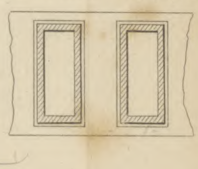


Transverse Section.

Plan.



Detail of heating pipes.



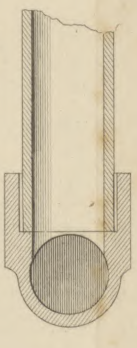
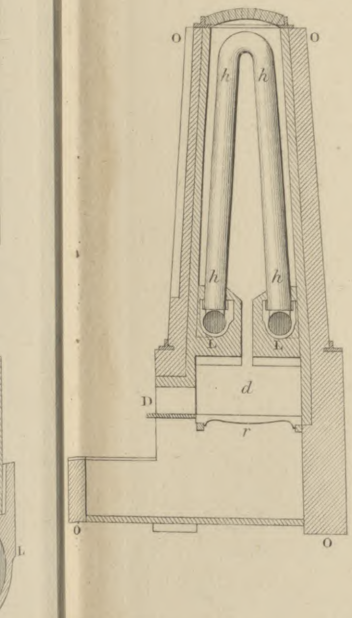
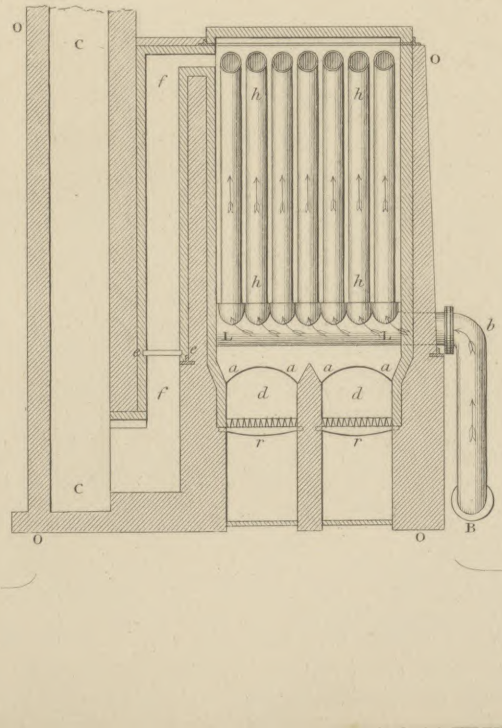
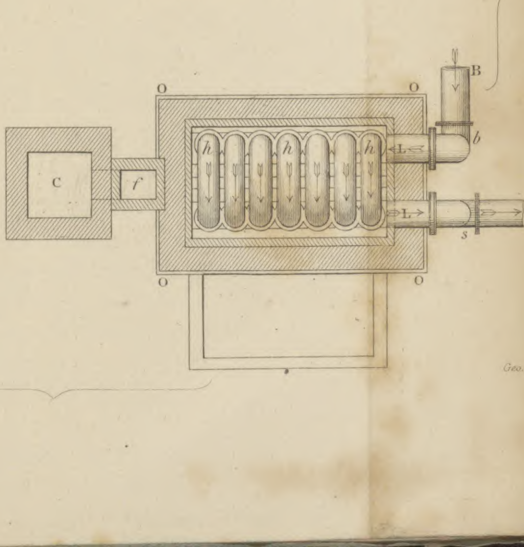

Joint of Heating pipe in lying pipe.

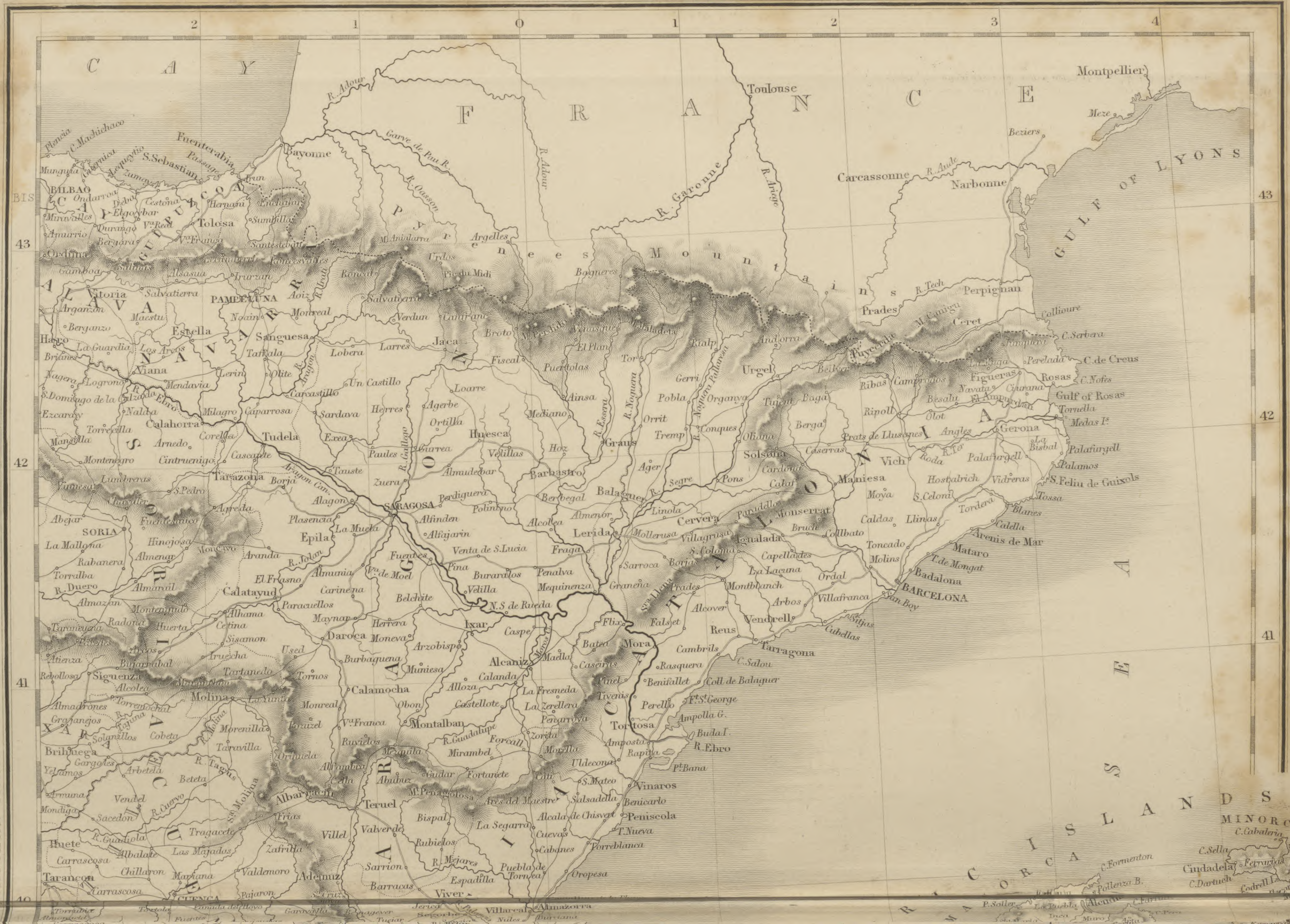
Fig. 5.



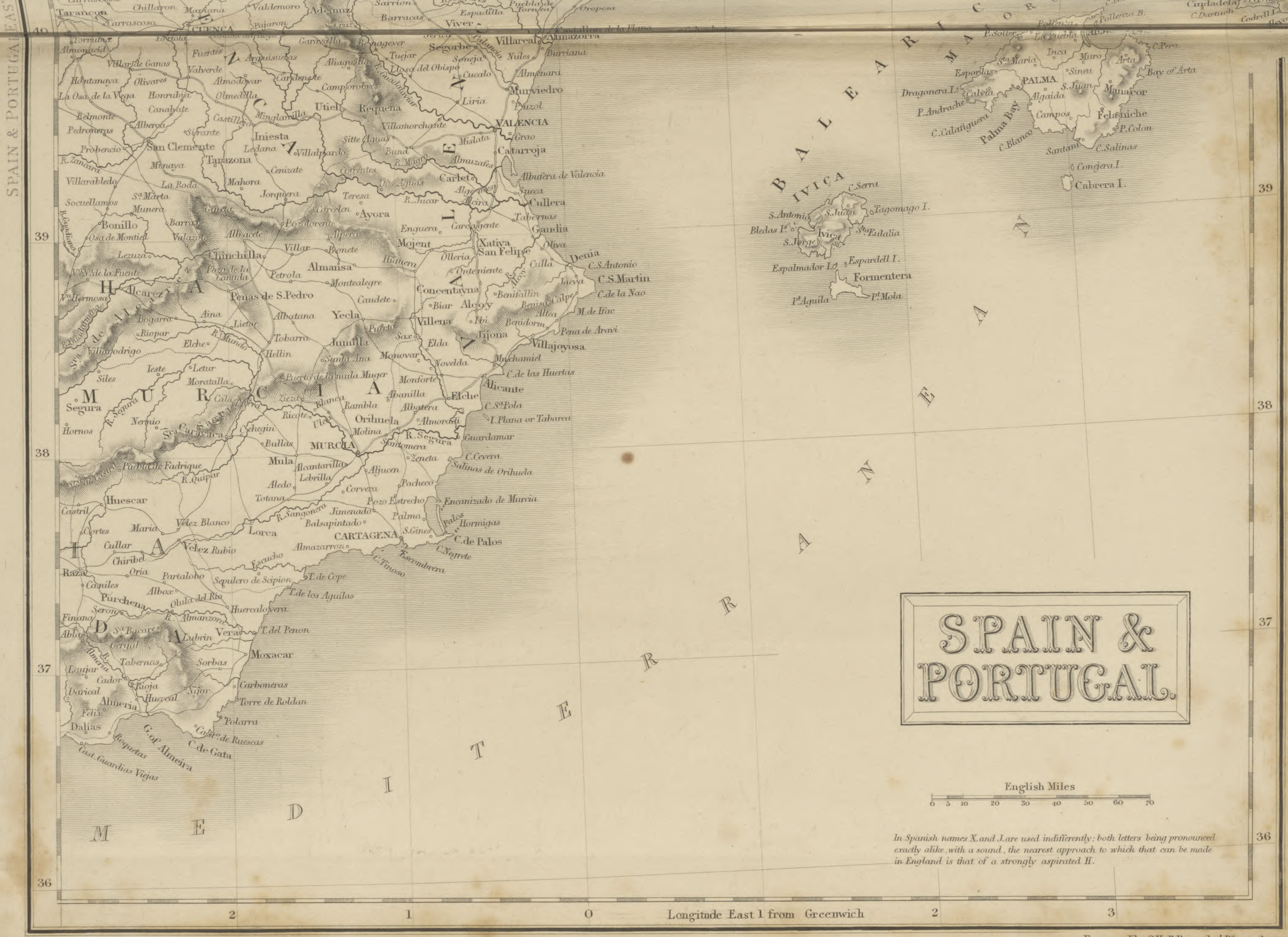




Geo. Ai

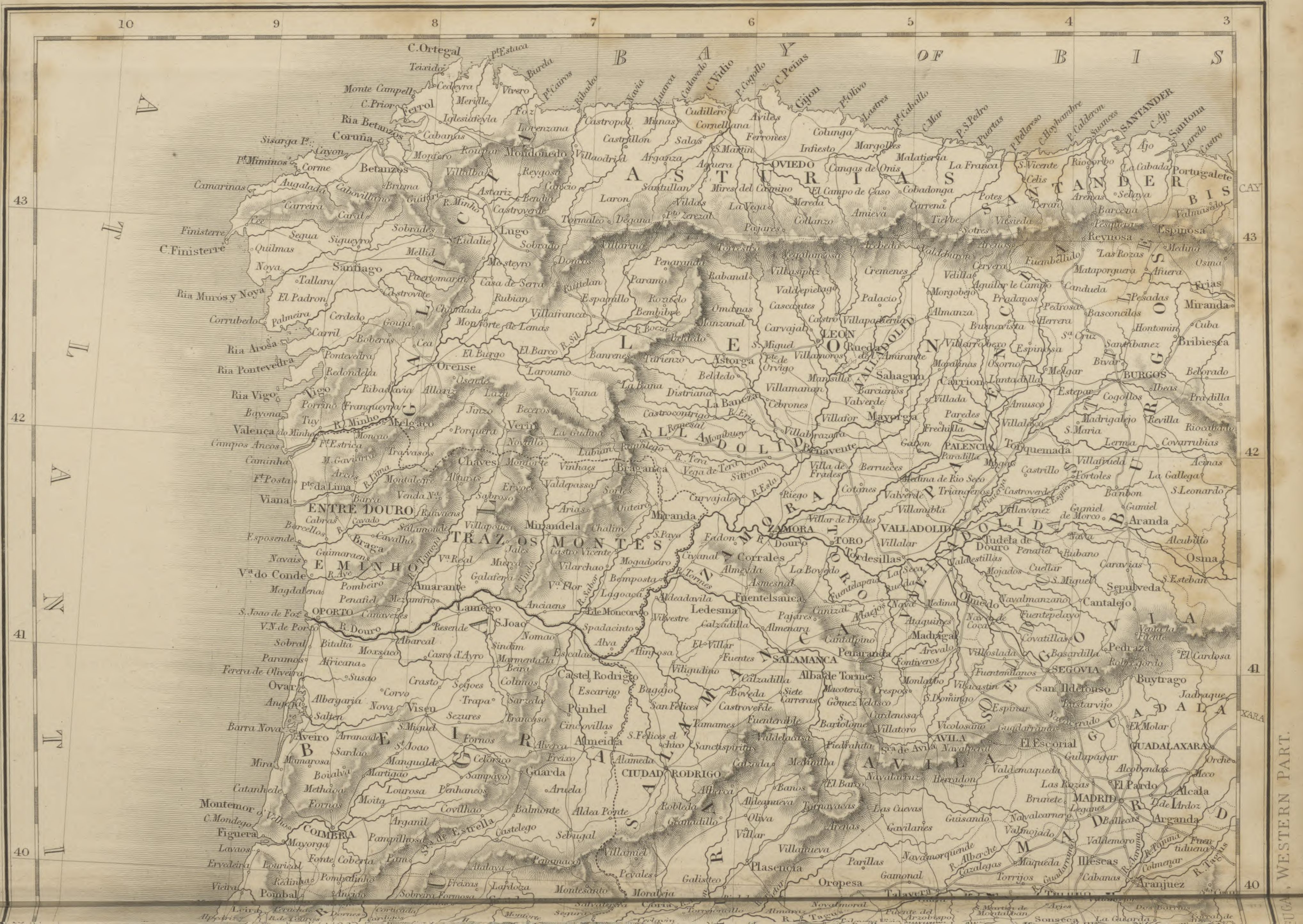


EASTERN PART.

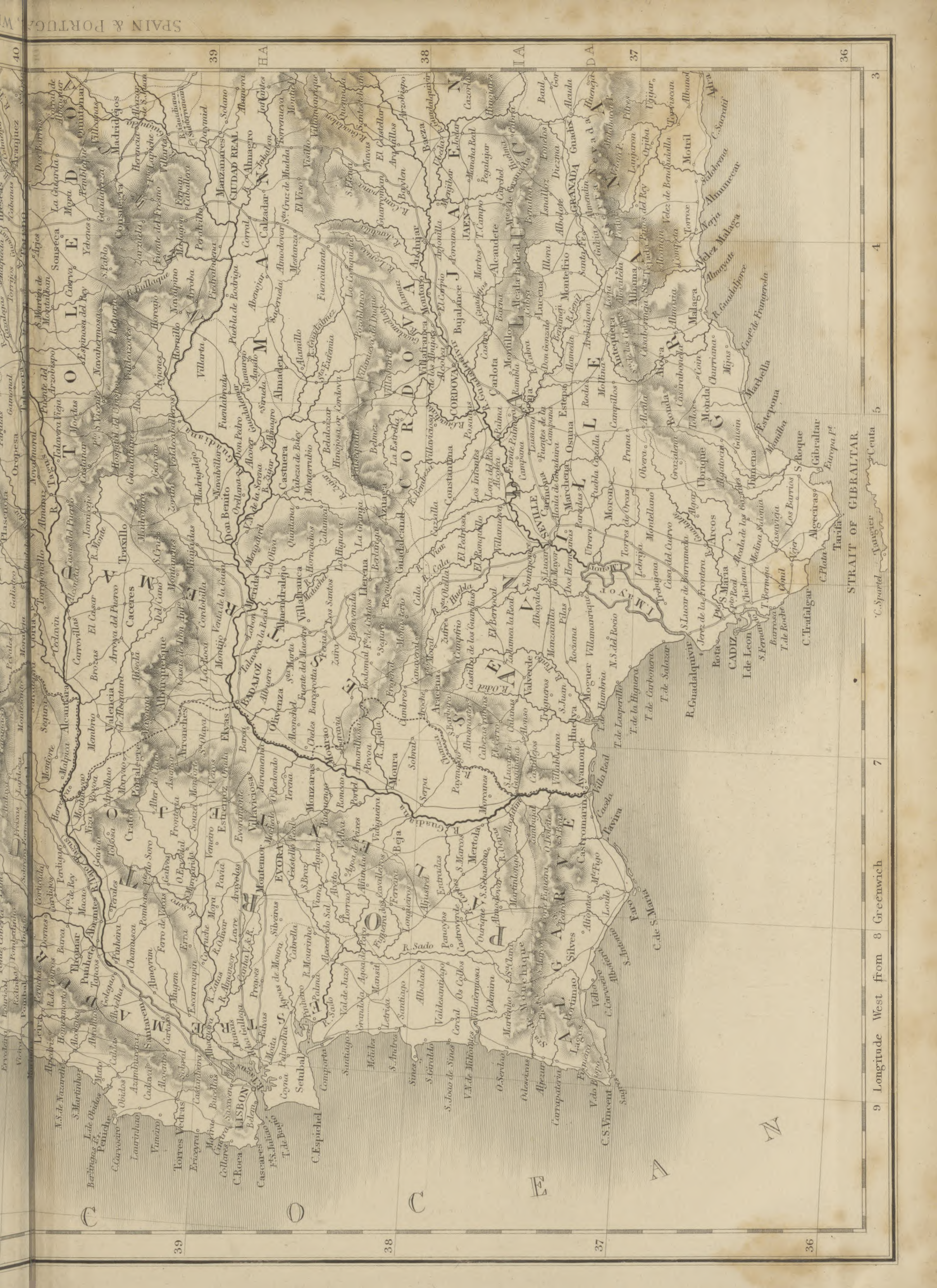


In Spanish names X. and J. are used indifferently; both letters being pronounced exactly alike, with a sound, the nearest approach to which that can be made in England is that of a strongly aspirated H.

Engraved by S Hall Bury Str.t Bloomsbury



UGAL, WESTERN PART.


SPAIN & PORTUGAL, W
STRAIT OF GIBRALTAR
Longitude West from Greenwich
O C E A N
CORDOVA
SEVILLE
GRANADA
JAEN
ALGARVE
ALEMTEJO
ESTREMADURA
LISBON
CADIZ
Gibraltar
C. S. Vincent
C. Trafalgar
Ceuta
Tangier
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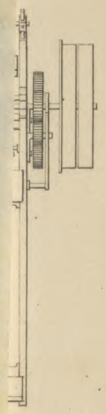
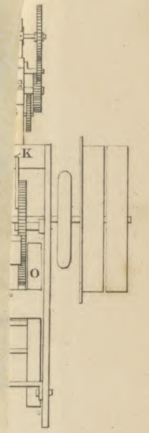
TE CCCCLXV.





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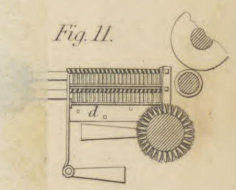


Geo. Aikman Sculp^t

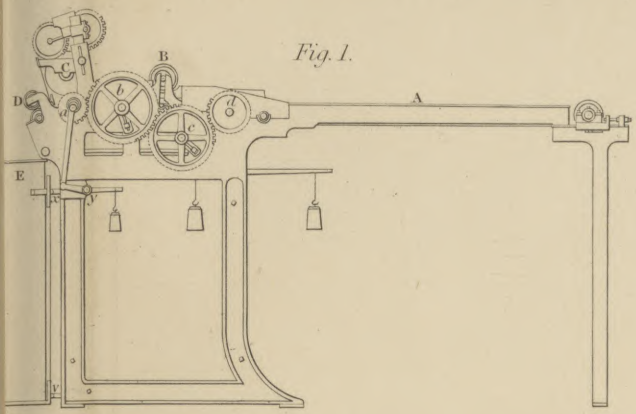
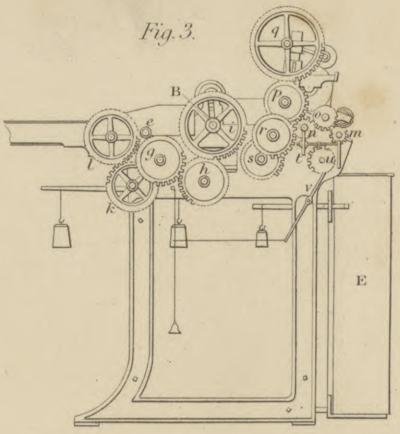


Fig. 1.



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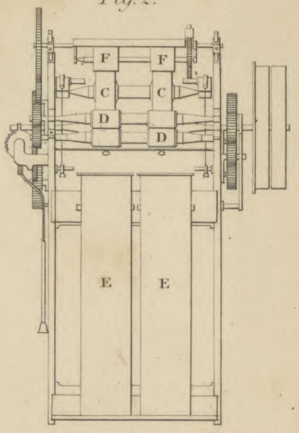

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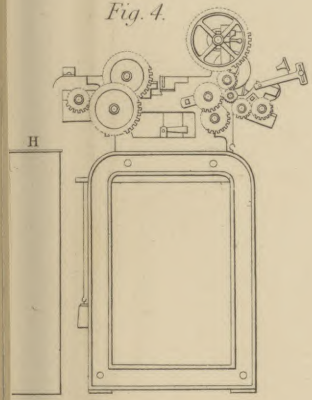

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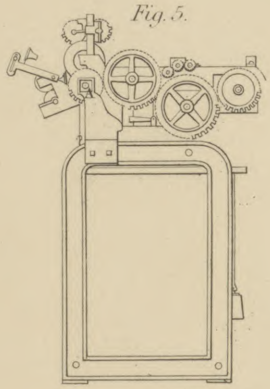

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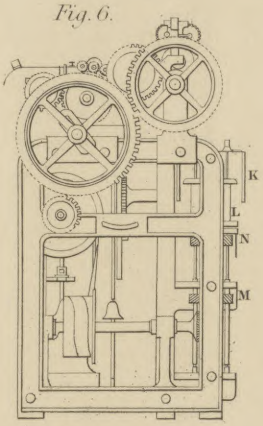

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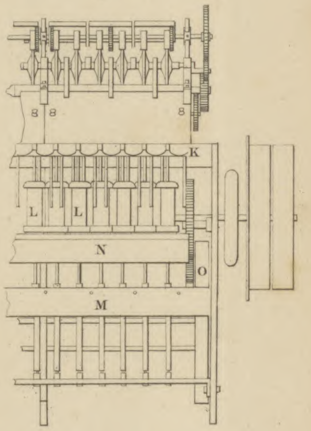

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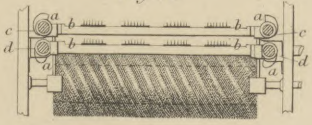

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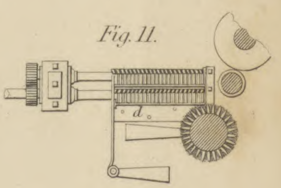


Fig. 11.

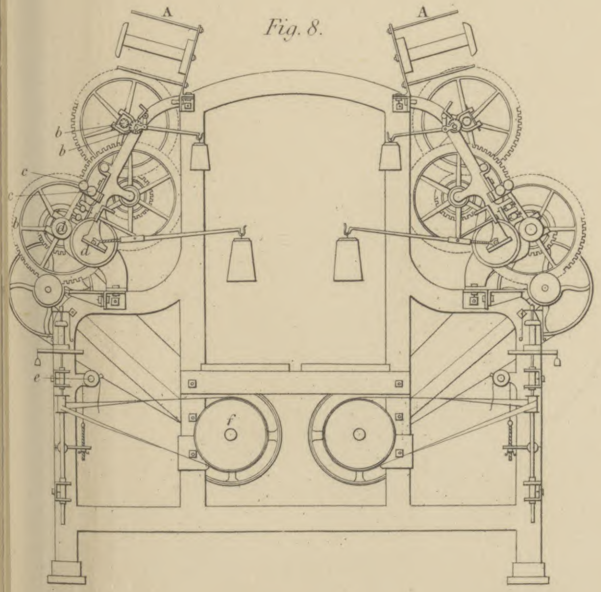


Fig. 8.

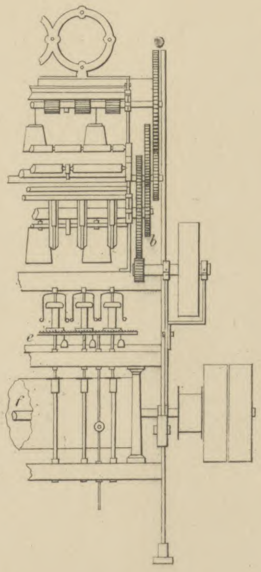


Fig. 9.

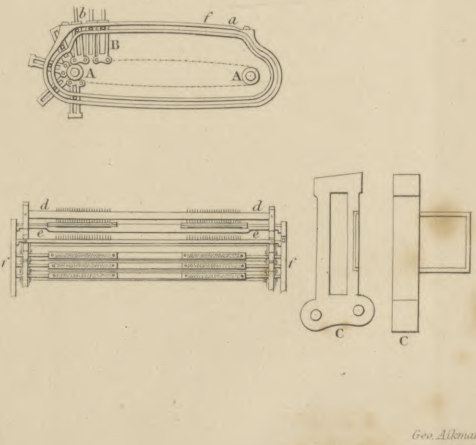


Fig. 10.

Geo. Aikman. Sculpt.

SMITH'S SELF ACTING COTTON MULE.

Fig. 1 Side Elevation.

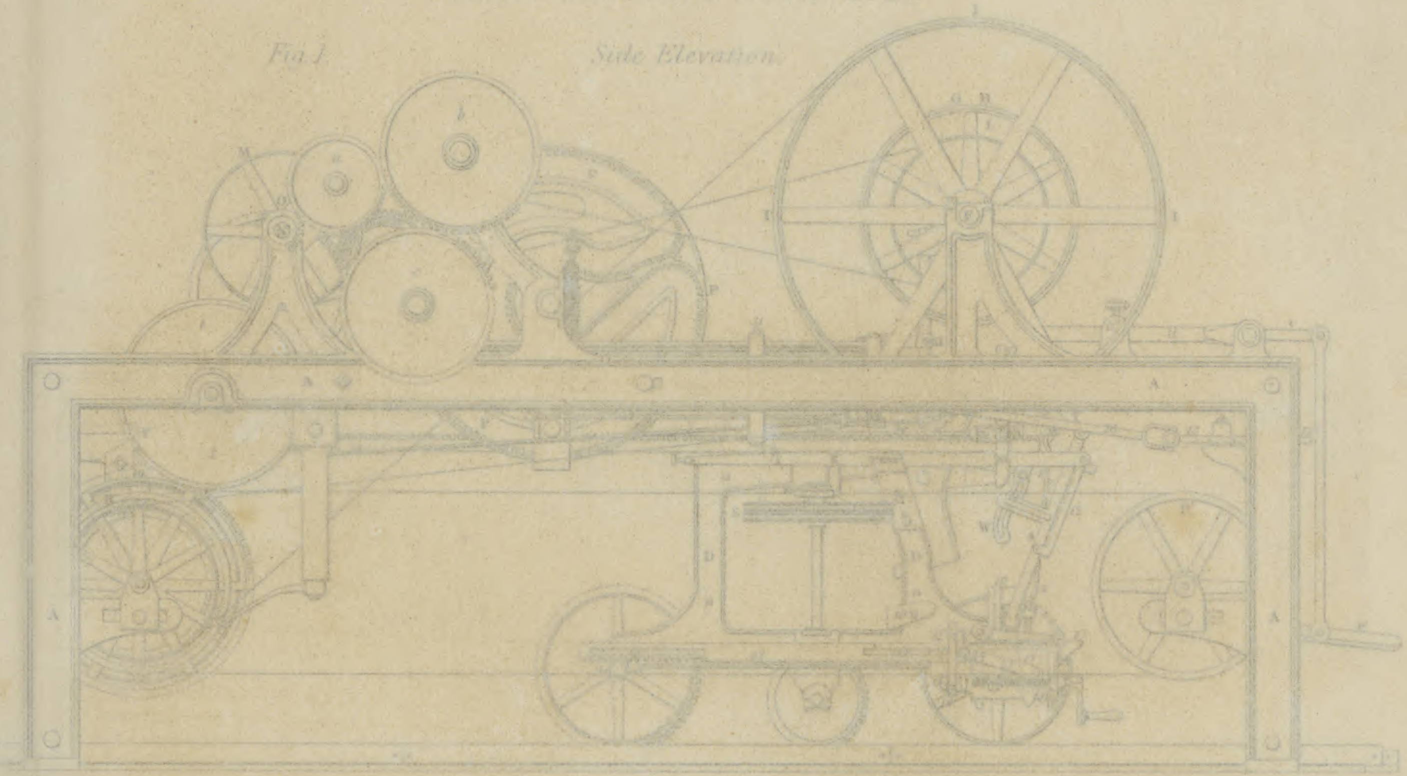
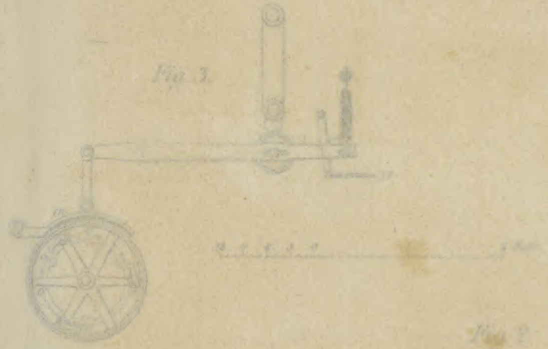


Fig. 3.



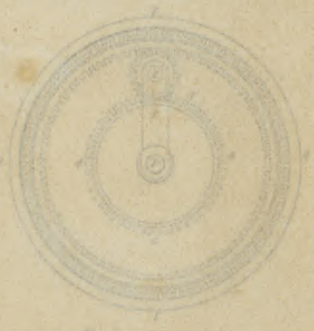


Fig. 4

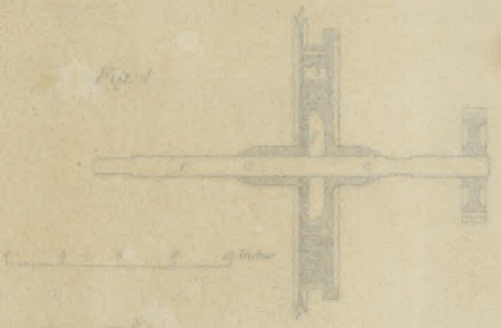
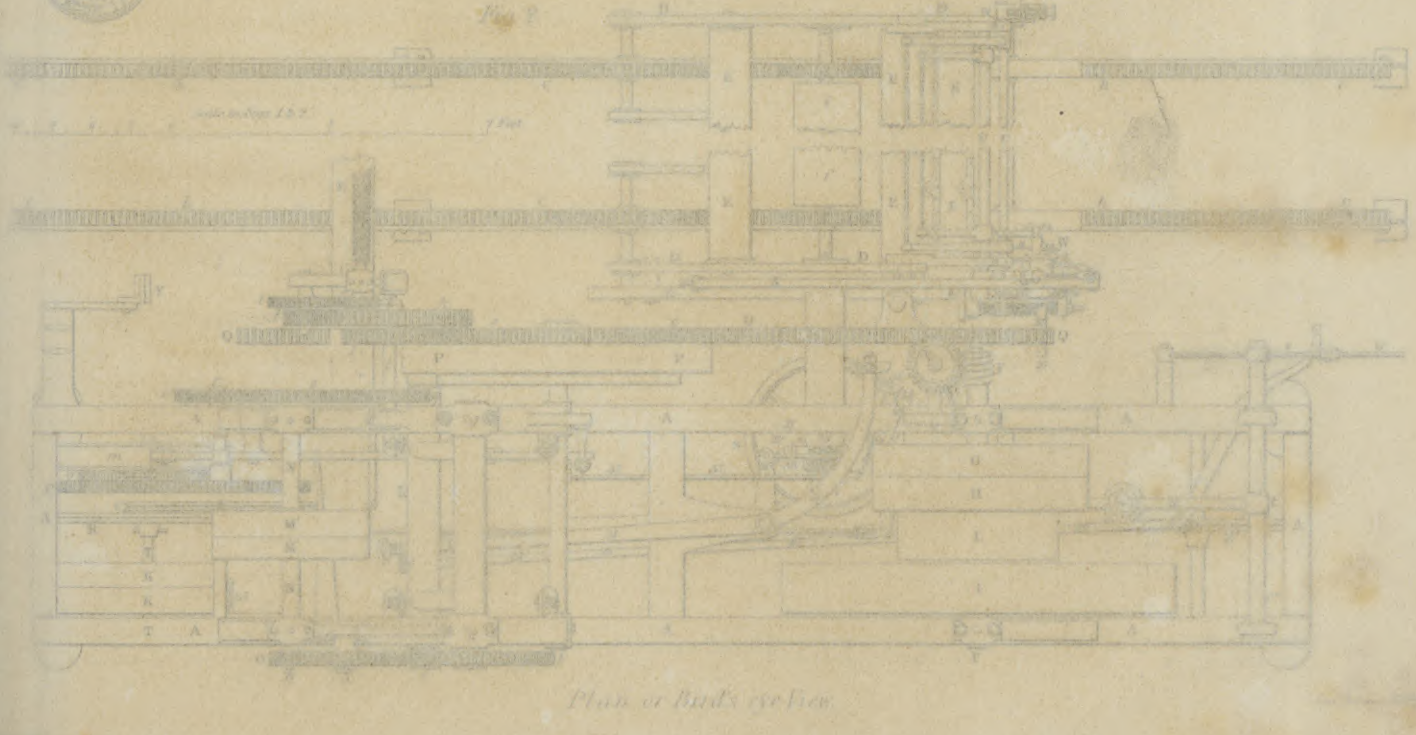


Fig. 2



Plan or Bird's eye View.

SMITH'S SELF ACTING COTTON MULE.

Fig. 1. Side Elevation.

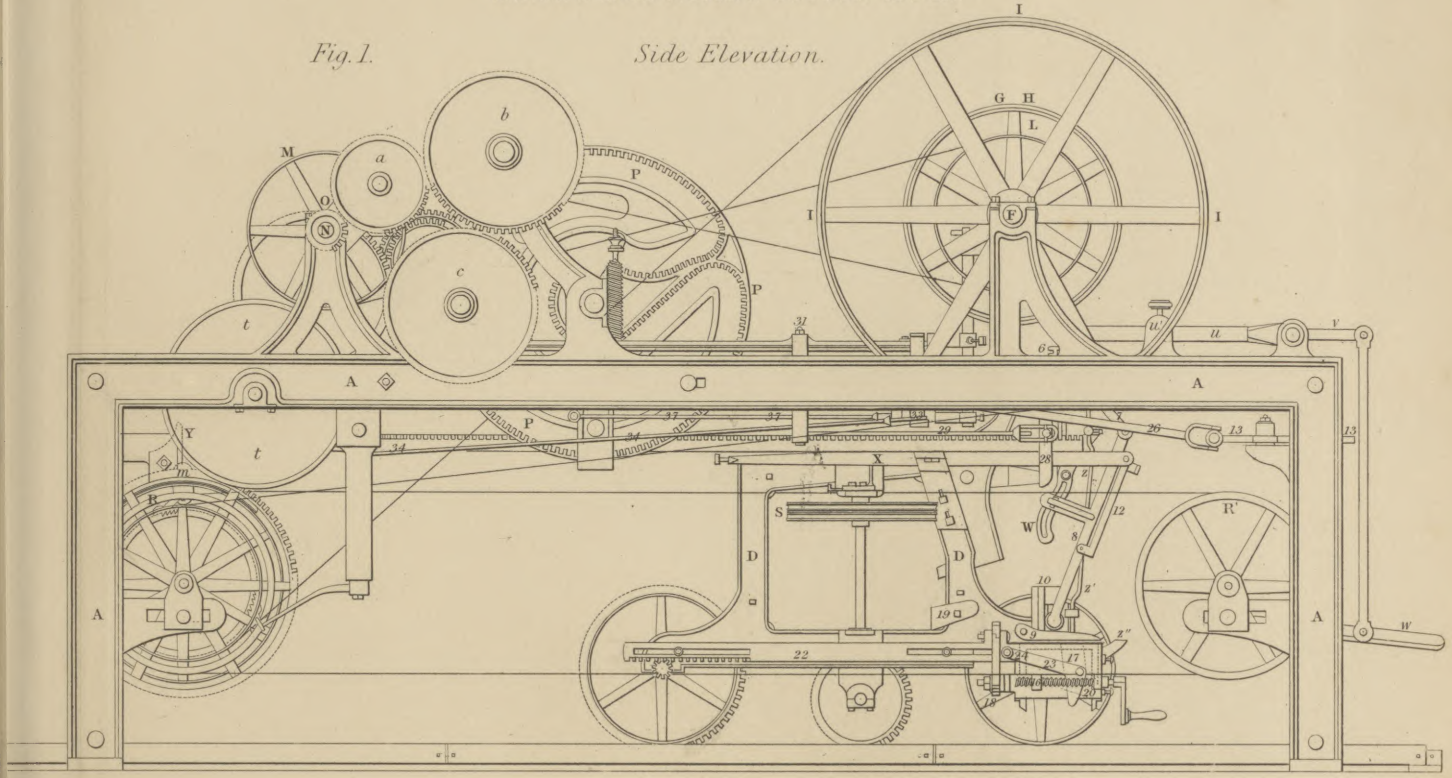


Fig. 3.

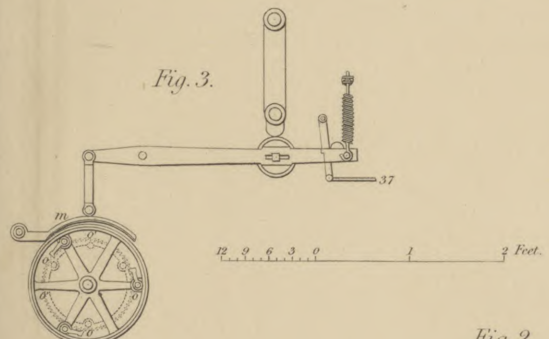


Fig. 4.

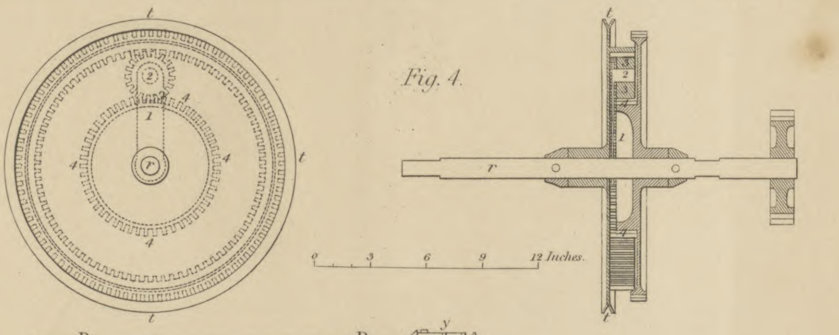
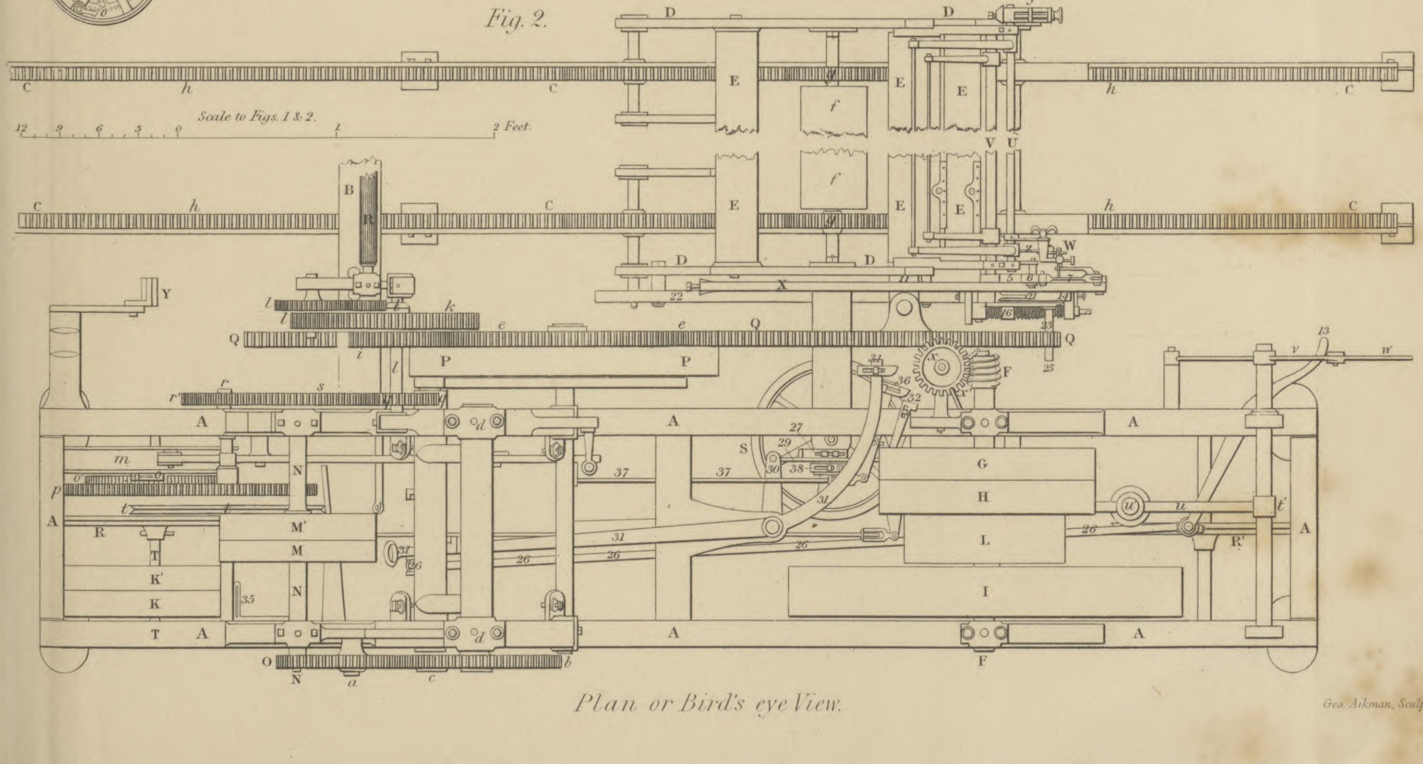


Fig. 2.



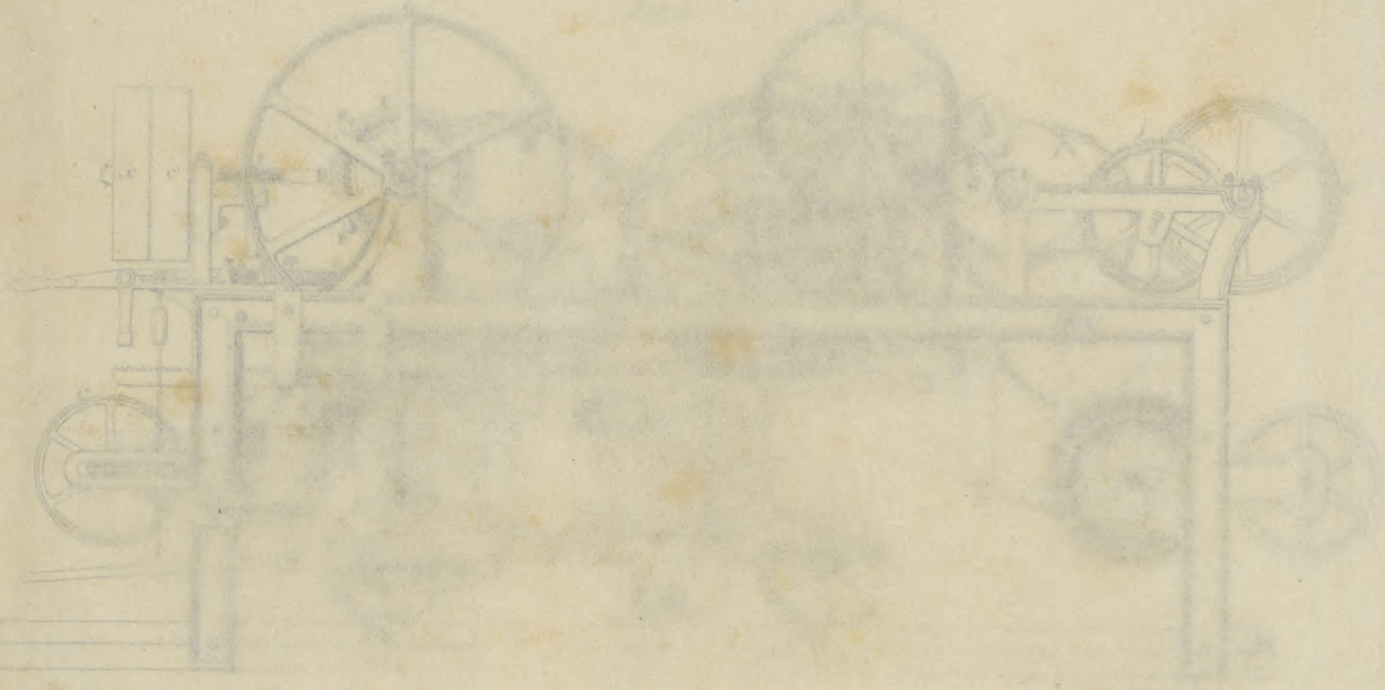
Plan or Bird's eye View.

Geo. Aikman, Sculpt.

SMITH'S SELF ACTING WOOLLEN MULE.

Side Elevation.

Fig. 1.



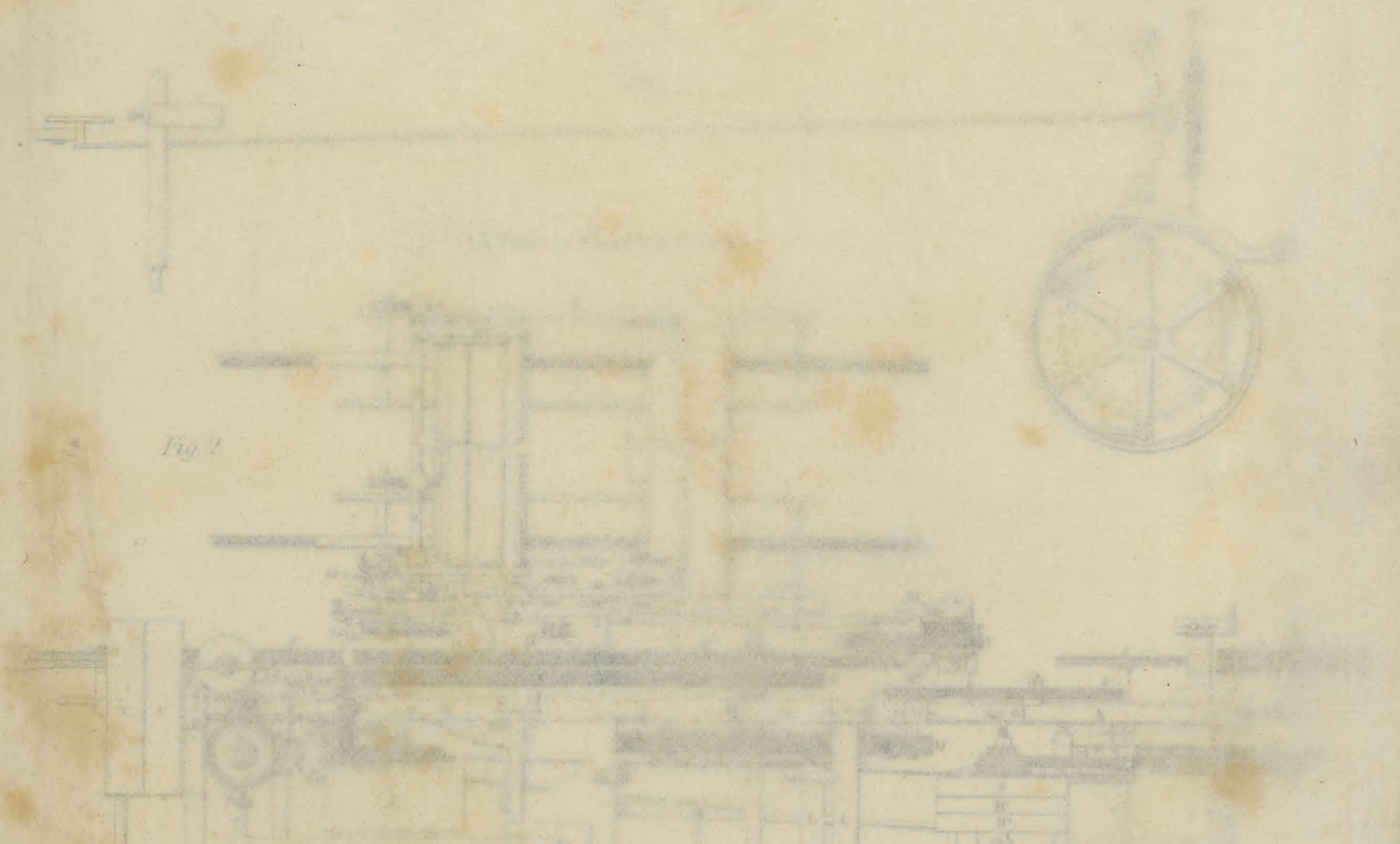


Fig. 2

SPINNING.

SMITH'S SELF ACTING WOOLLEN MULE.

Side Elevation.

Fig. 1.

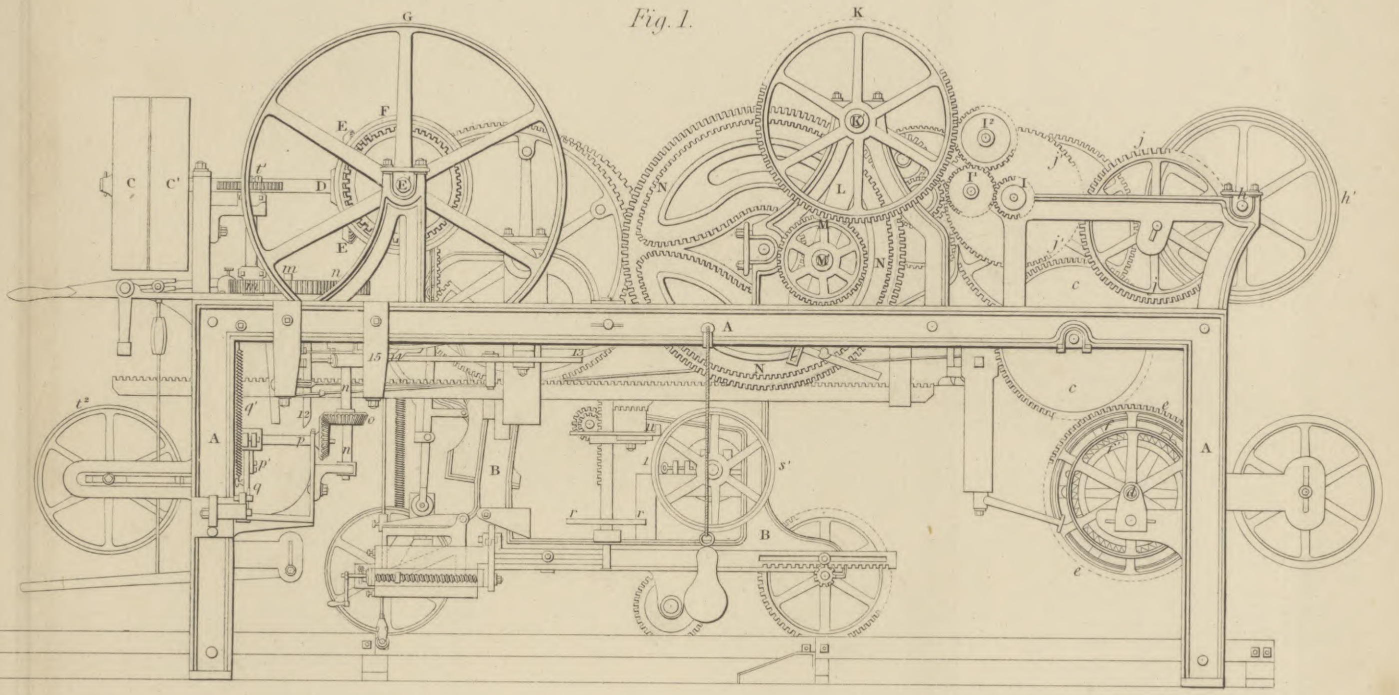
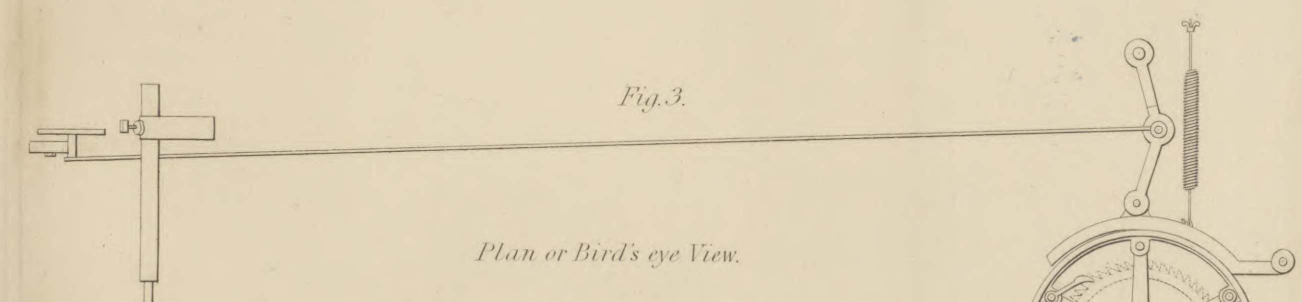
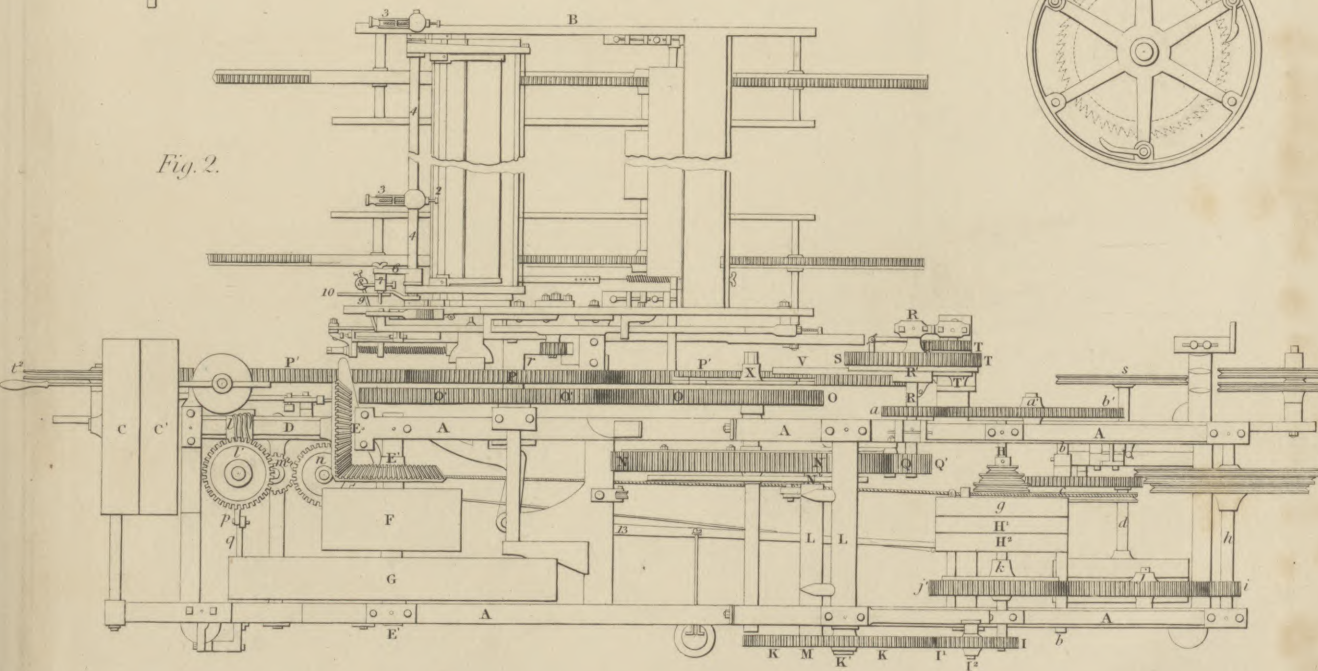


Fig. 3.



Plan or Bird's eye View.

Fig. 2.



Geo. Aikman. Sculpt.

Front Elevation.

Fig. 1.

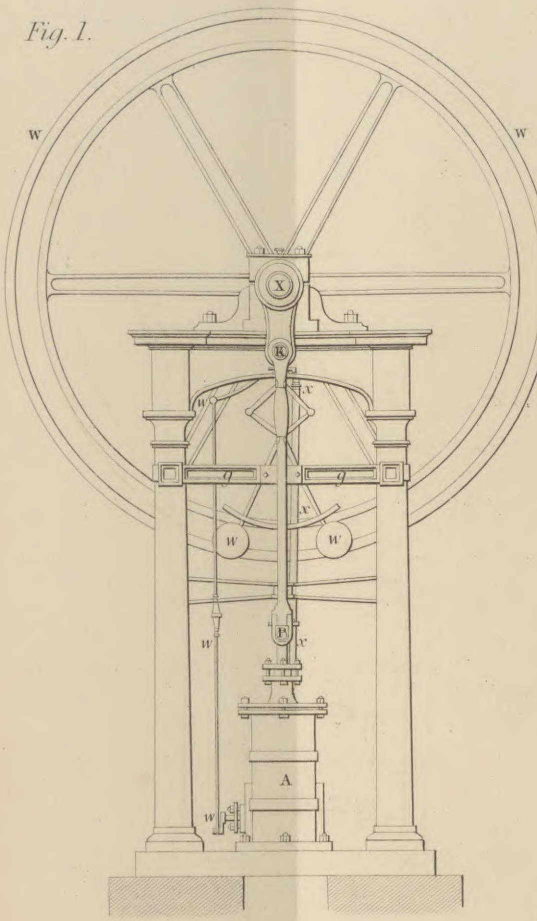


Fig. 2.

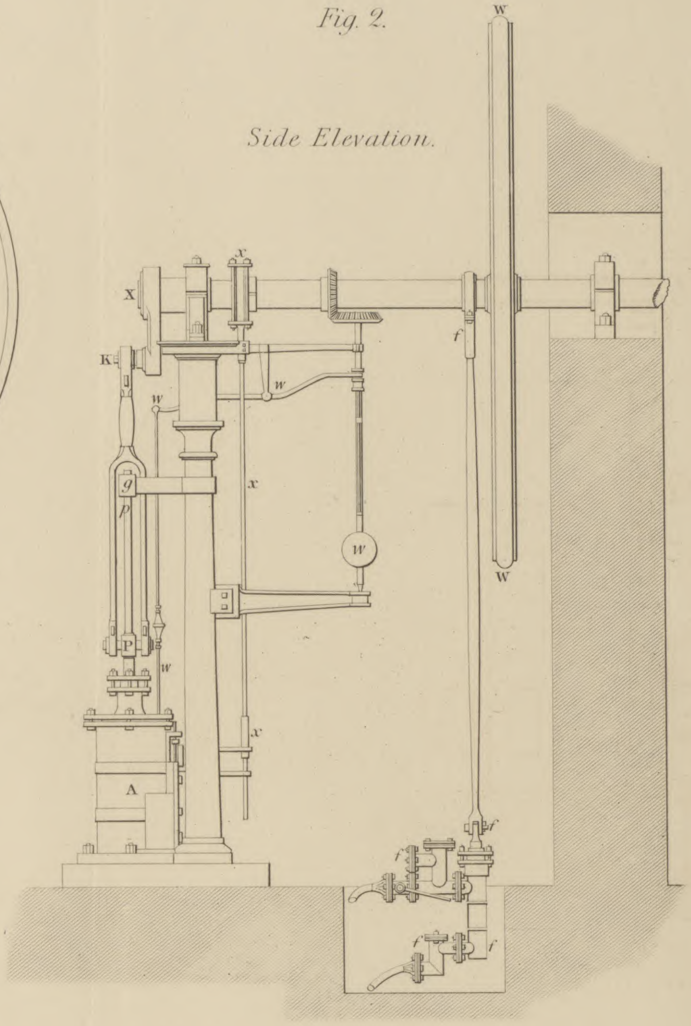
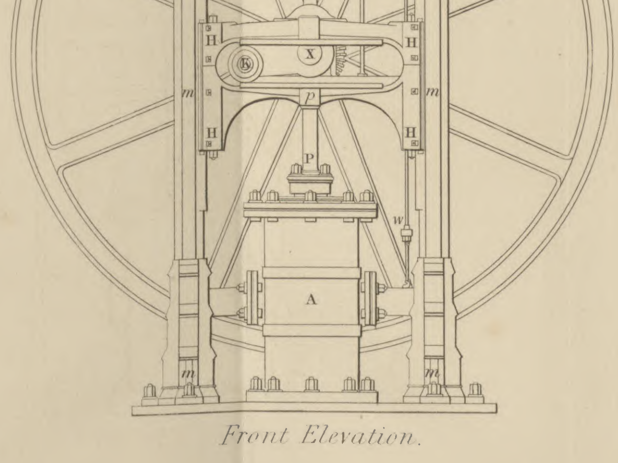
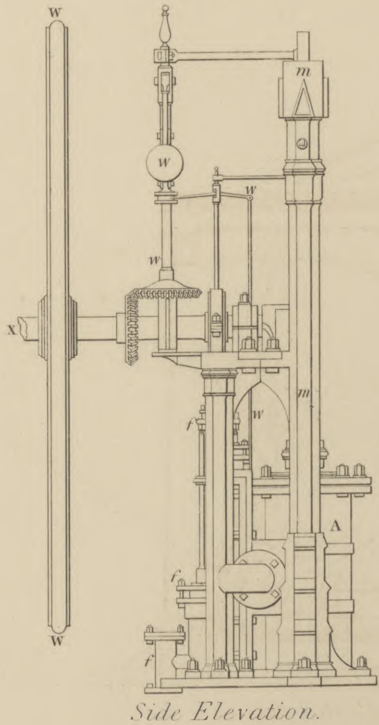

Side Elevation.

Fig. 3.



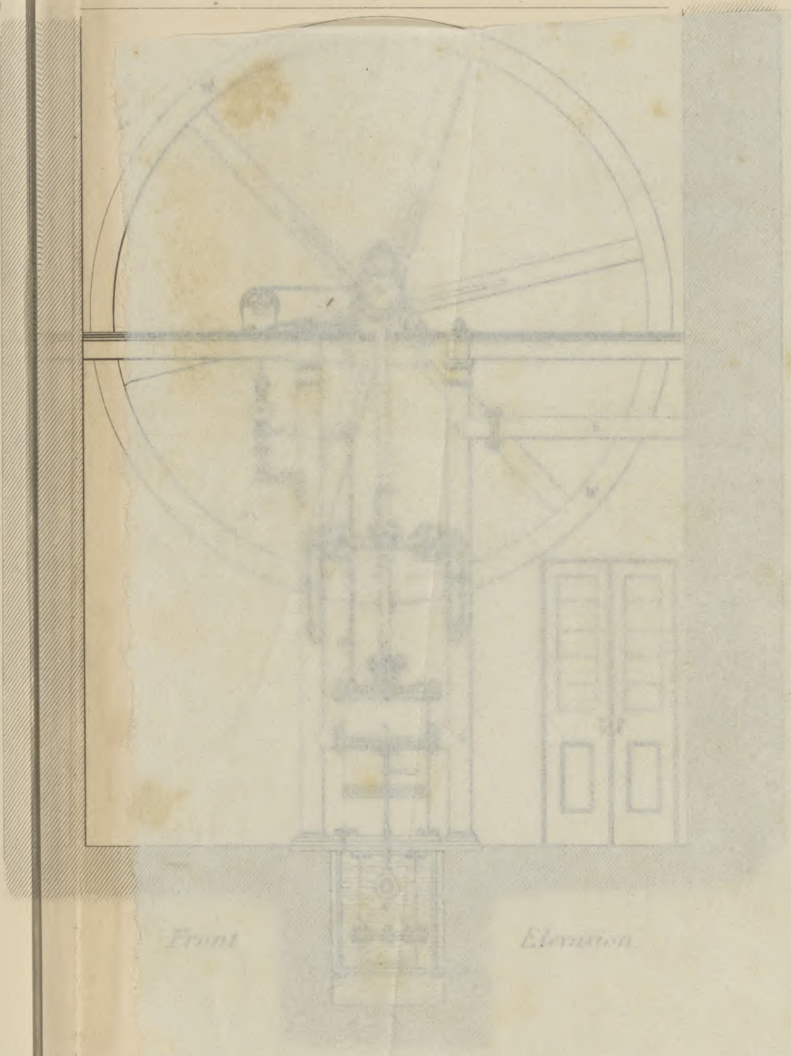
Front Elevation.

Fig. 4.



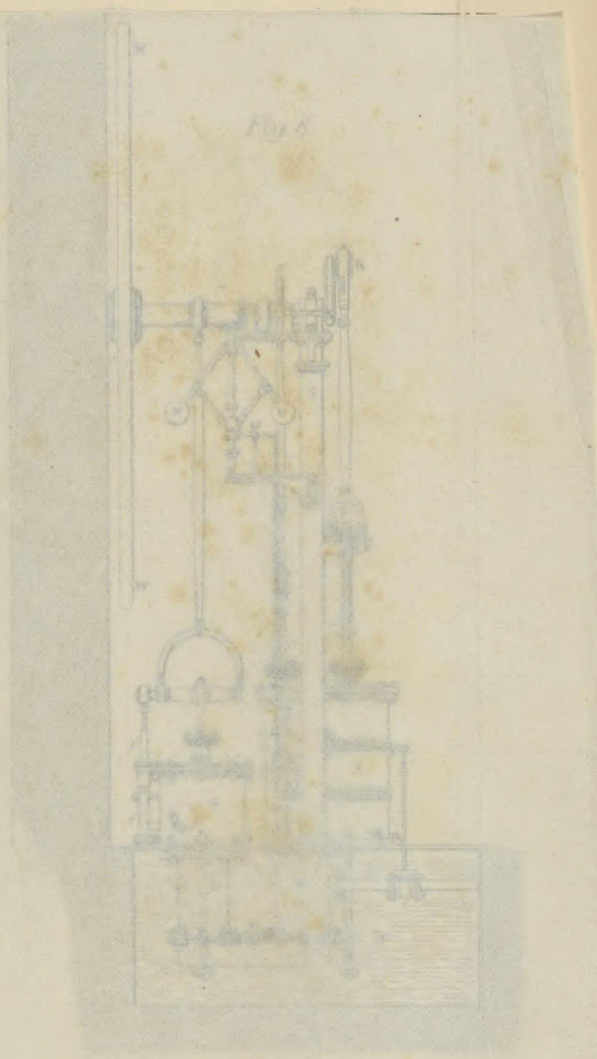
Side Elevation.

Fig. 7.



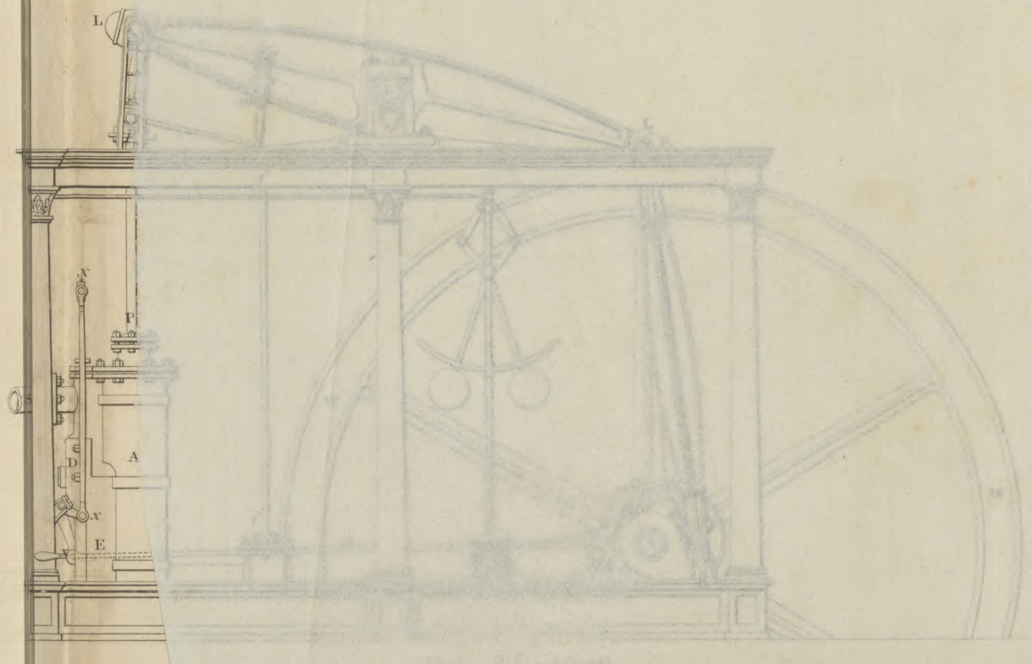
Front Elevation

Fig. 8.



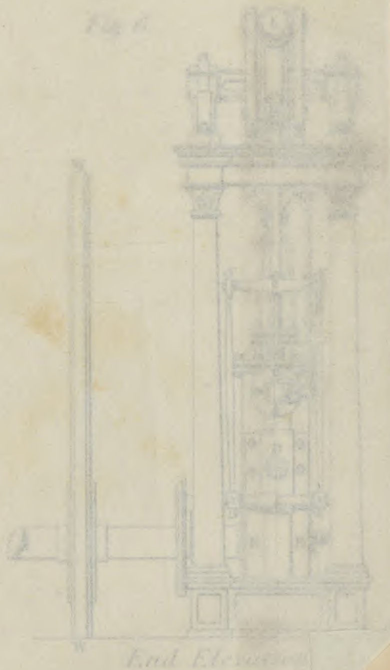
Side Elevation

Fig. 5.



Side Elevation

Fig. 6.



End Elevation

Fig. 1.

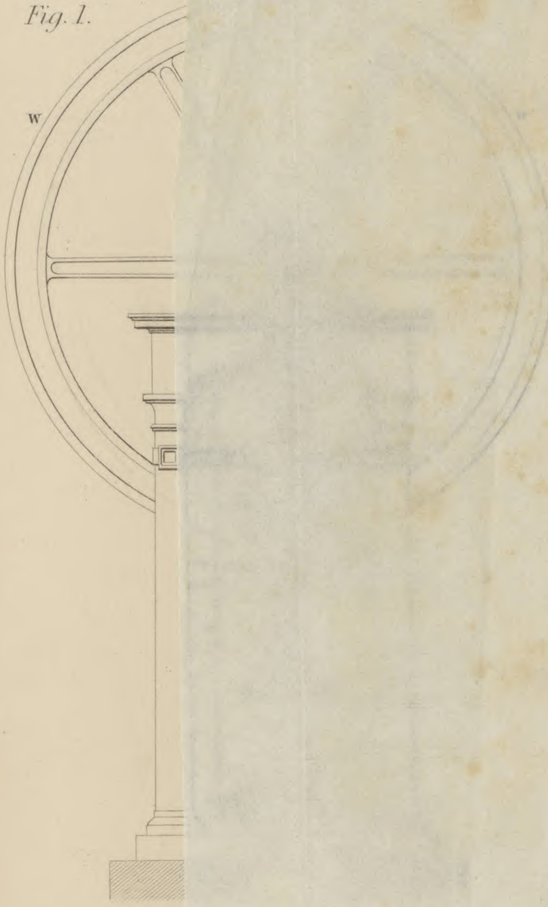
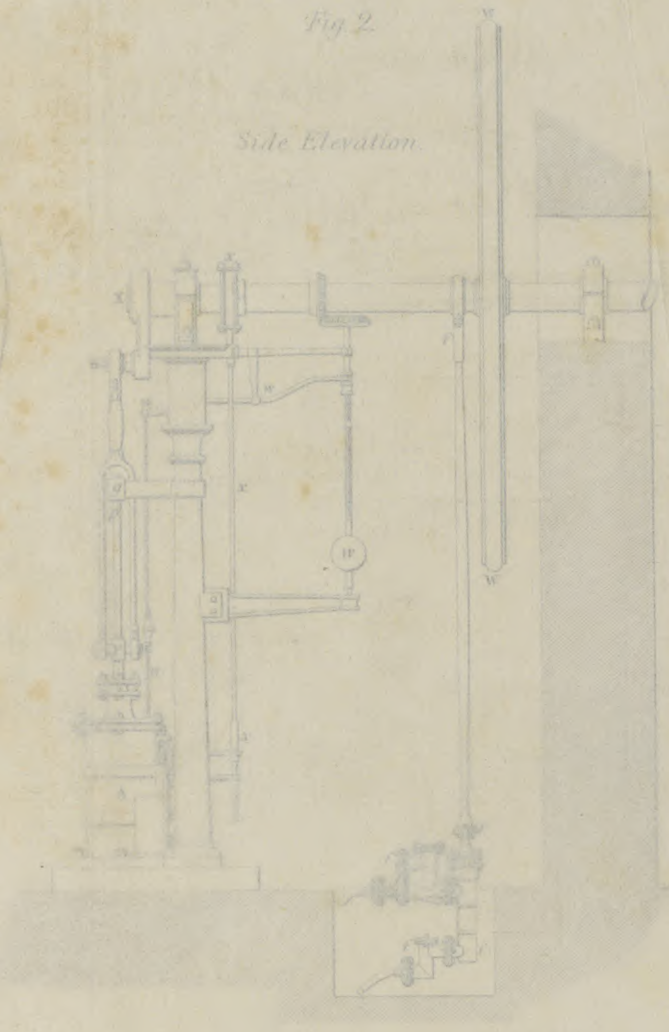
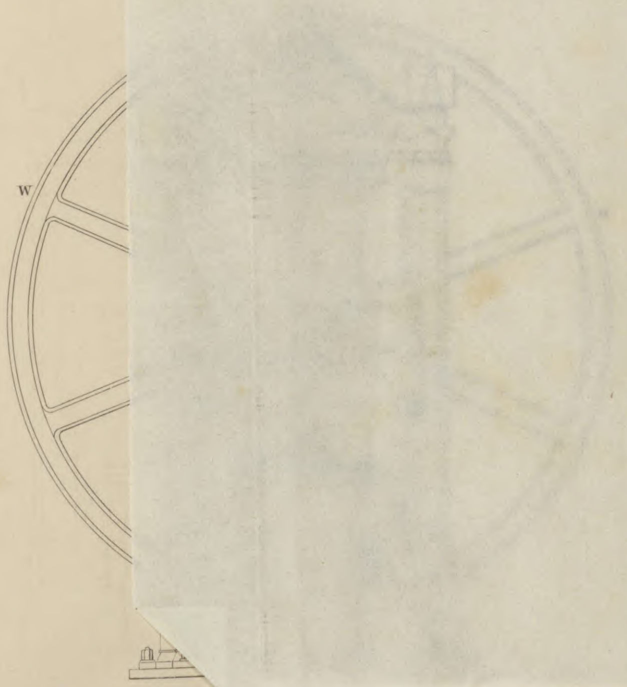


Fig. 2.

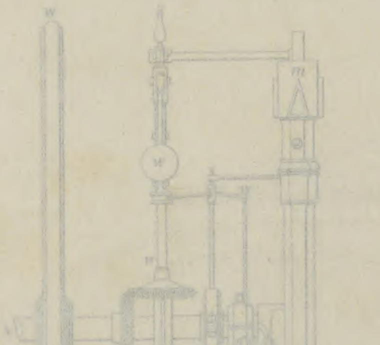
Side Elevation.





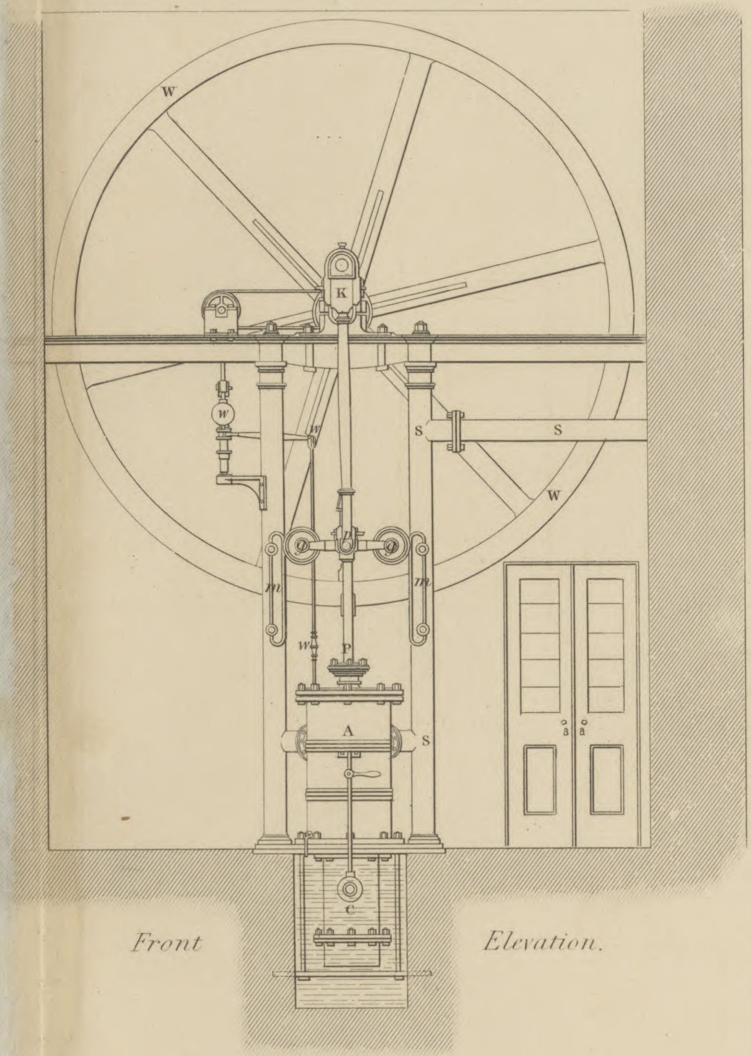
Front Elevation.

Fig. 4.

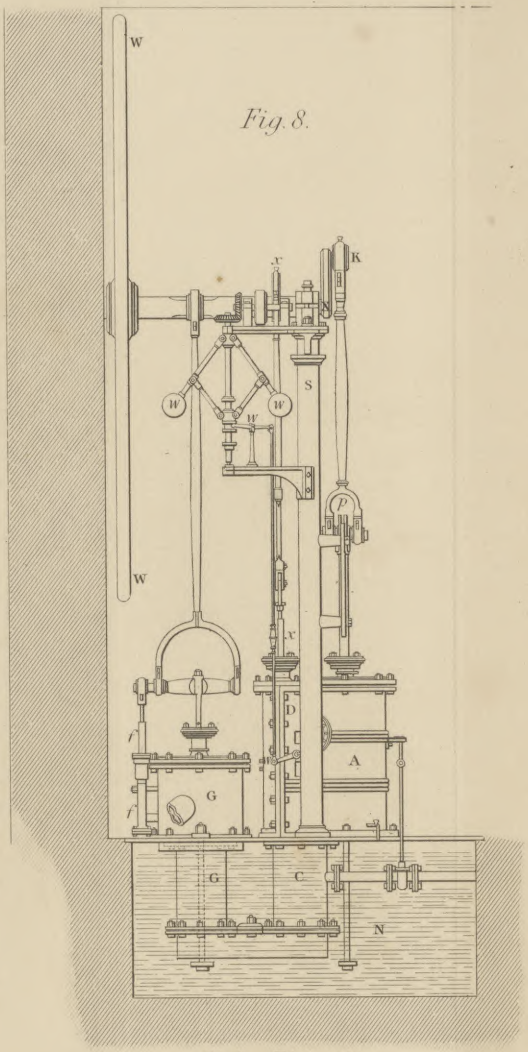


Side Elevation.

Fig. 7.

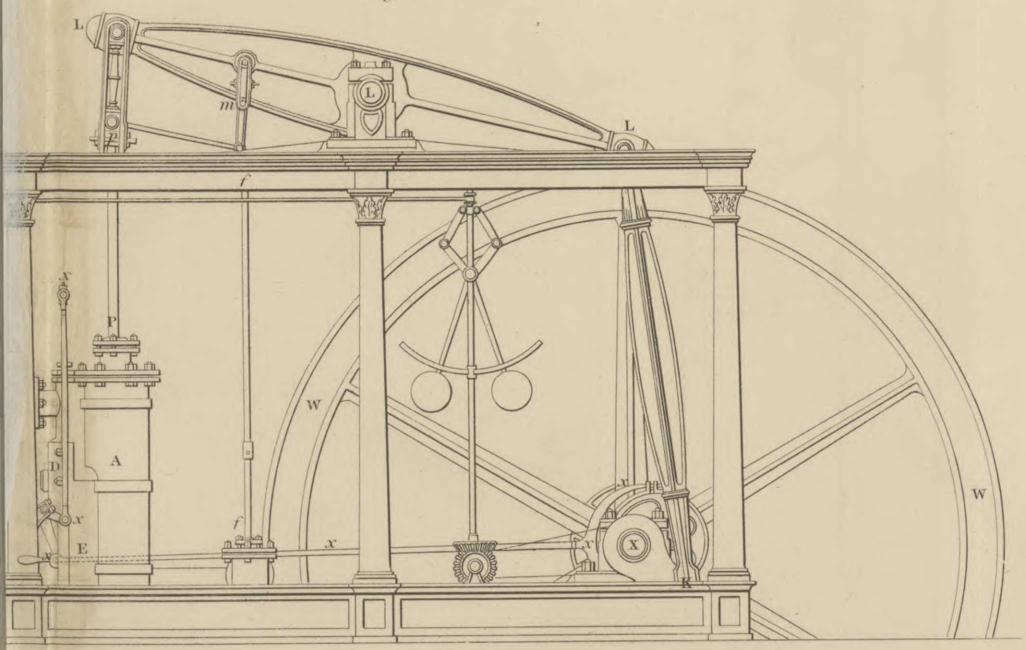


Front Elevation.



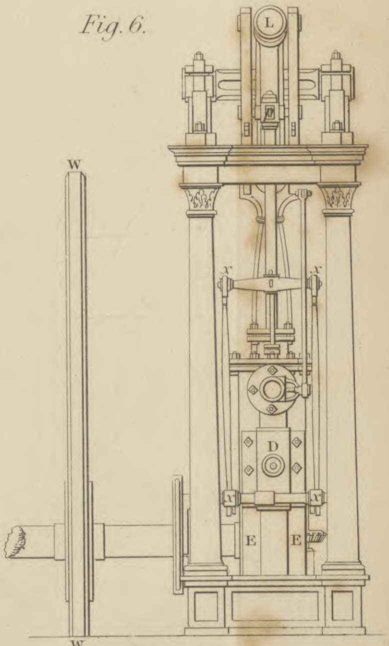
Side Elevation.

Fig. 5.



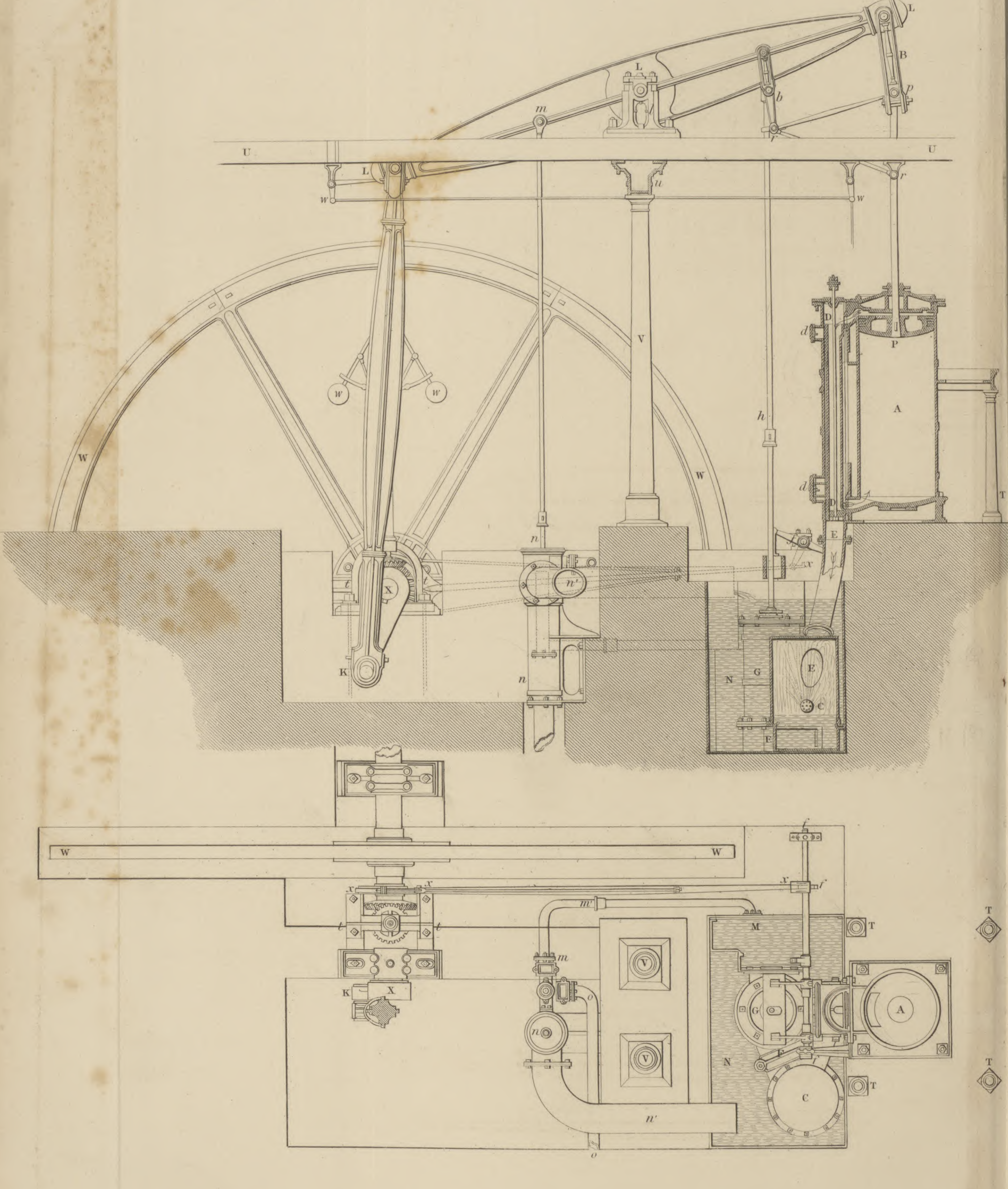
Side Elevation.

Fig. 6.



End Elevation.

STEAM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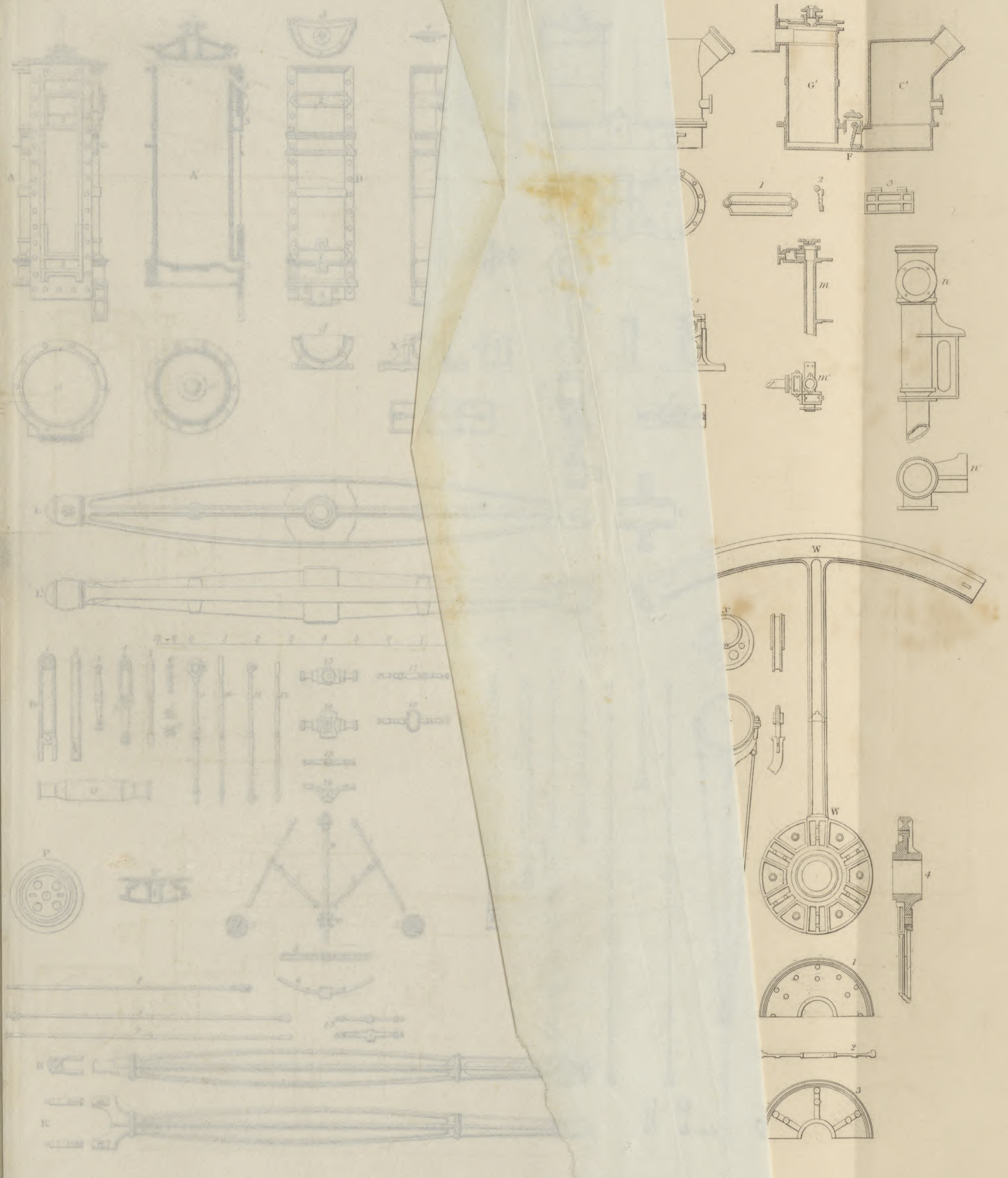
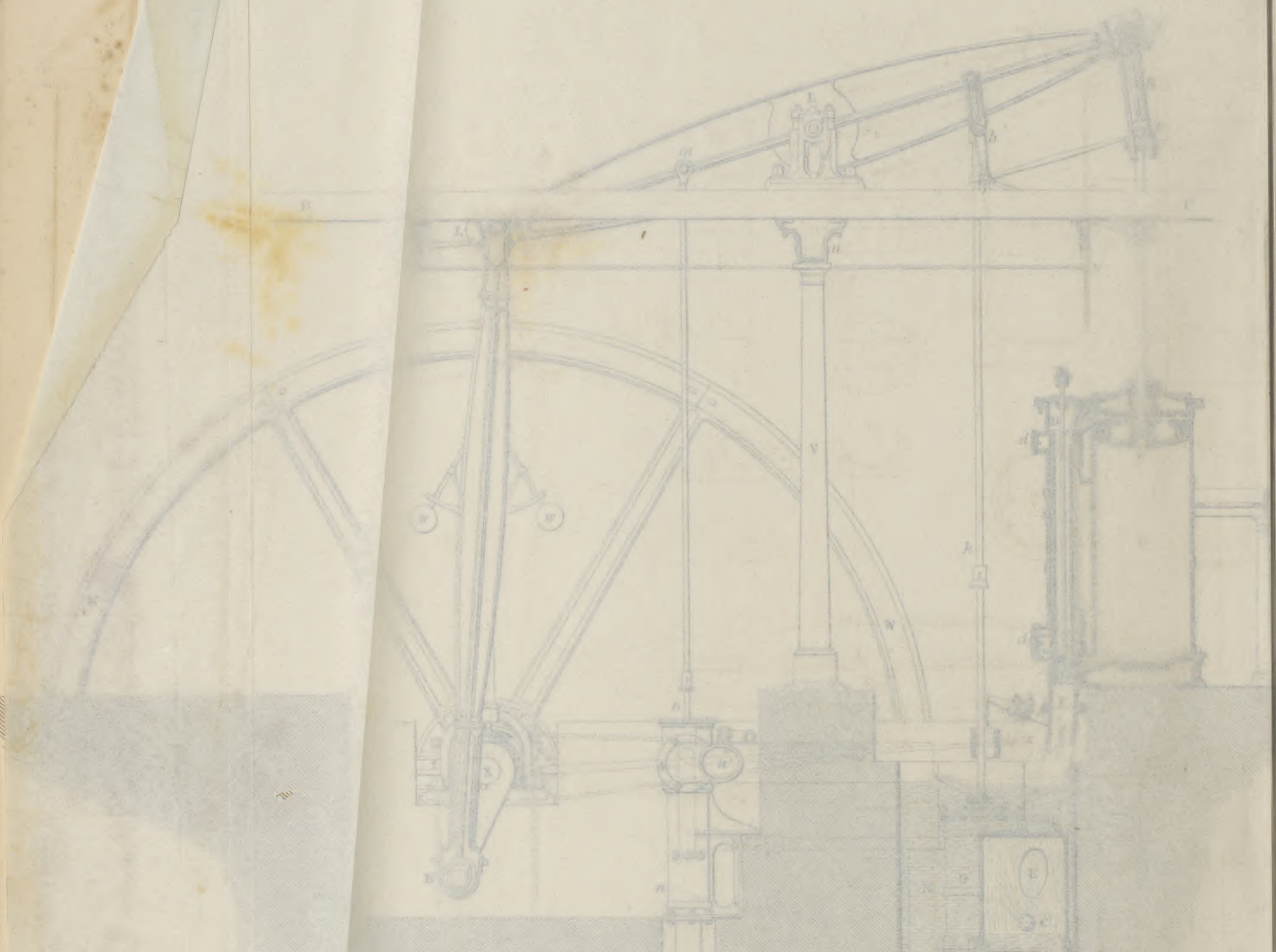
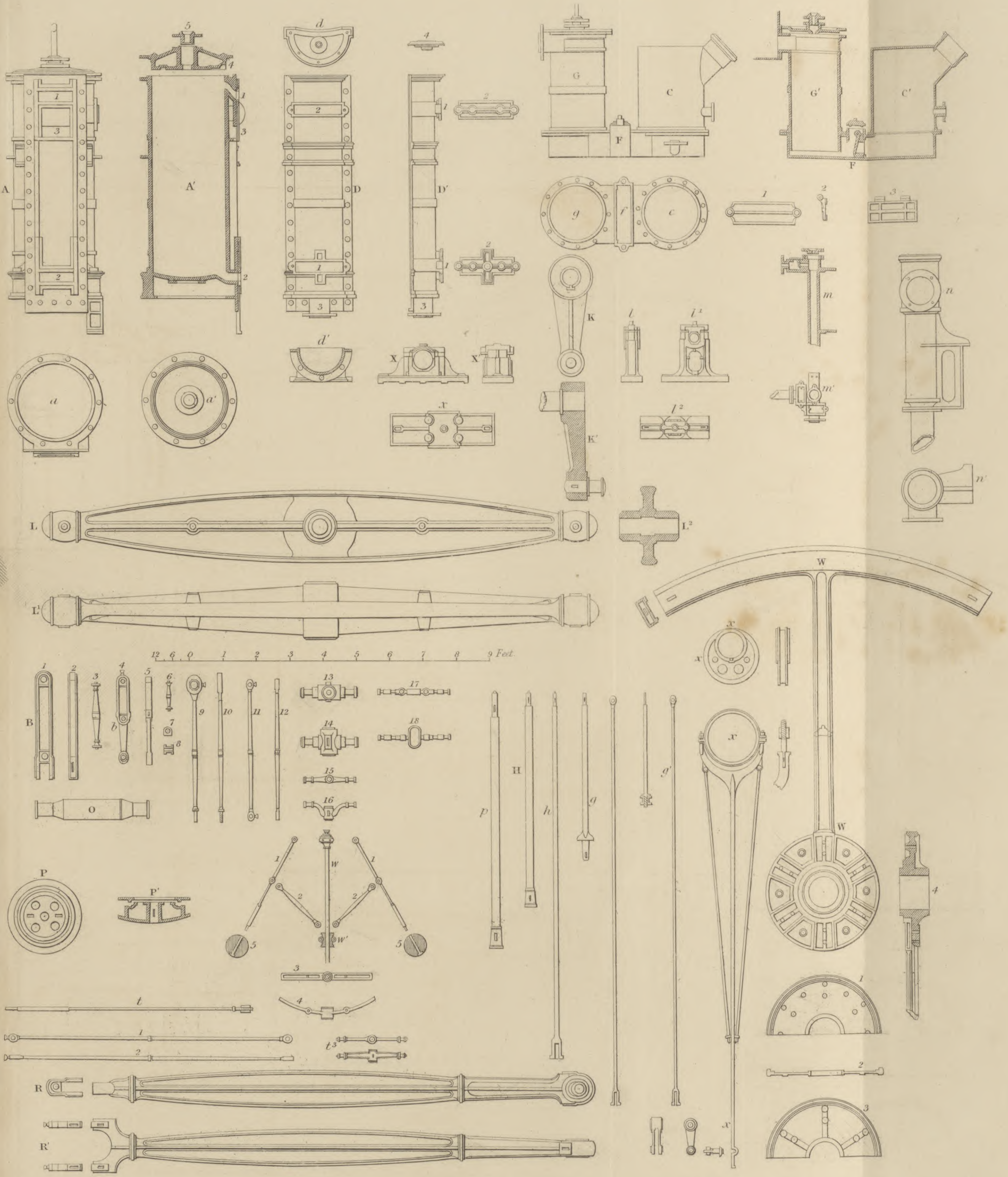


Geo. Aikman, Sculp^t

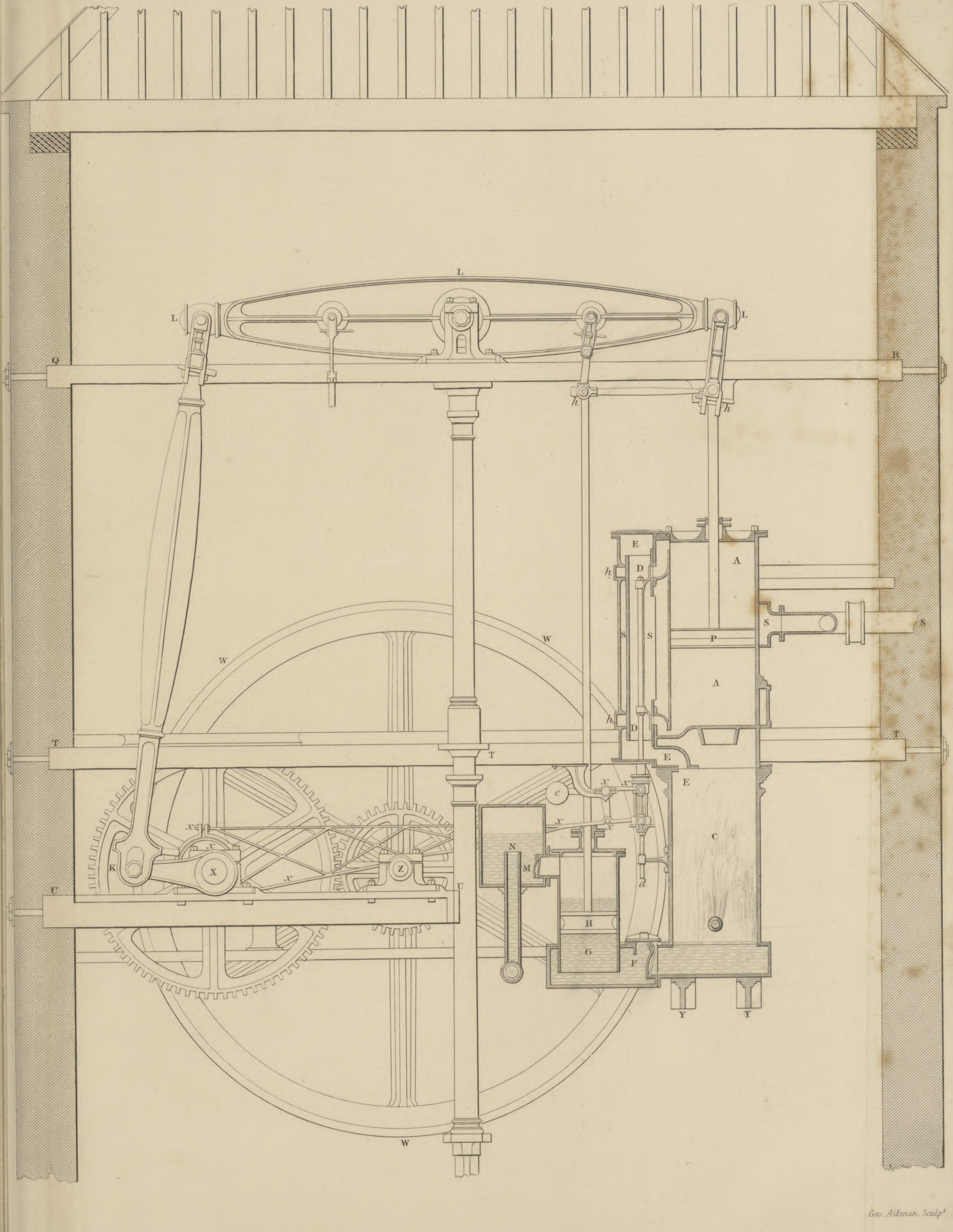




Geo. Aikman, Sculpt.

STEAM ENGINE.

PLATE CCCCLXX.



Geo. Aikman, Sculpt.

High Pressure Engine used at the Liverpool Railway Station.

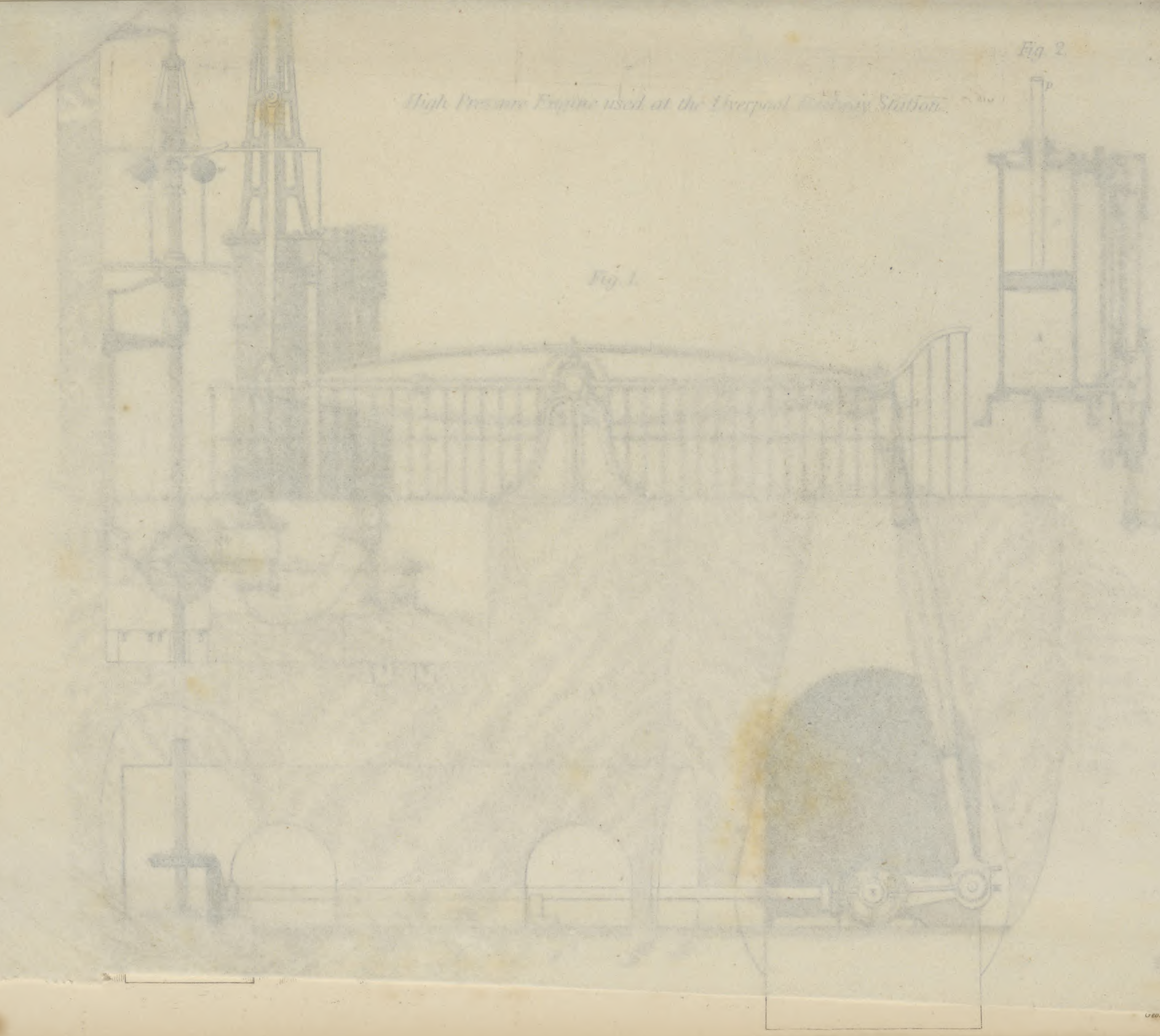


Fig. 1.

Fig. 2.

PLATE CCCCLXI.

STEAM ENGINE.

High Pressure Engine used at the Liverpool Railway Station.

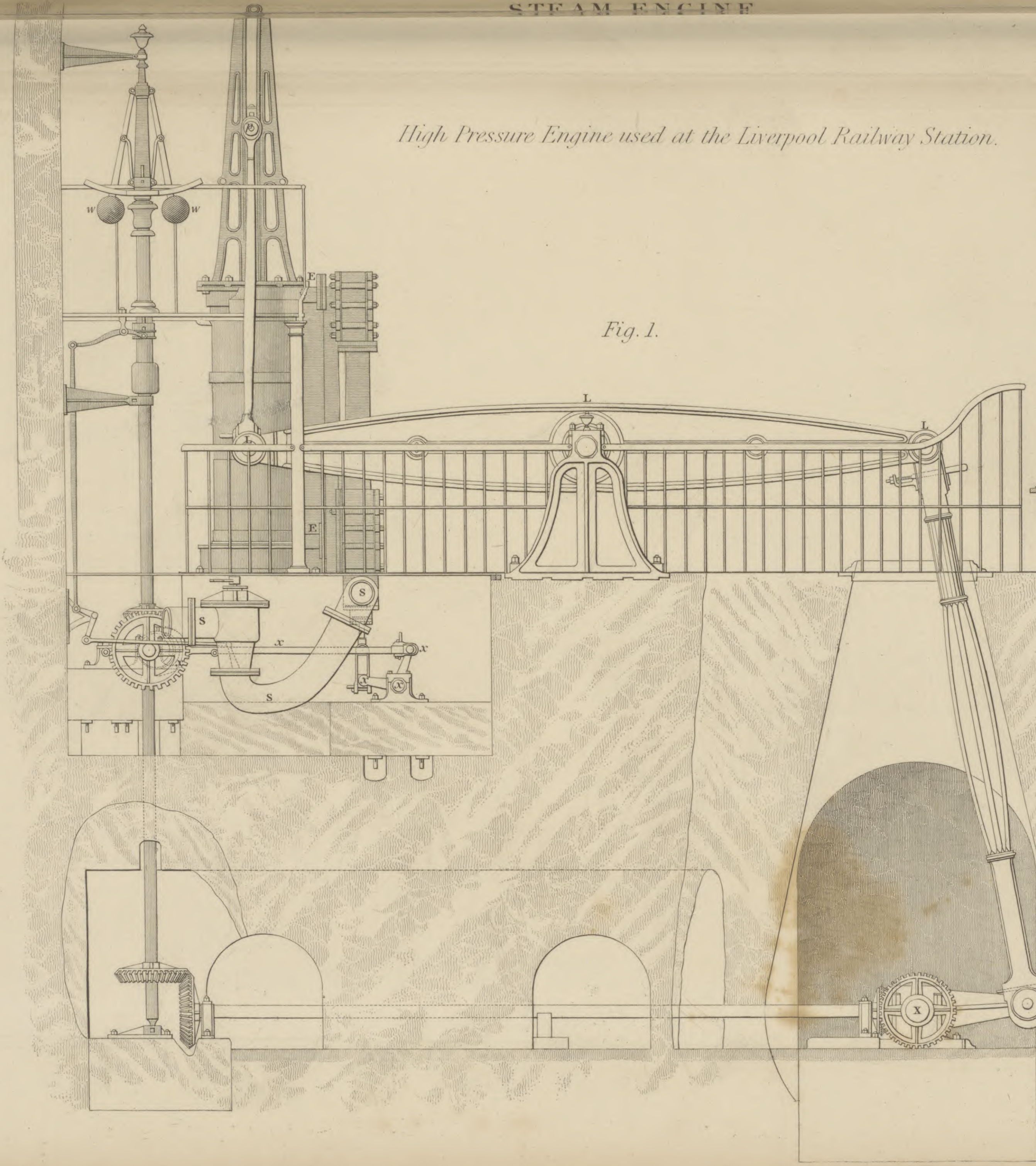


Fig. 1.

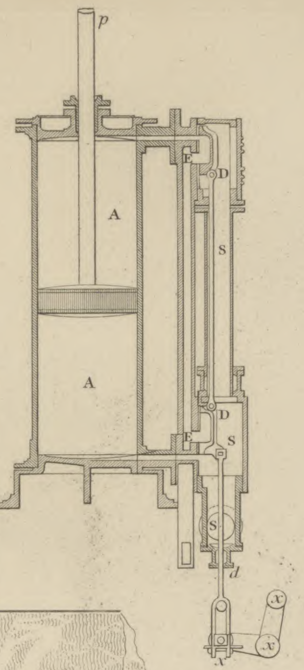


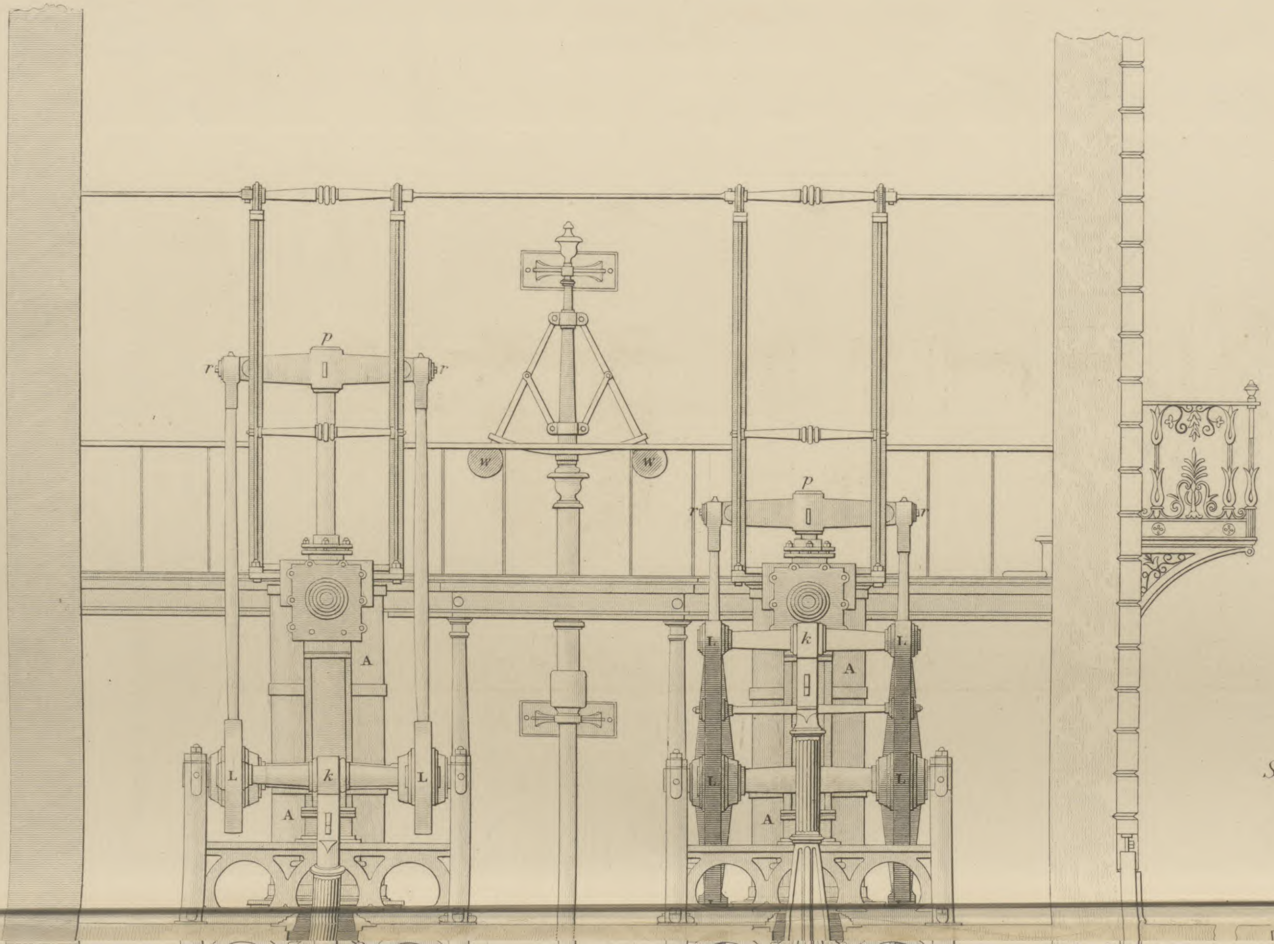
Fig. 2.

Geo. Aikman, Sculp^t

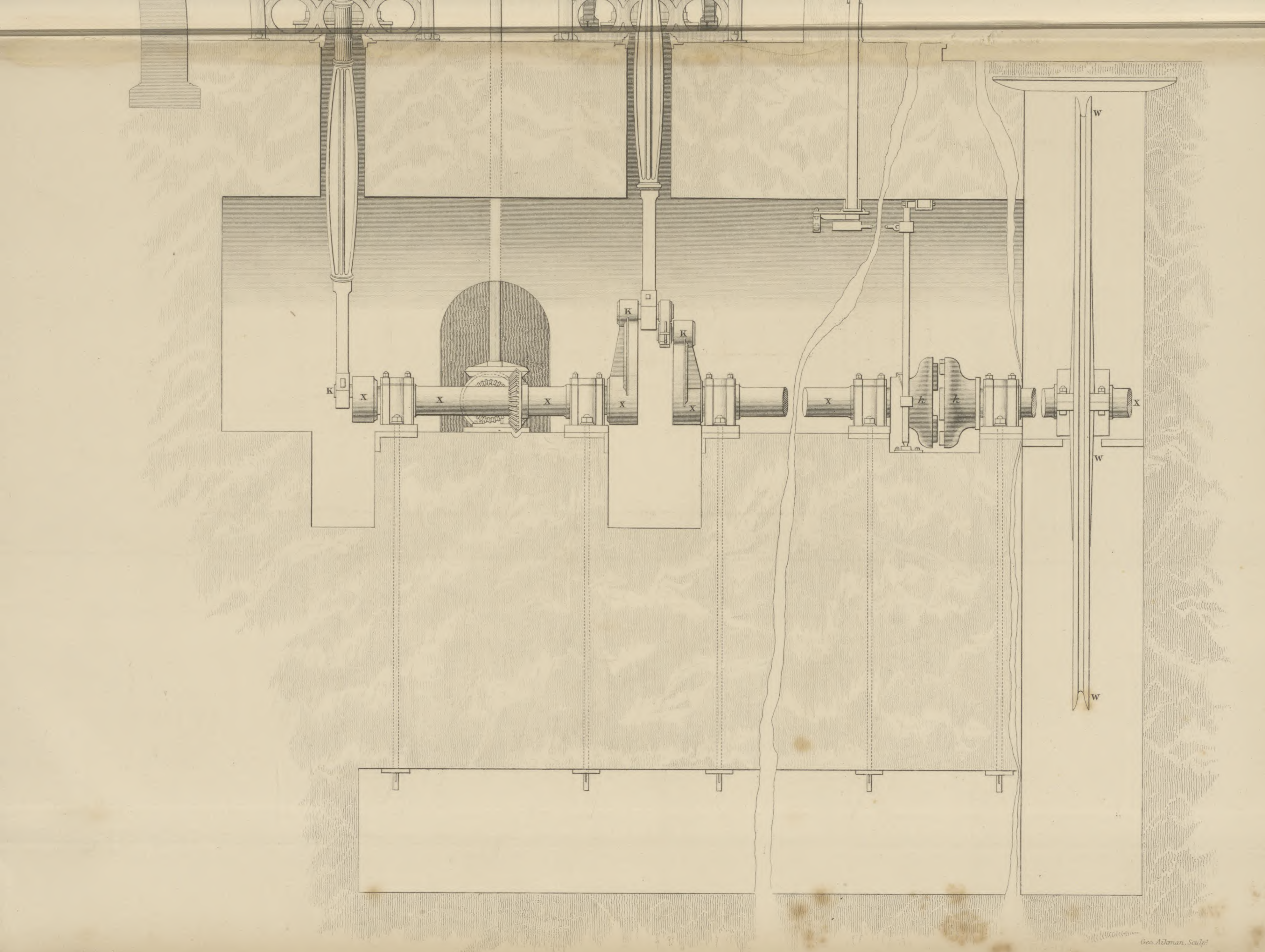
STEAM ENGINE.

PLATE CCCCLXXII.

High Pressure Engine used at the Liverpool Railway Station.

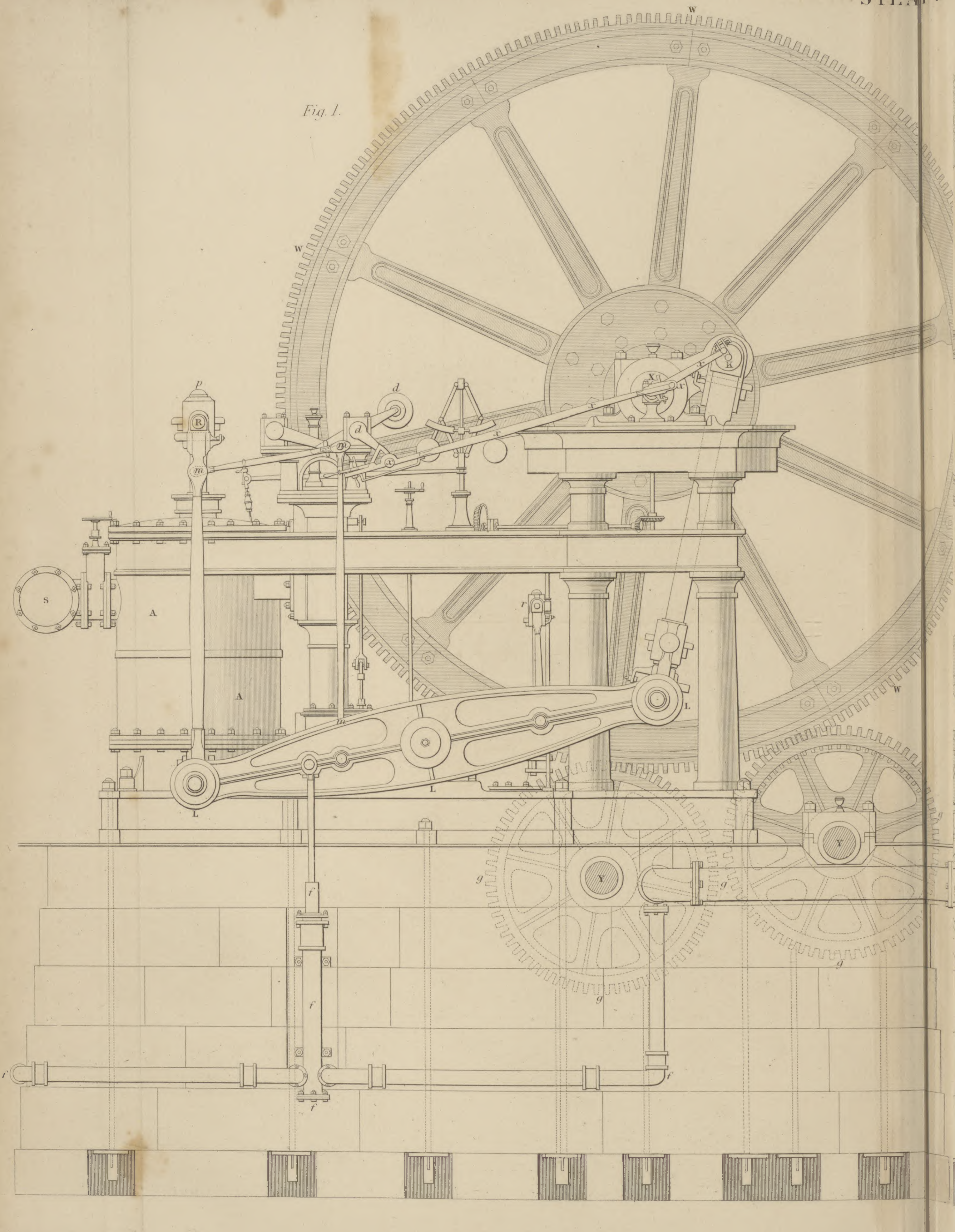


Sectional End Elevation.



Geo. Aikman, Sculpt.

Fig. 1.



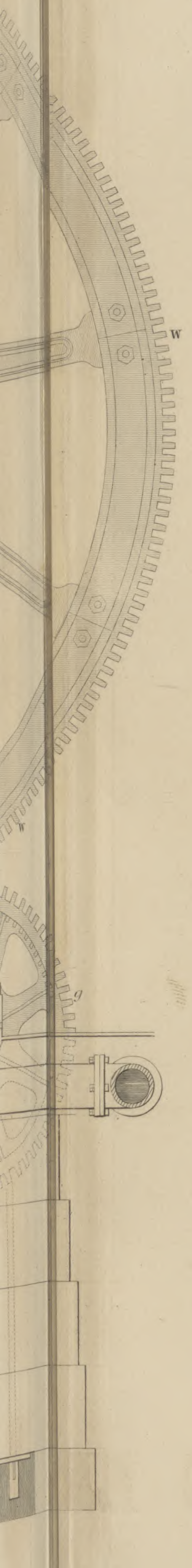
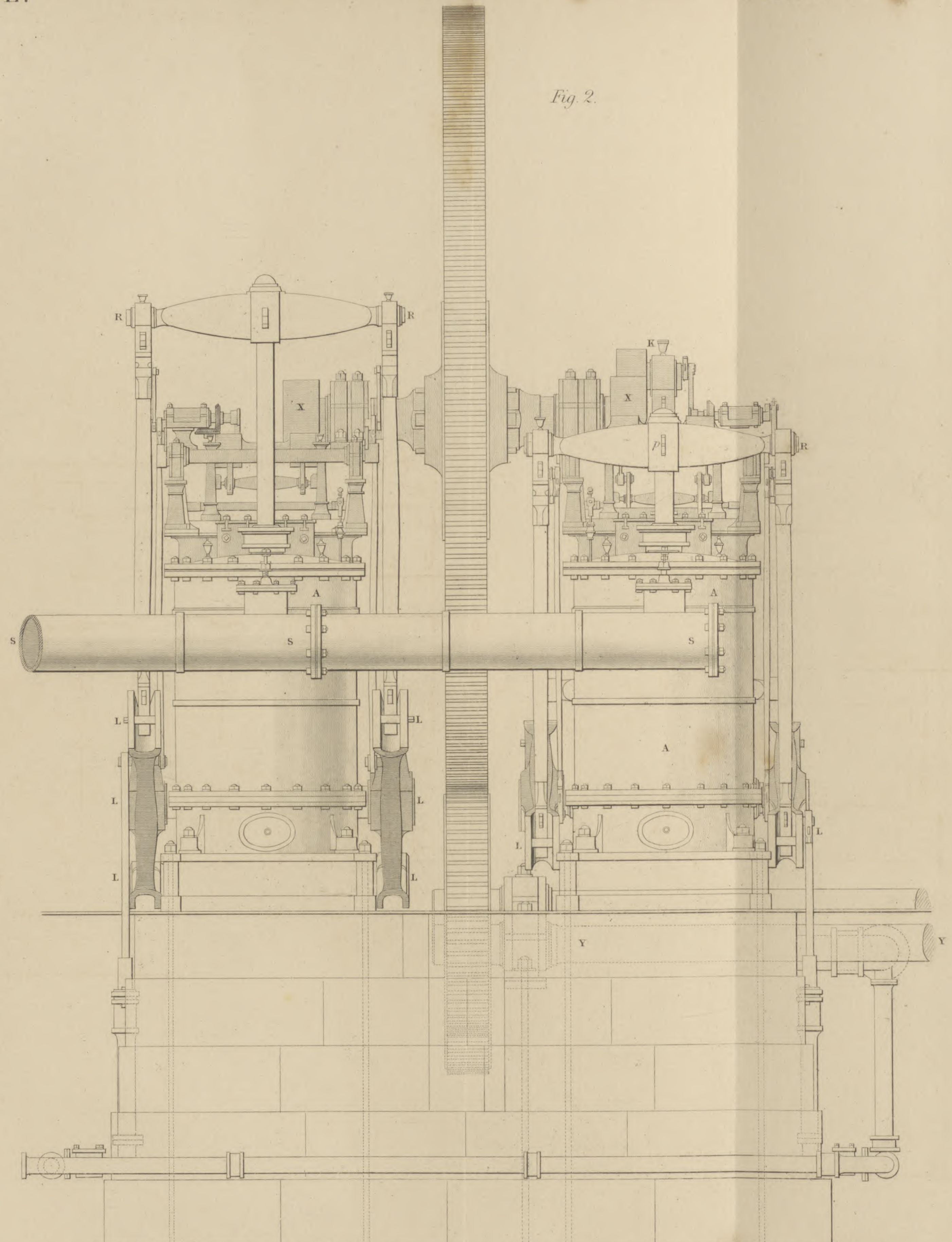


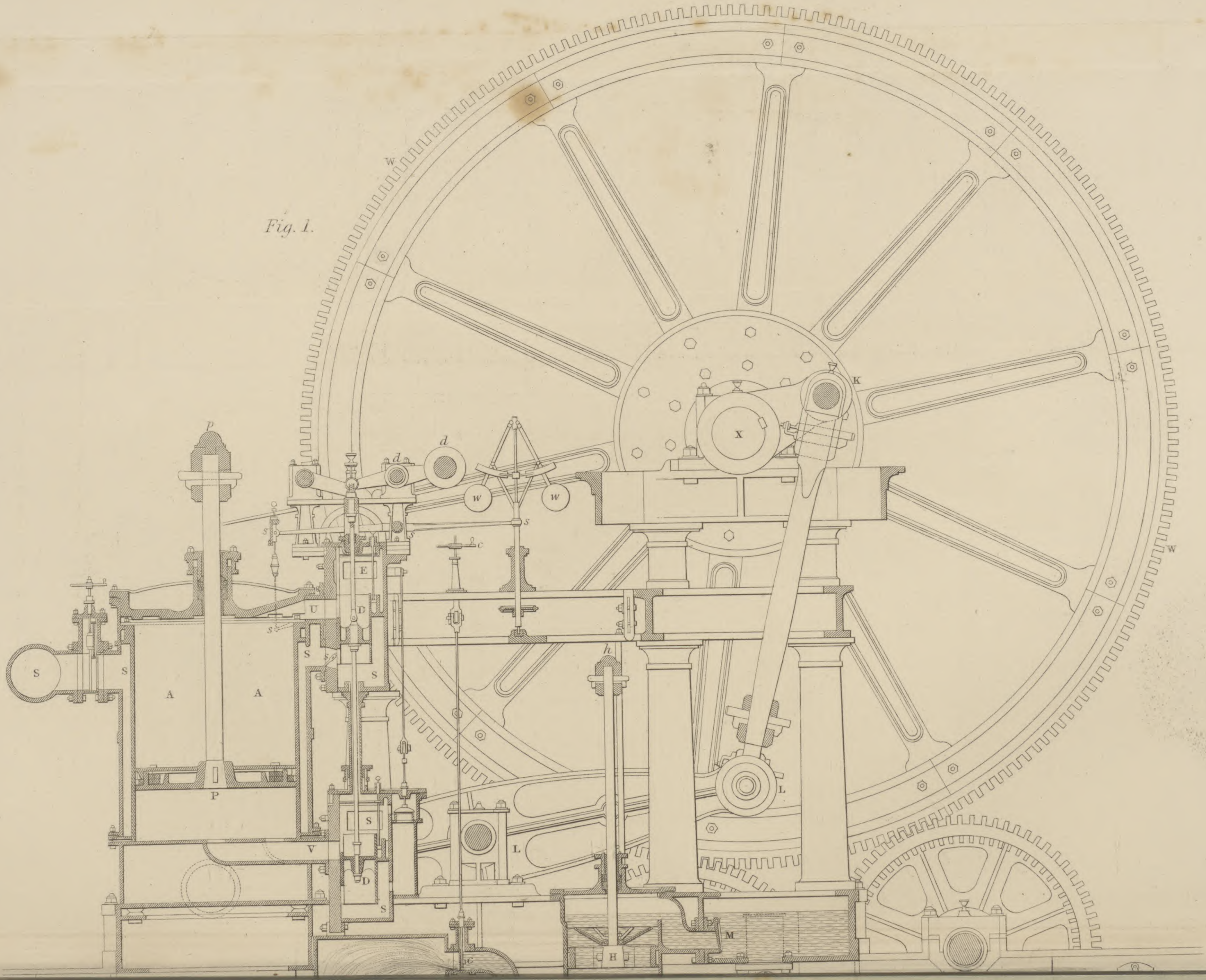
Fig. 2.

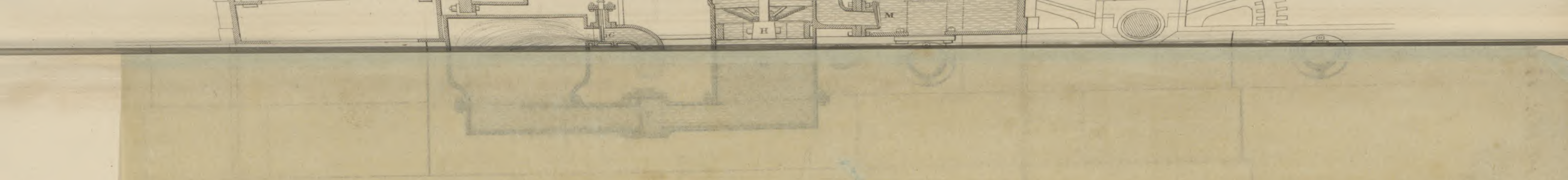


Geo. Aikman, Sculpᵗ.

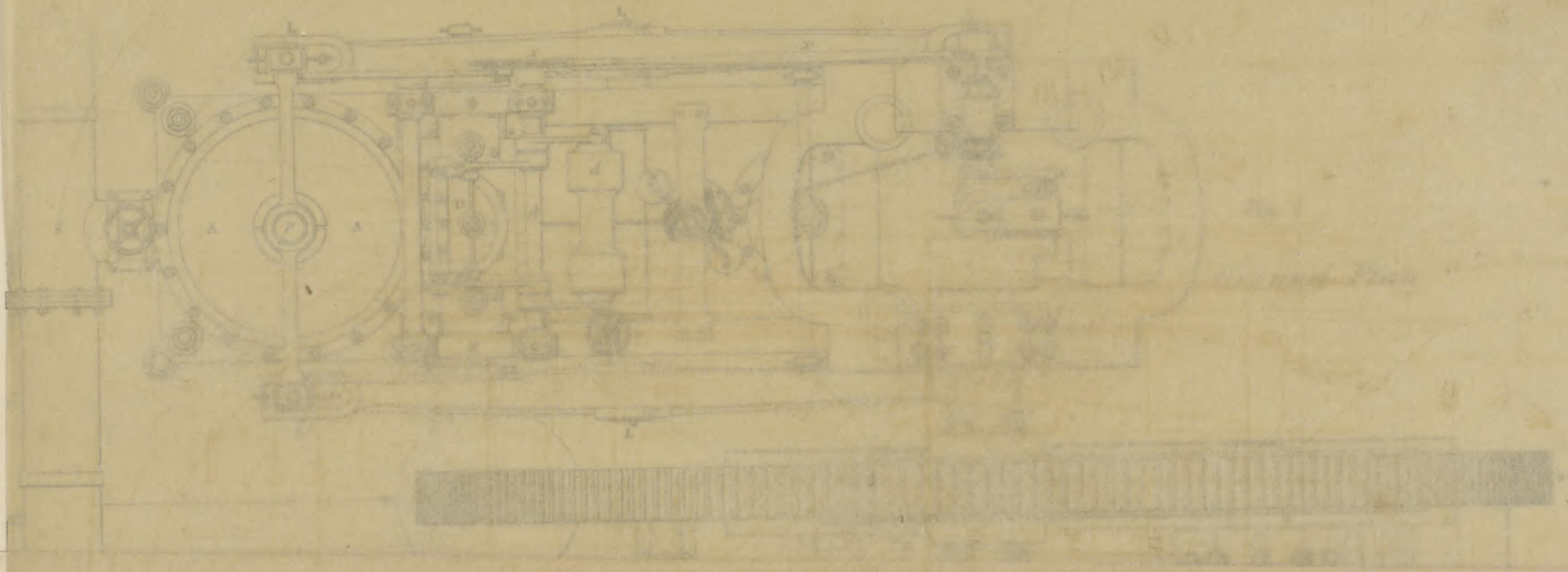
STEAM ENGINE.

Fig. 1.

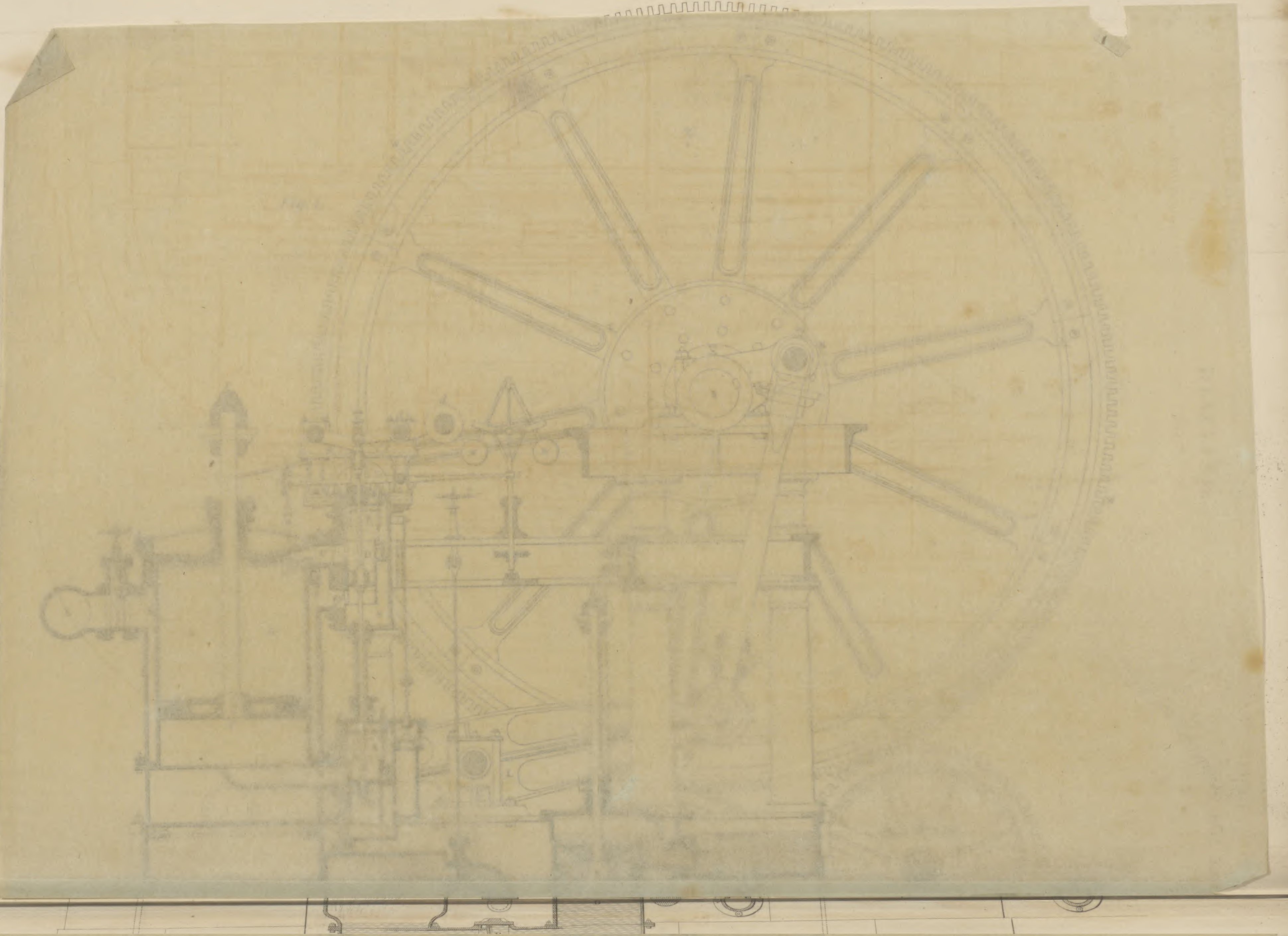


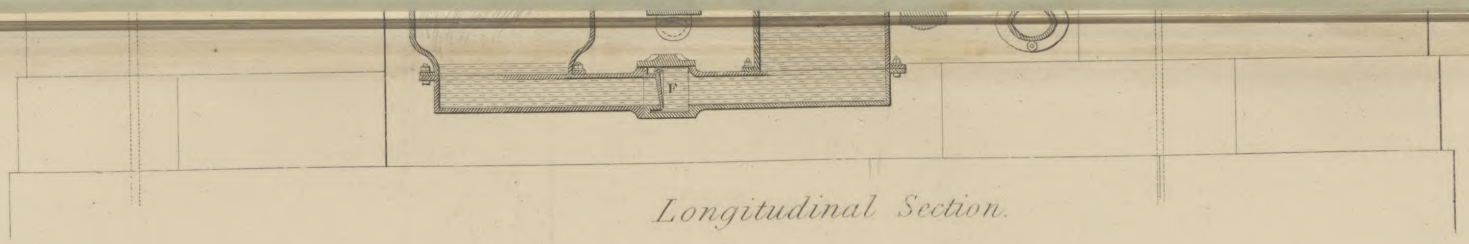


Longitudinal Section



Geo. Aikman, Sculp.





Longitudinal Section.

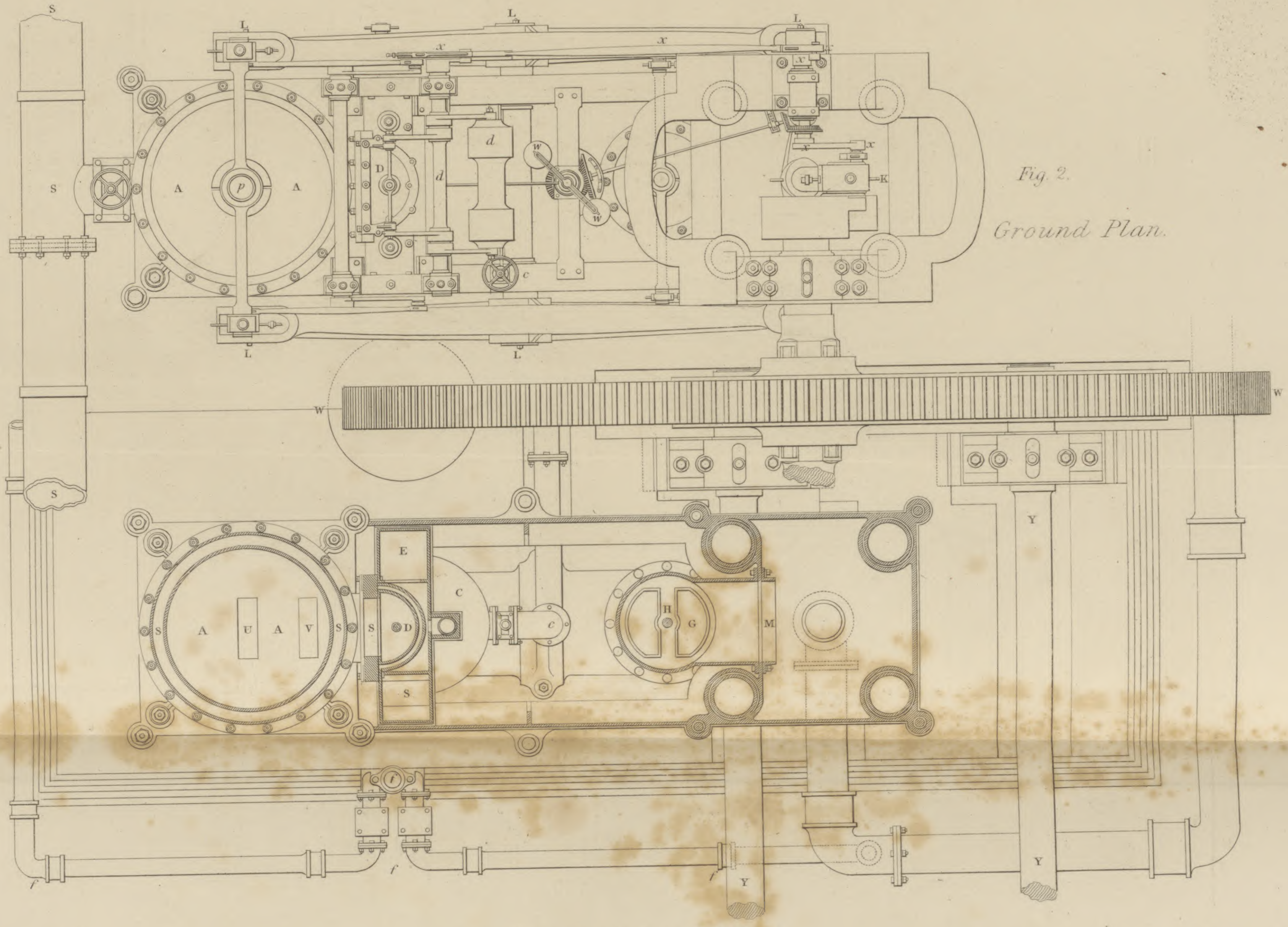
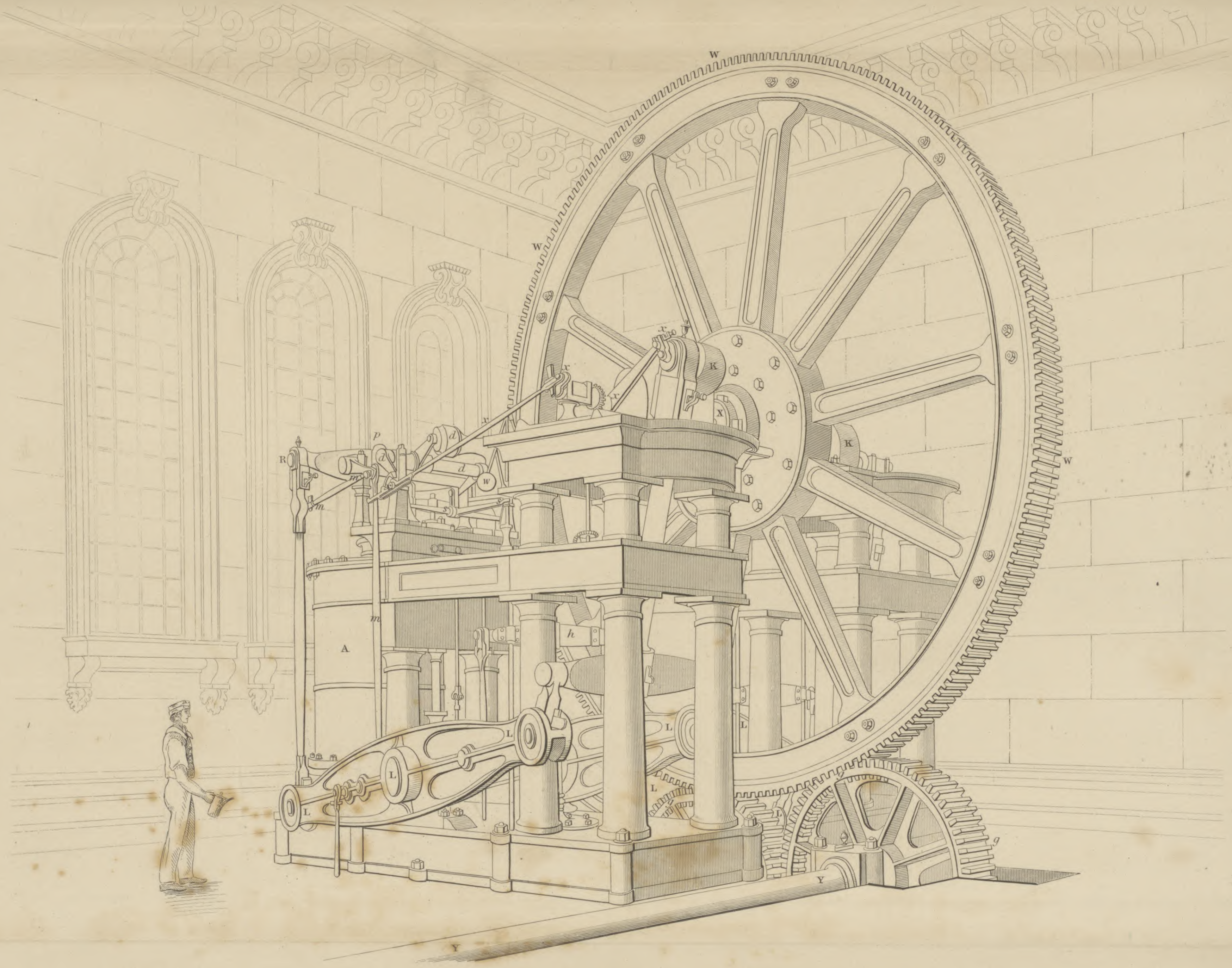


Fig. 2.

Ground Plan.

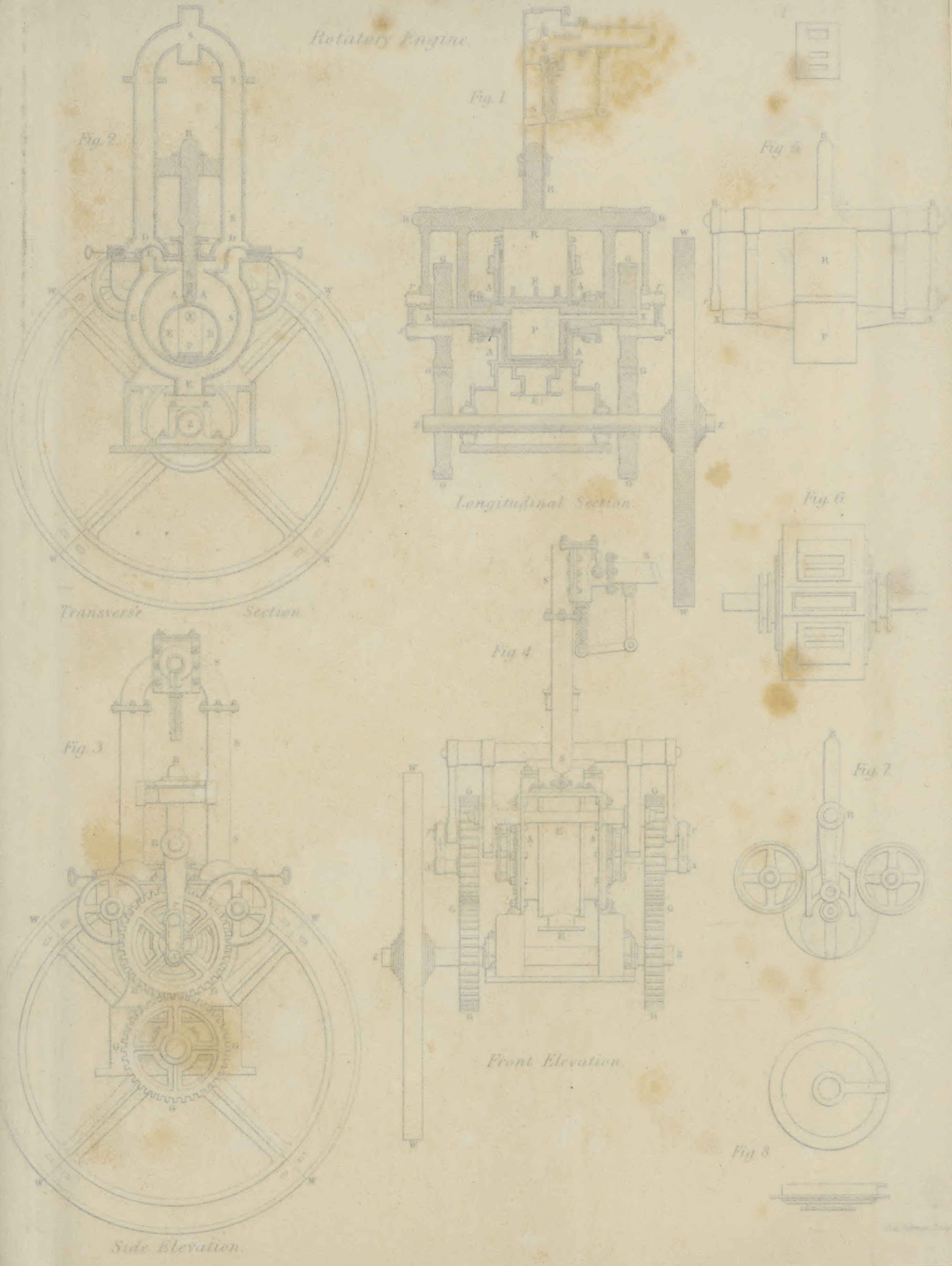
Sectional Ground Plan.

STEAM ENGINE.



Geo. Aikman, Sculp.

Rotatory Engine.



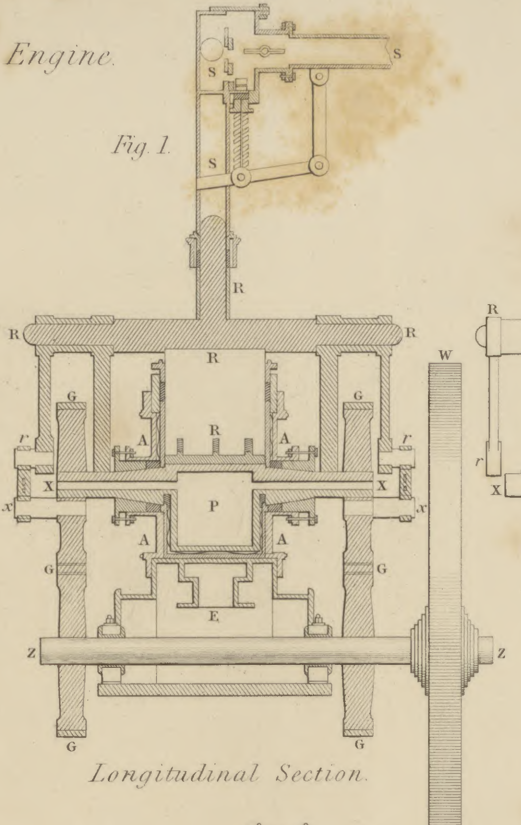
Geo. Aikman Sculpt.

STEAM ENGINE.

PLATE CCCCLXXVI.

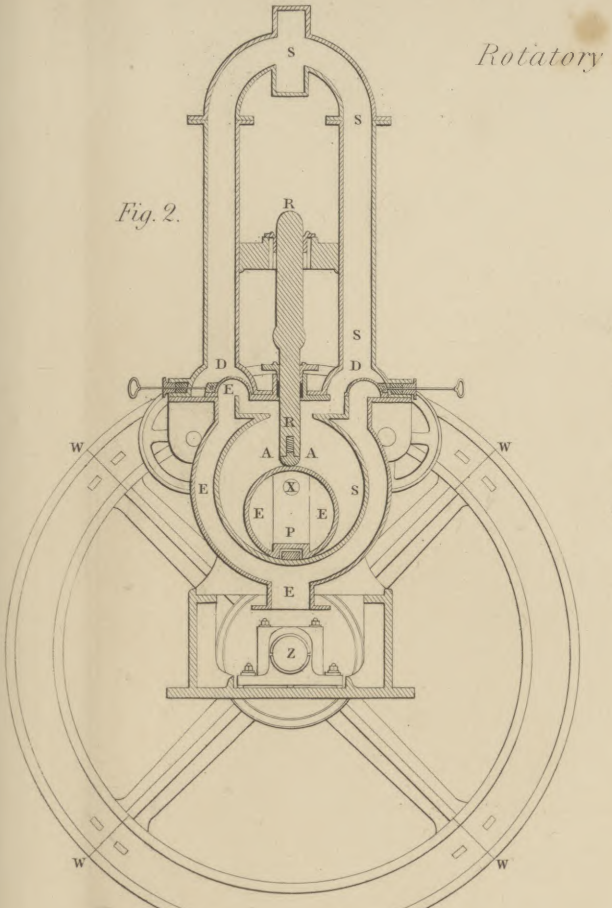
Rotatory Engine.

Fig. 1.



Longitudinal Section.

Fig. 2.



Transverse Section.

Fig. 5.

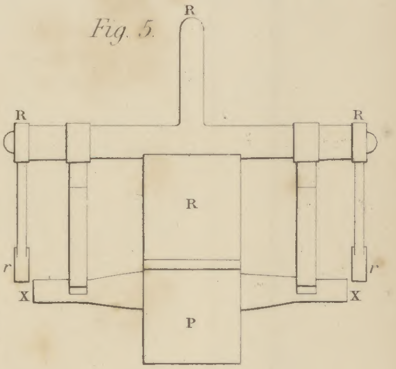


Fig. 6.

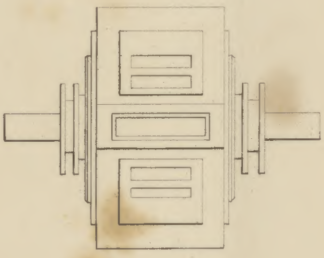
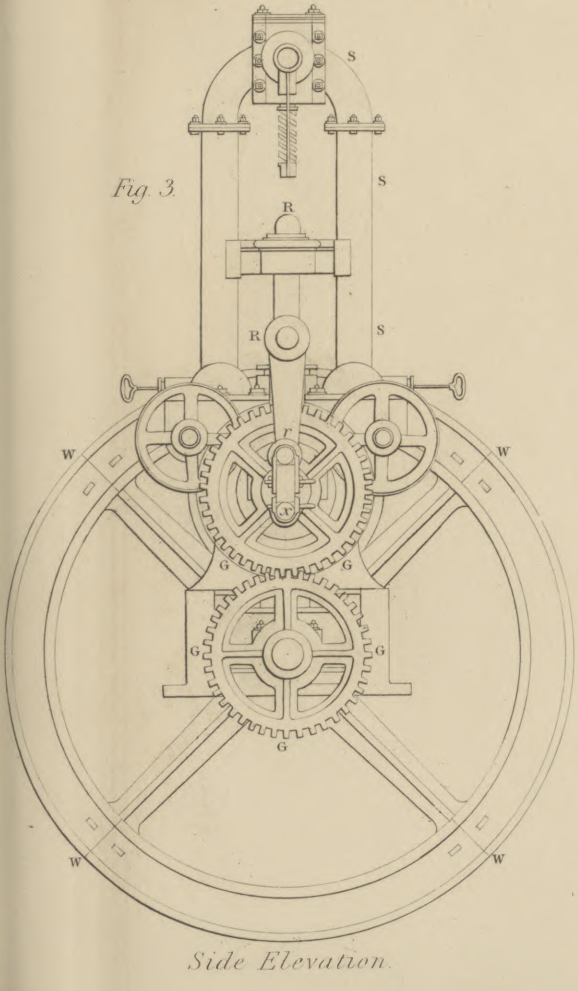
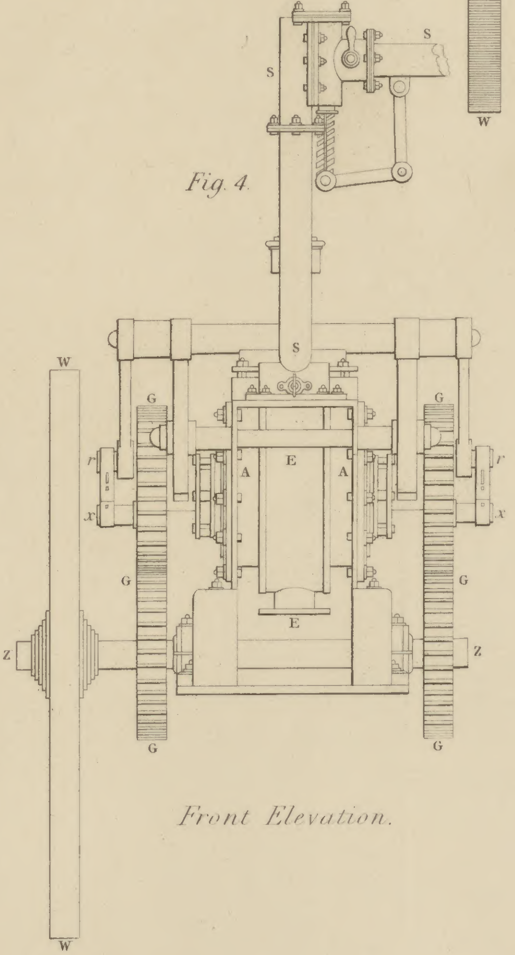


Fig. 3.



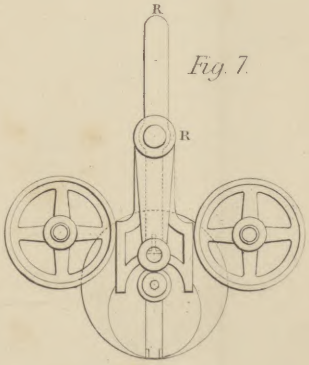
Side Elevation.

Fig. 4.



Front Elevation.

Fig. 7.



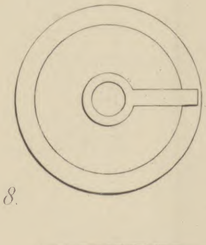
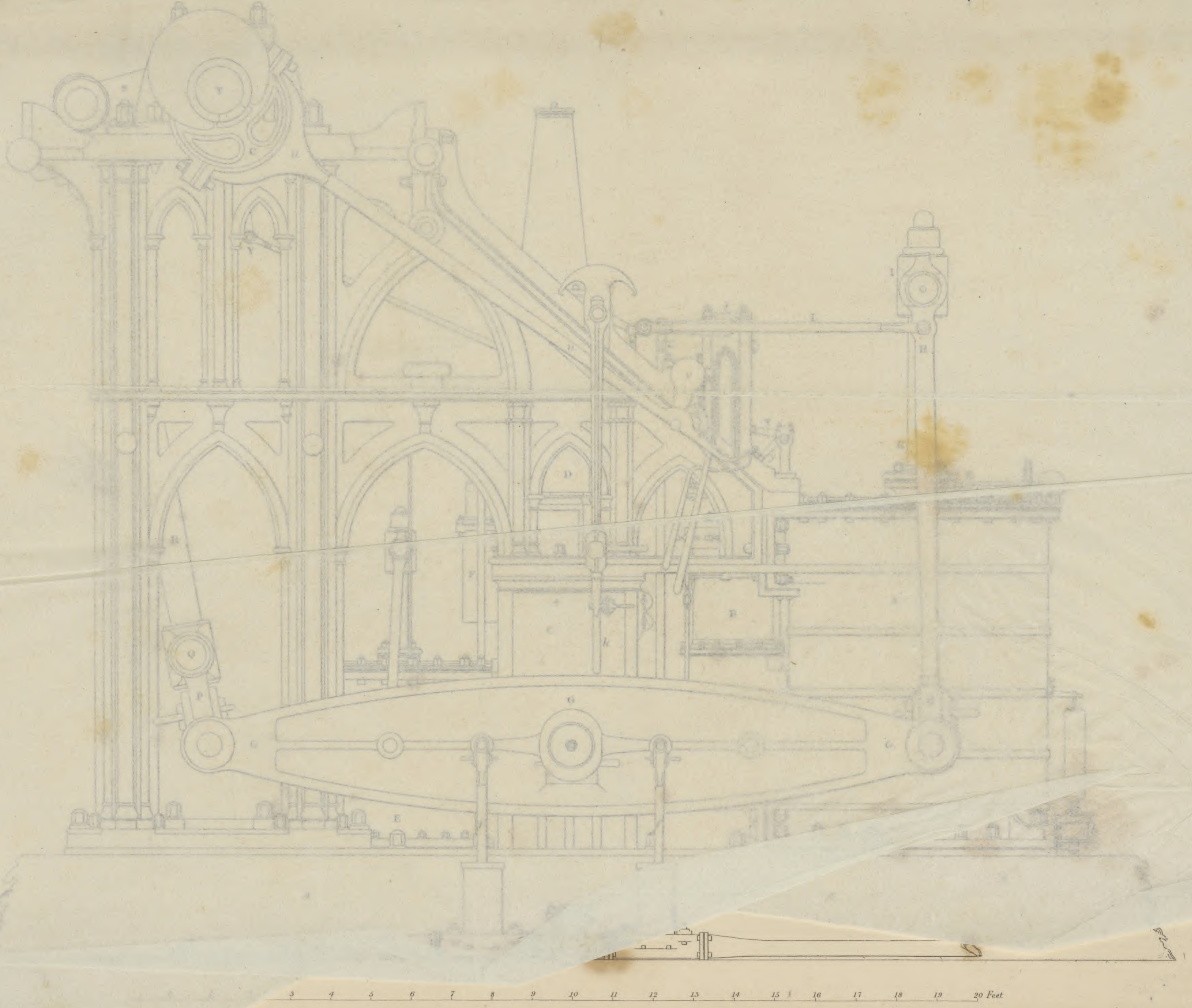


Fig. 8.

Geo. Aikman, Sculpt.

STEAM NAVIGATION.

PLATE [illegible]XVII.

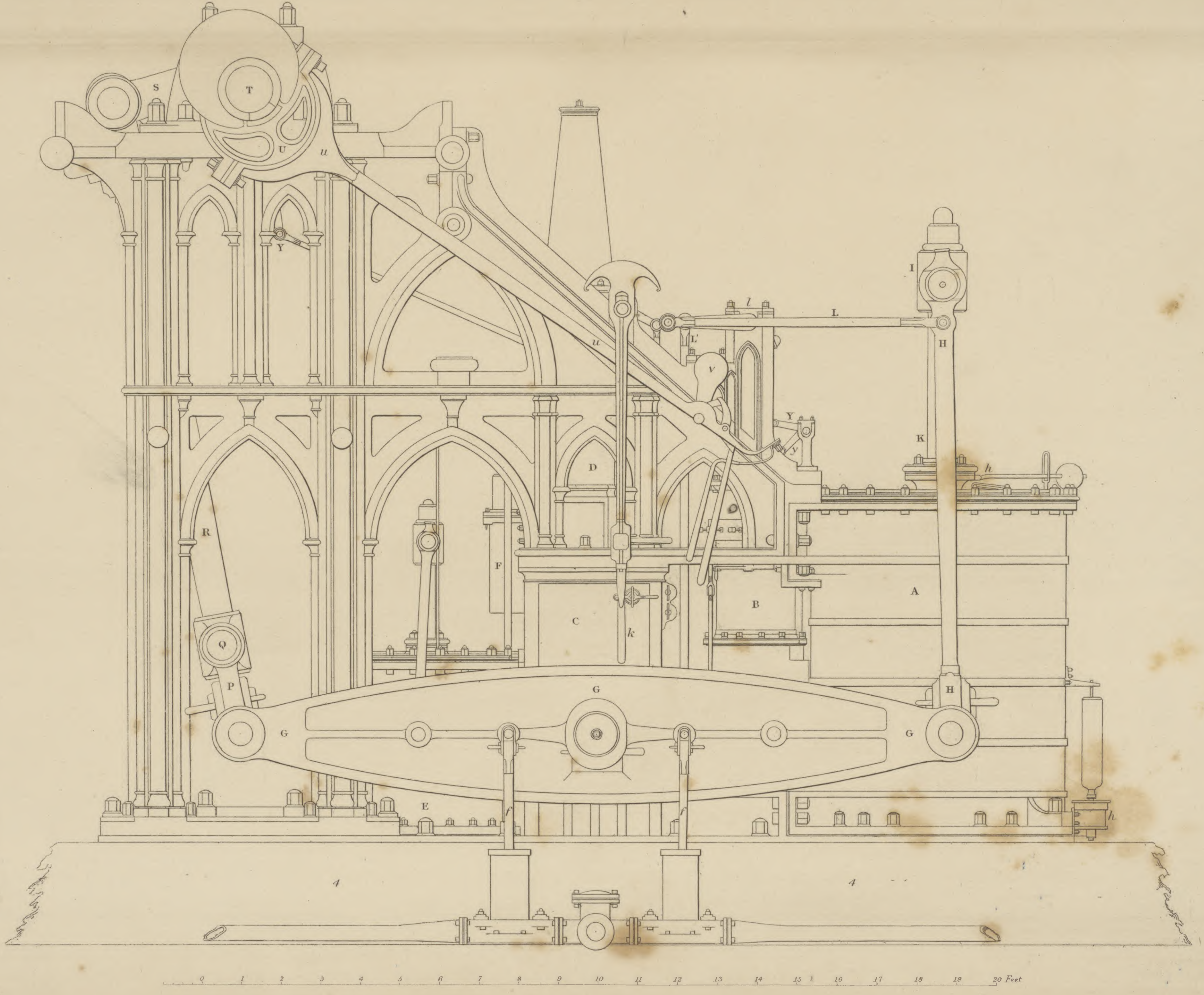


Geo. Aikman, Sculp.t

STEAM NAVIGATION. PLATE CCCCLXXVII.

STEAM NAVIGATION.

PLATE CCCCLXXVII.



Geo. Aikman. Sculp.t

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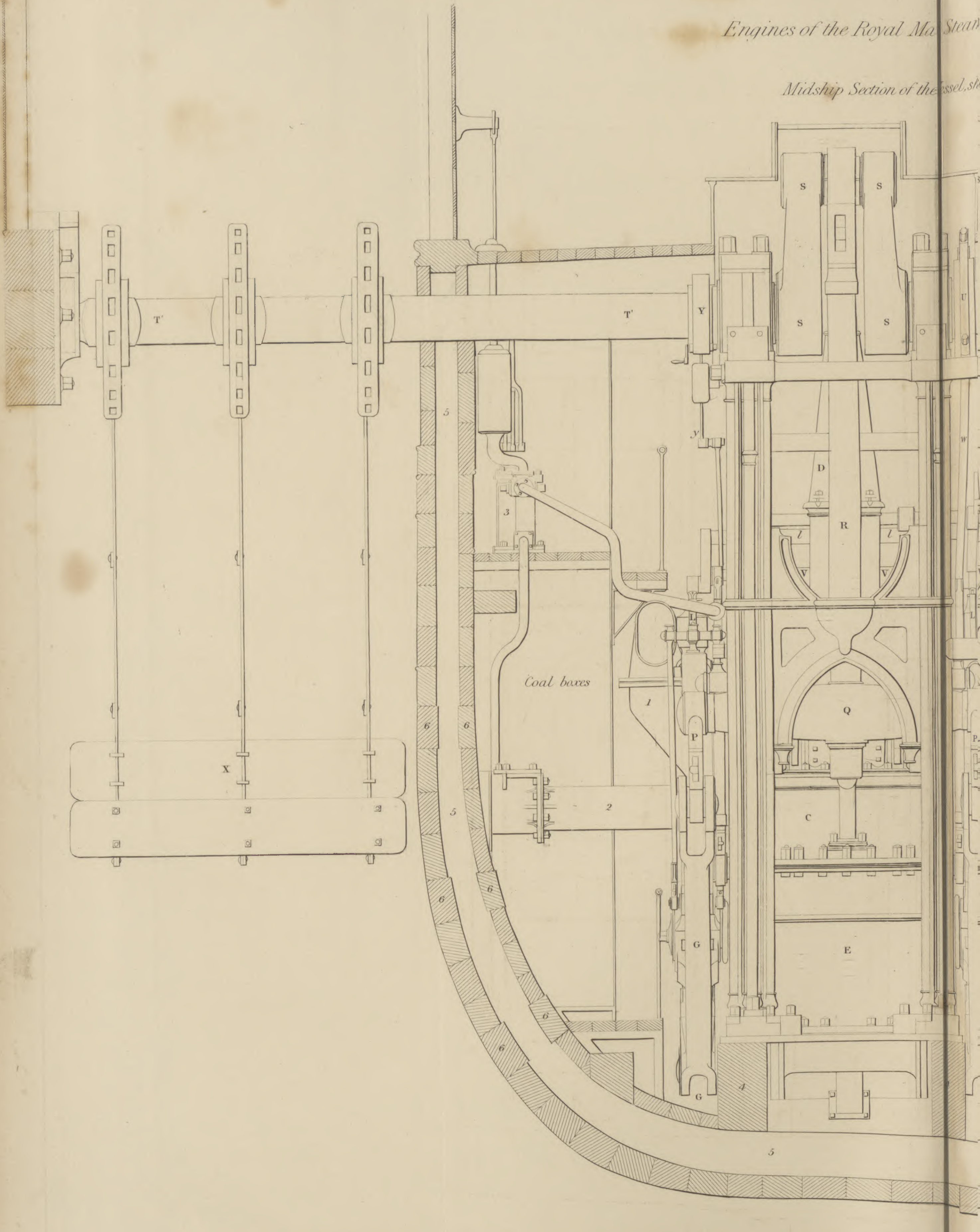
Engines of the Royal Ma Steam

Midship Section of the essel, sh

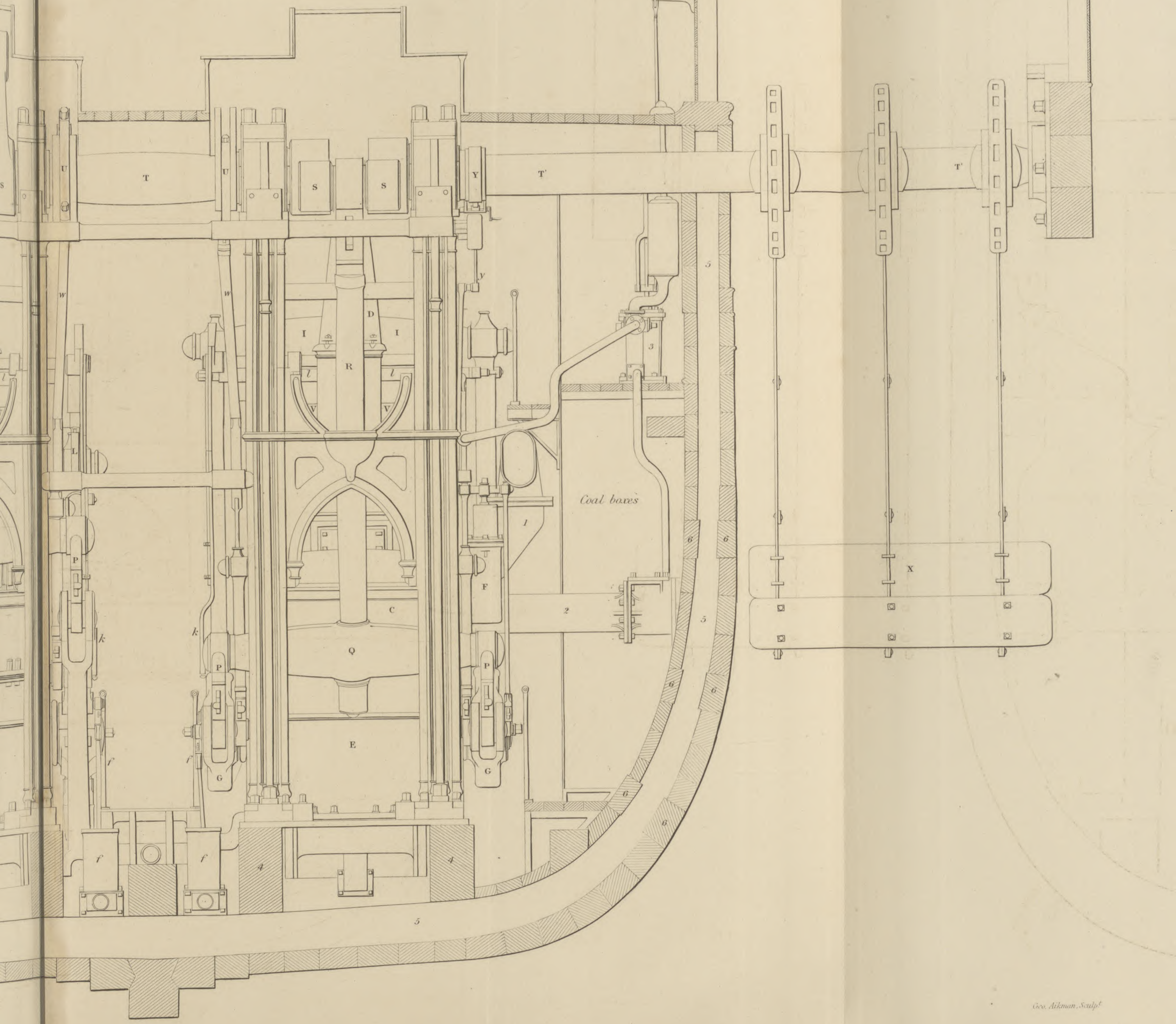


STEAM NAVIGATION.

PLATE CCCCLXXVIII.

al Ma Steam Ships Britannia, Acadia, Caledonia and Columbia.

on of the ssel, showing the Elevation of the Crank end of the Engine.



Geo. Aikman, Sculp!

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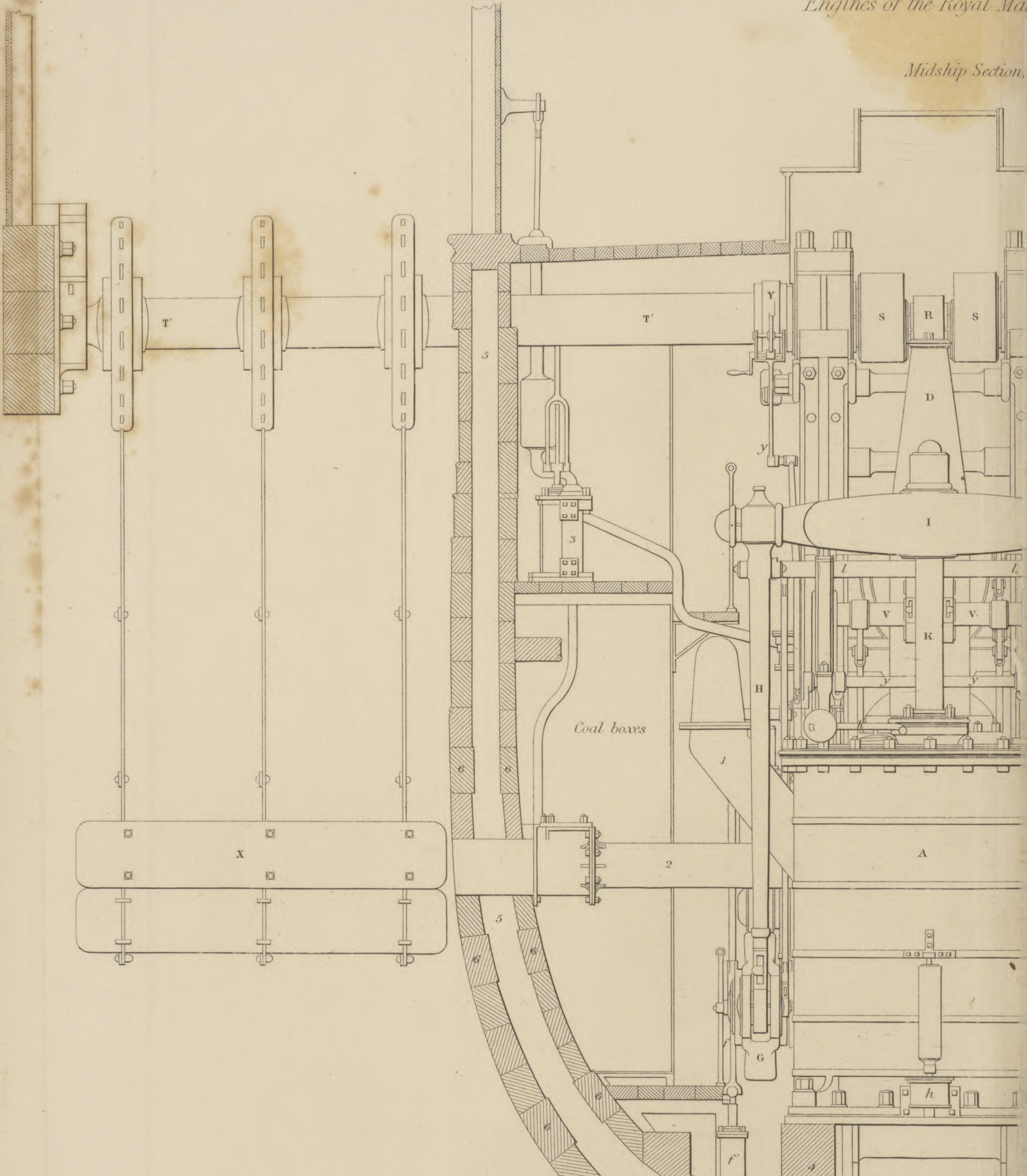
Engines of the Royal Ma Steam

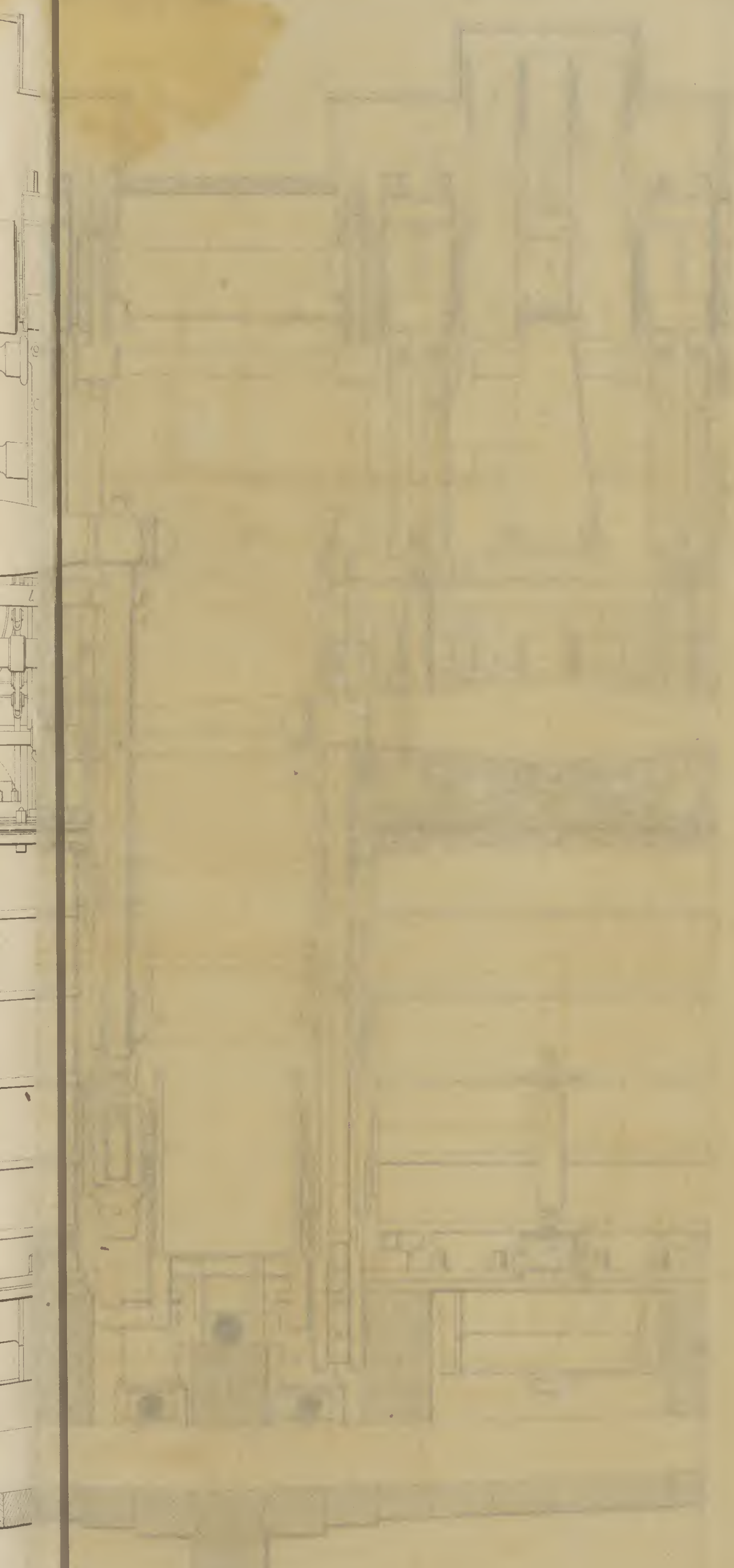
Midship Section,

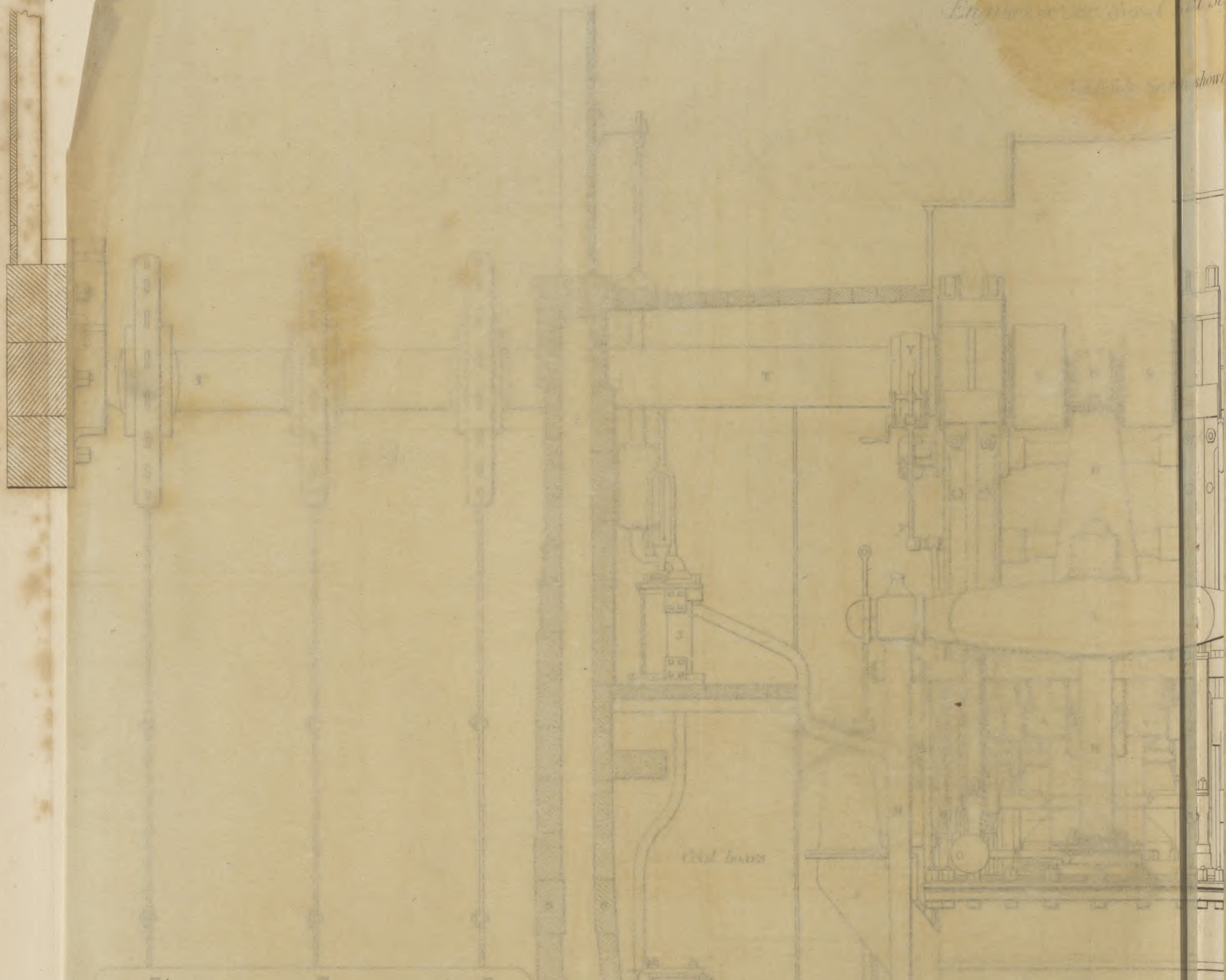


STEAM NAVIGATION.

Steam Ships: Britannia, Acadia, Caledonia and Columbia.

Section. [illegible] from the Cylinder end of the Engines.

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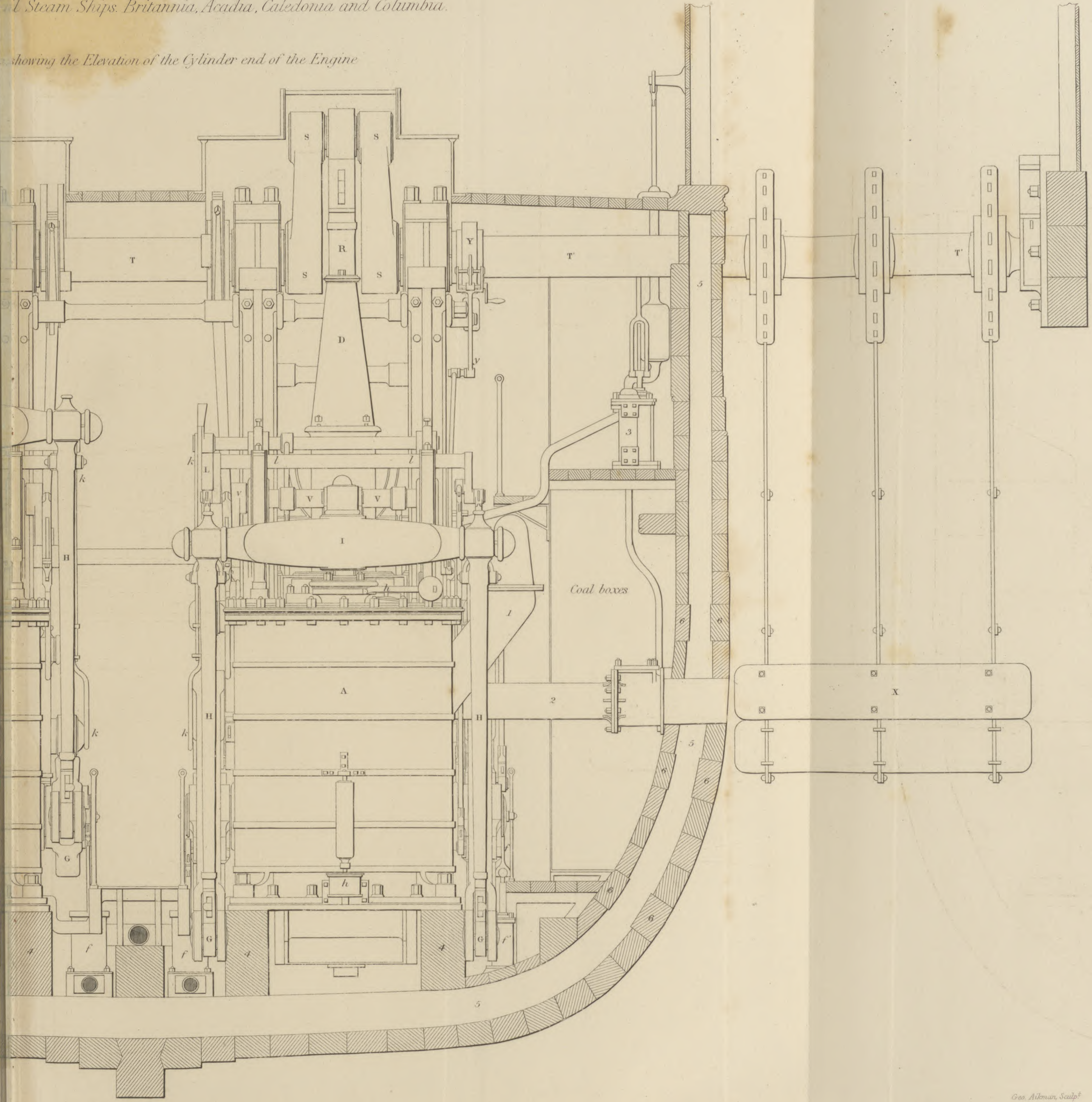
l Steam Ships: Britannia, Acadia, Caledonia and Columbia.

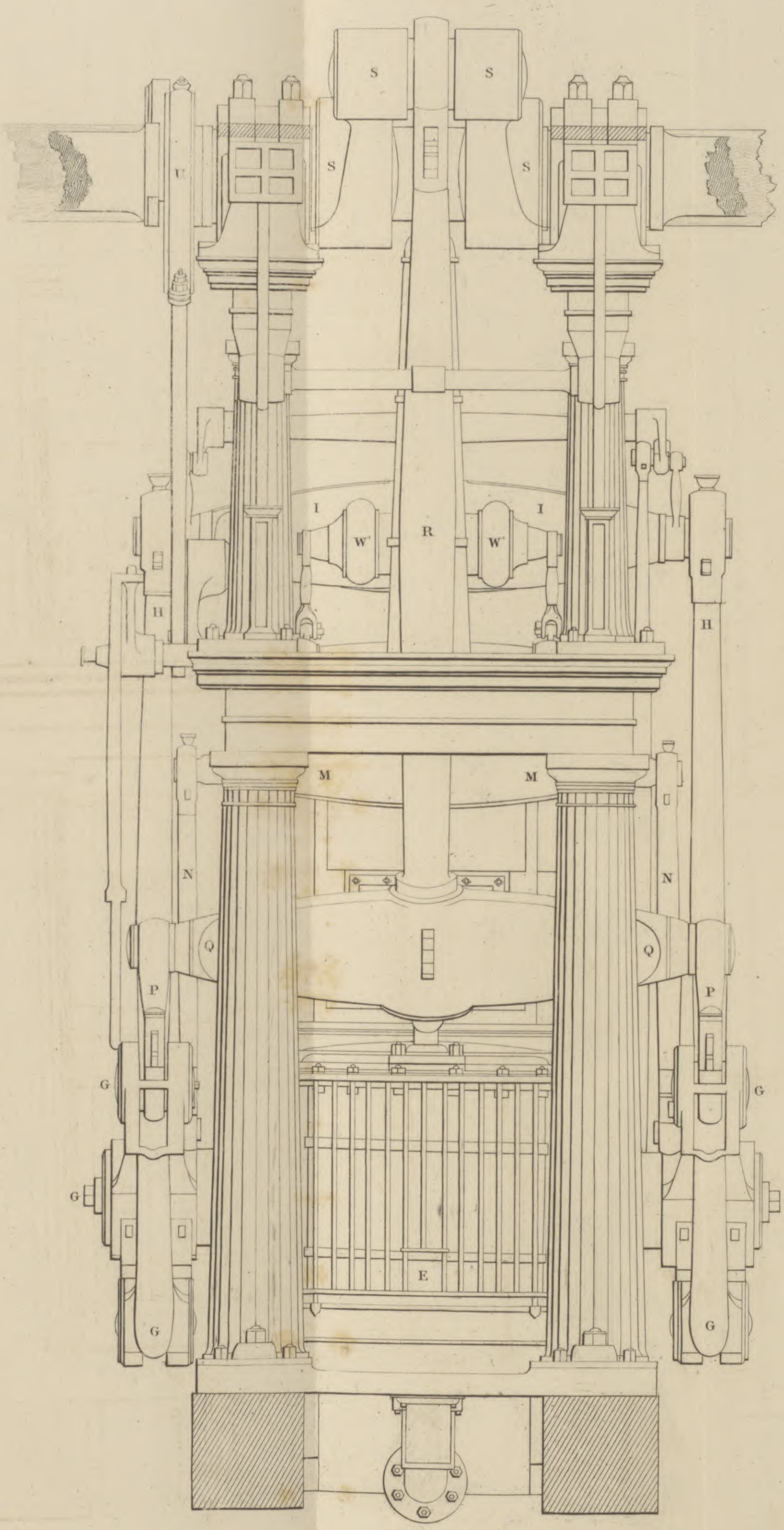
showing the Elevation of the Cylinder end of the Engine



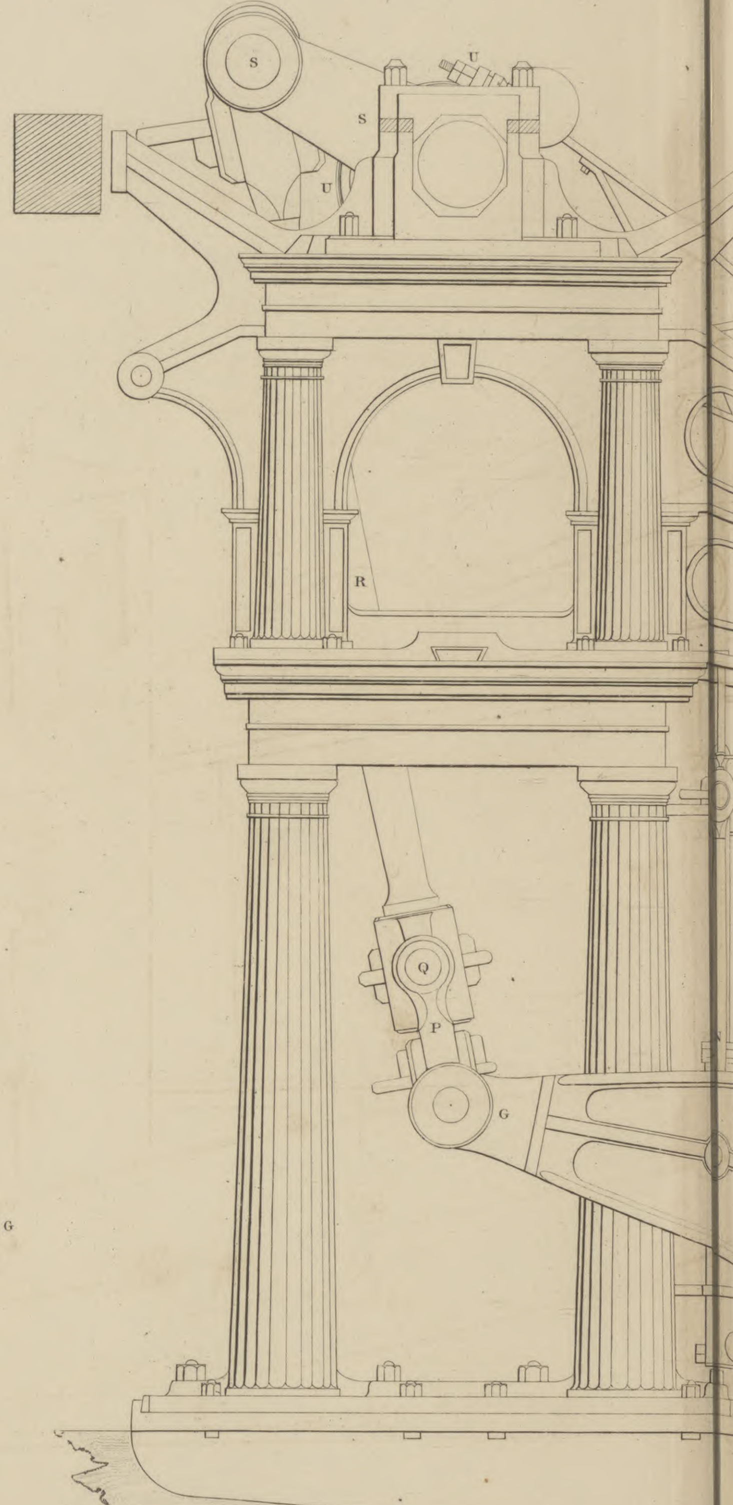
Geo. Aikman, Sculp^t.

STEAM NAVI ATI

End Elevation.

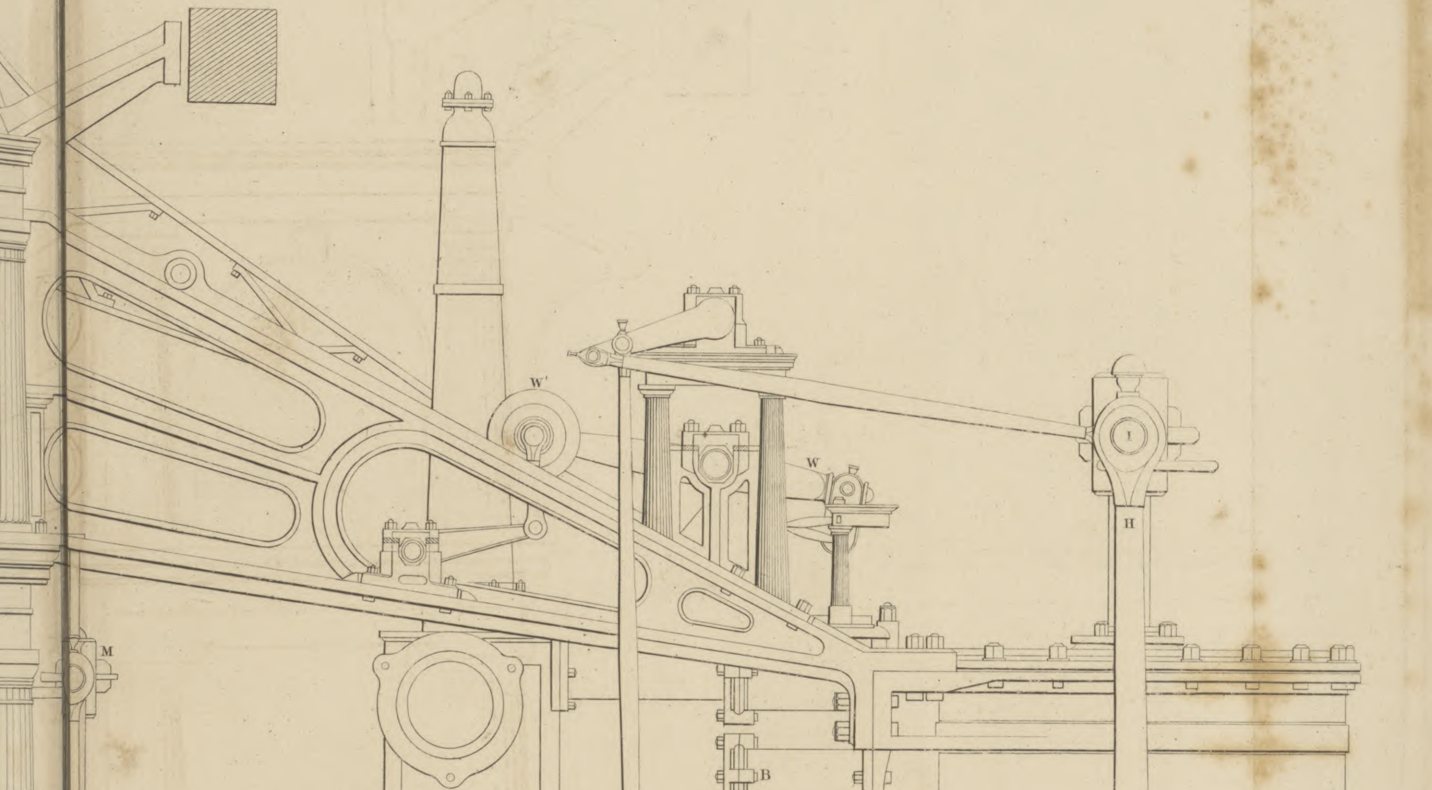


Engine of H.M. Mail acket



Mail cket Urgent

Side Elevation.

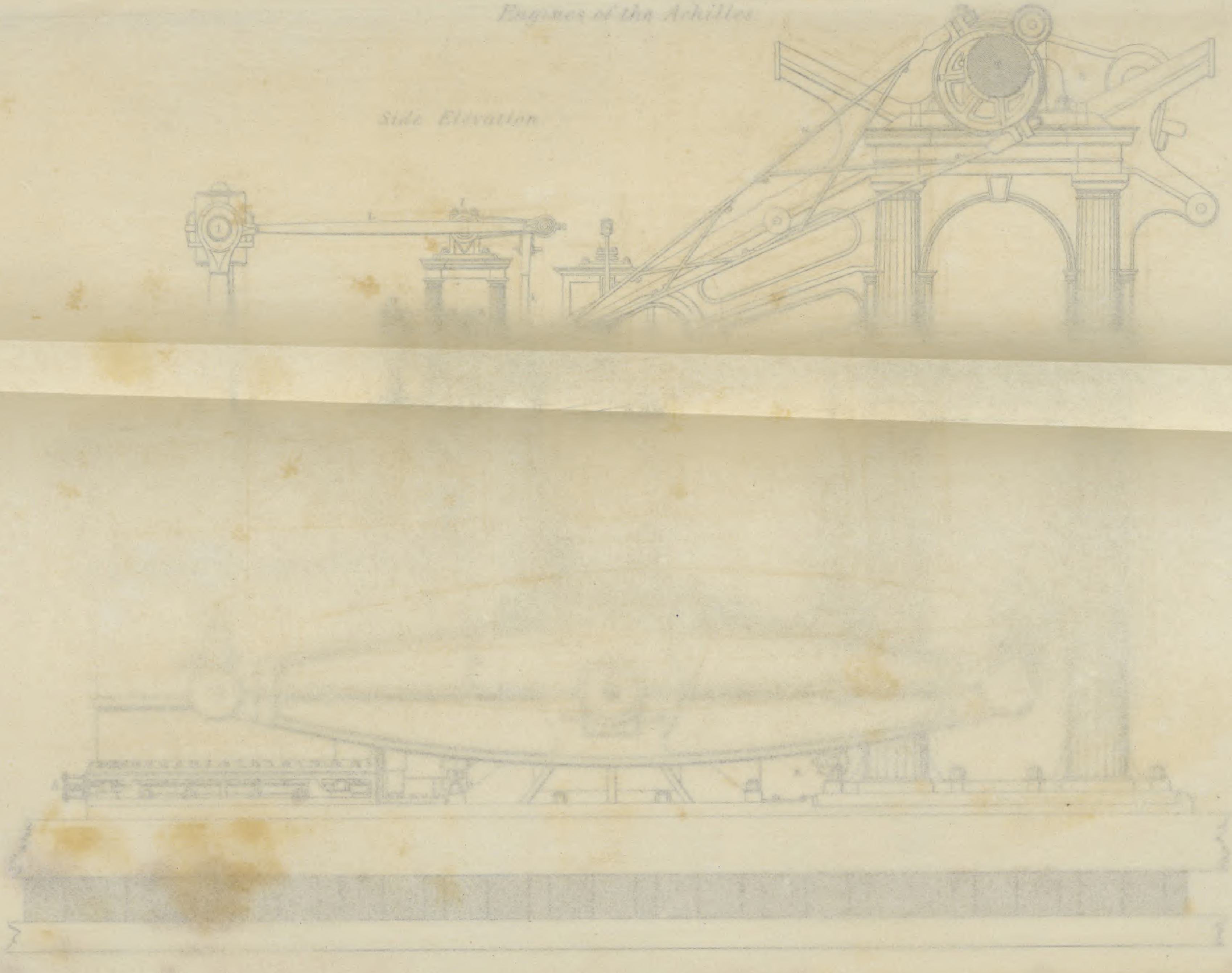


Geo. Aikman, Sculp.

STEAM NAVIGATION.

Engines of the Achilles.

Side Elevation.



Geo. Aikman, Sculp.t

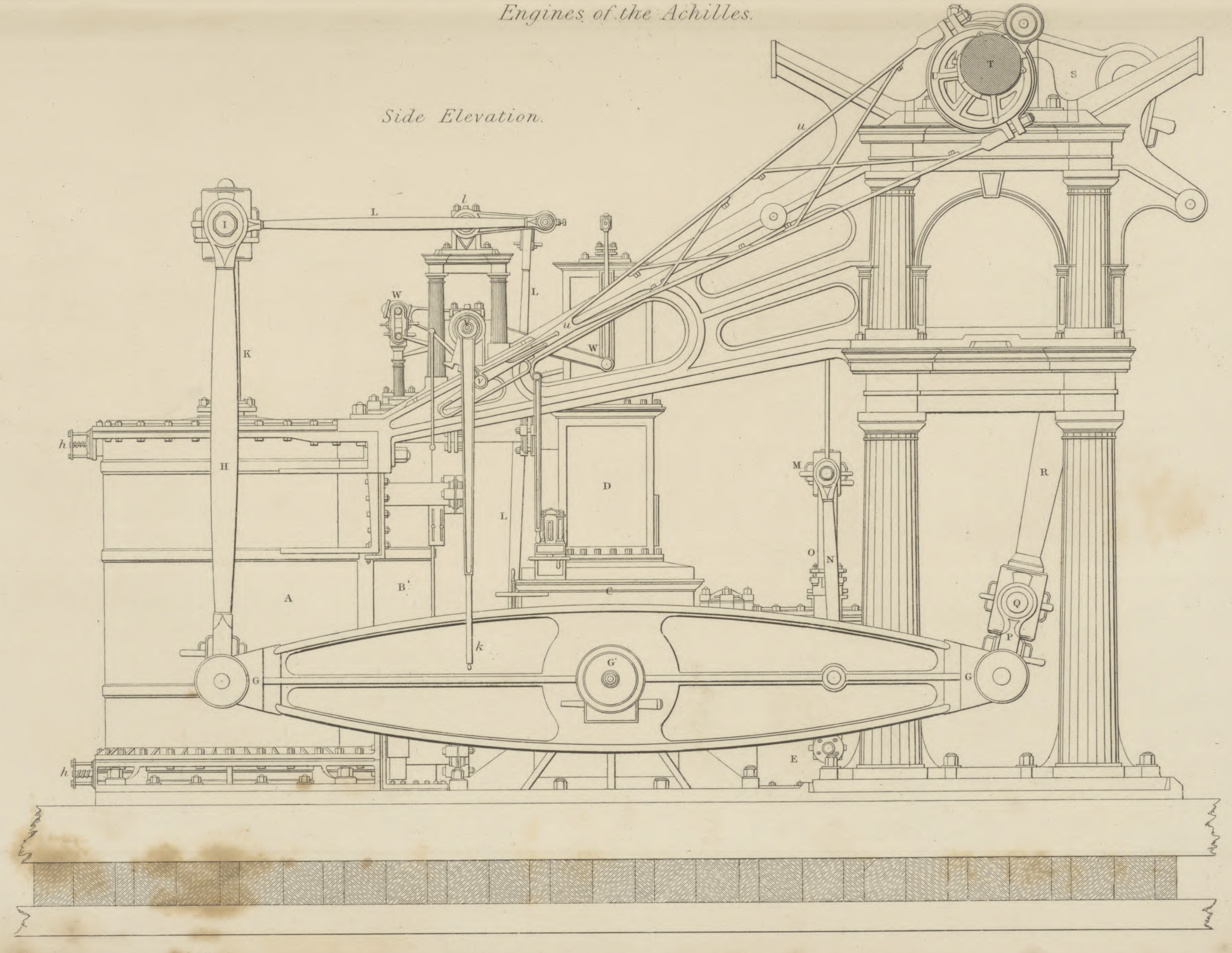
STEAM NAVIGATION

PLATE CCCCLXXI.

STEAM NAVIGATION.

Engines of the Achilles.

Side Elevation.



Geo. Aikman, Sculpt.

STEAM NAVI

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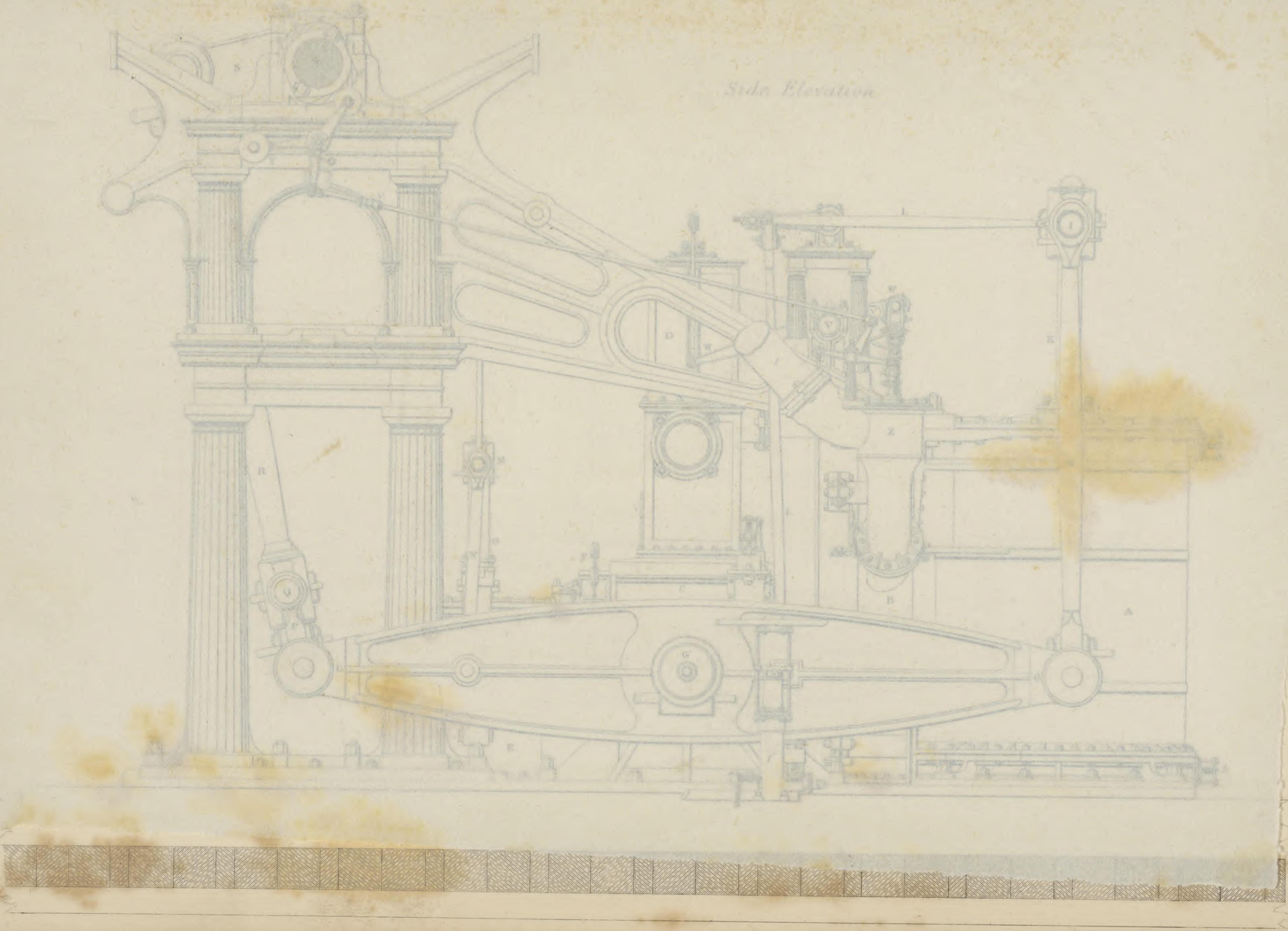
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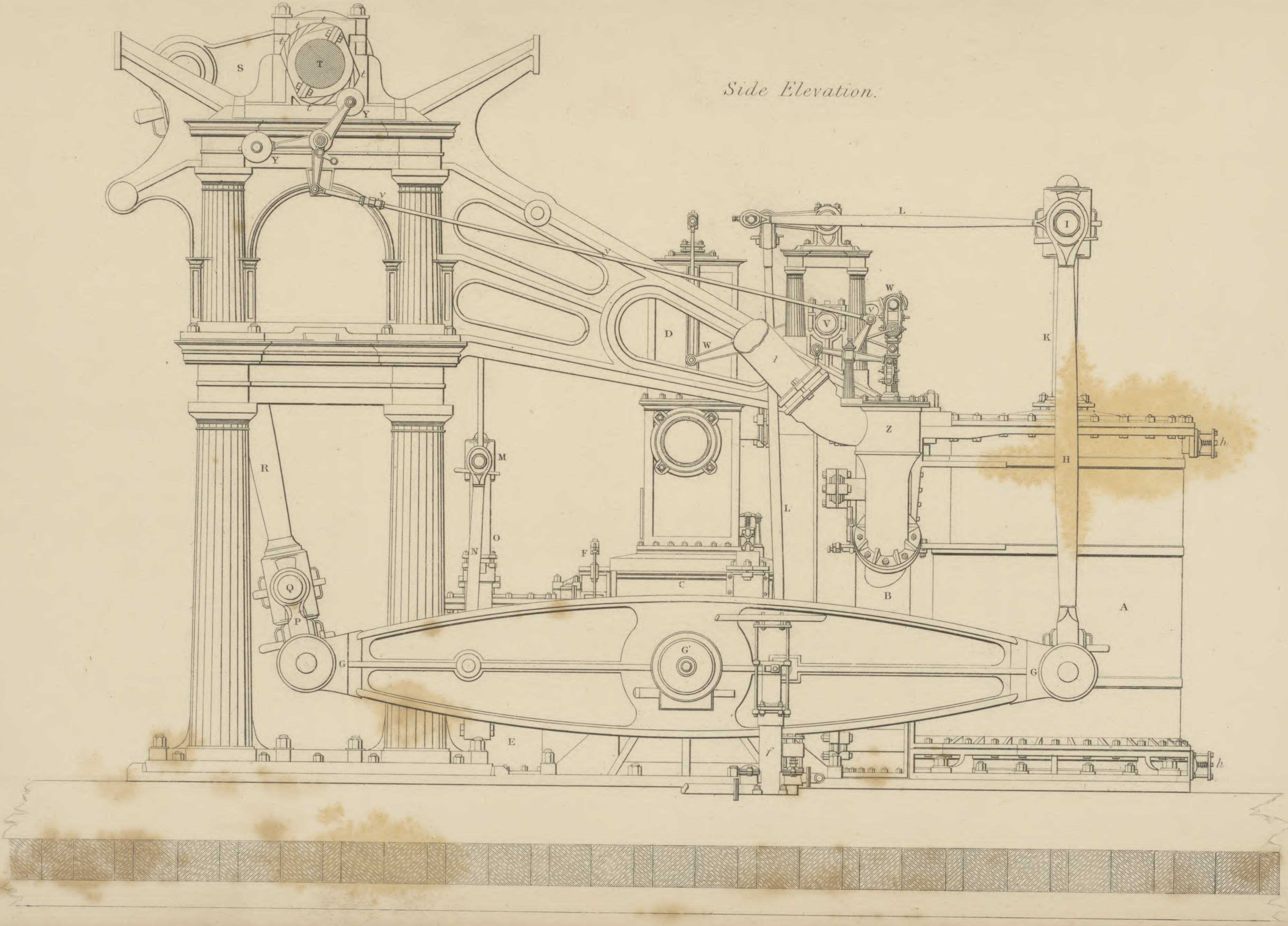
PLATE CCCCLXXVII.

STEAM NAVIGATION.

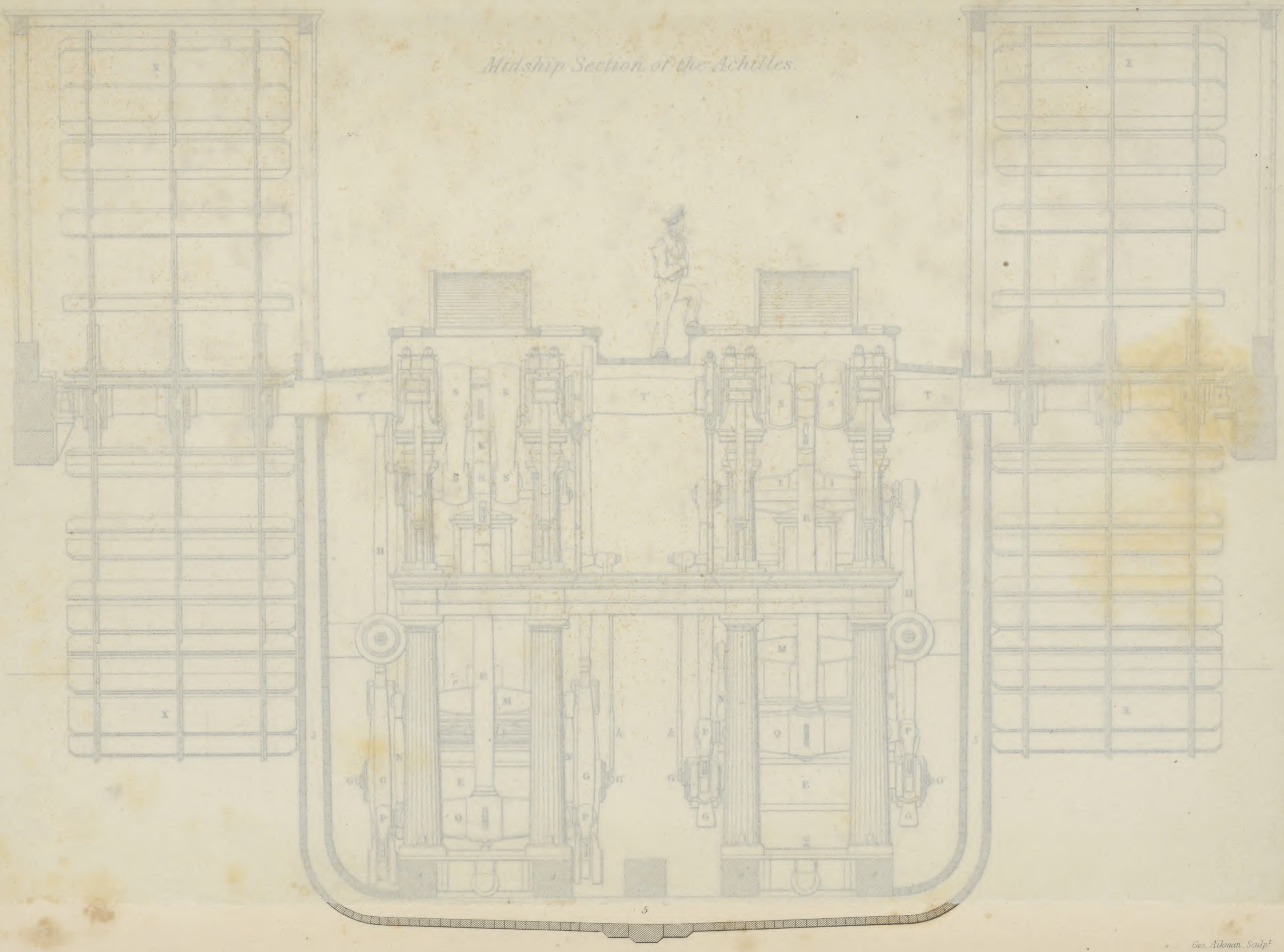
Engines of the Achilles.

Side Elevation.



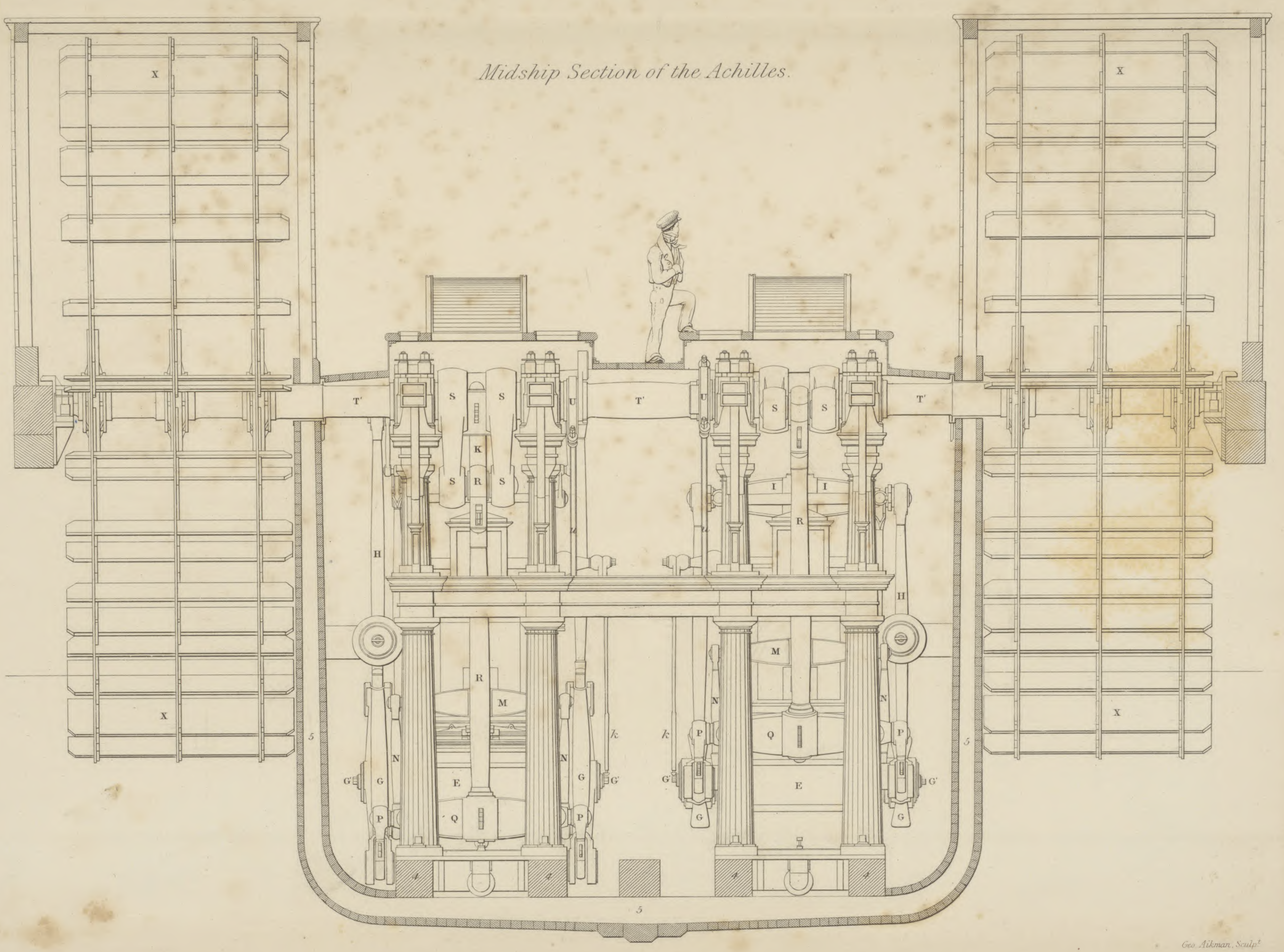
Geo. Aikman, Sculp^{t}

Midship Section of the Achilles.



Geo. Aikman, Sculp.t

Midship Section of the Achilles.

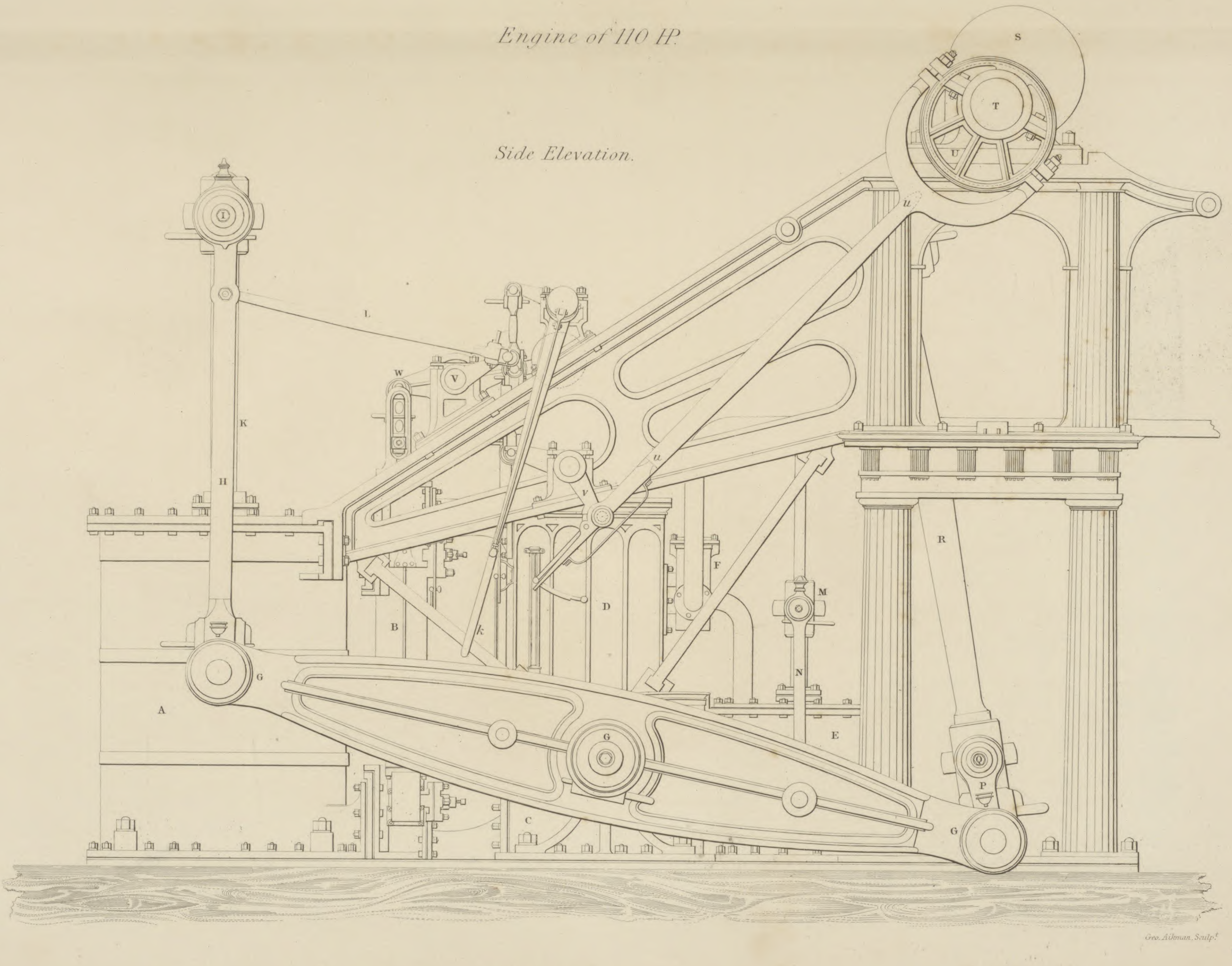


Geo. Aikman, Sculp.t

STEAM NAVIGATION. PLATE CCCCLXXXIV.

Engine of 110 HP.

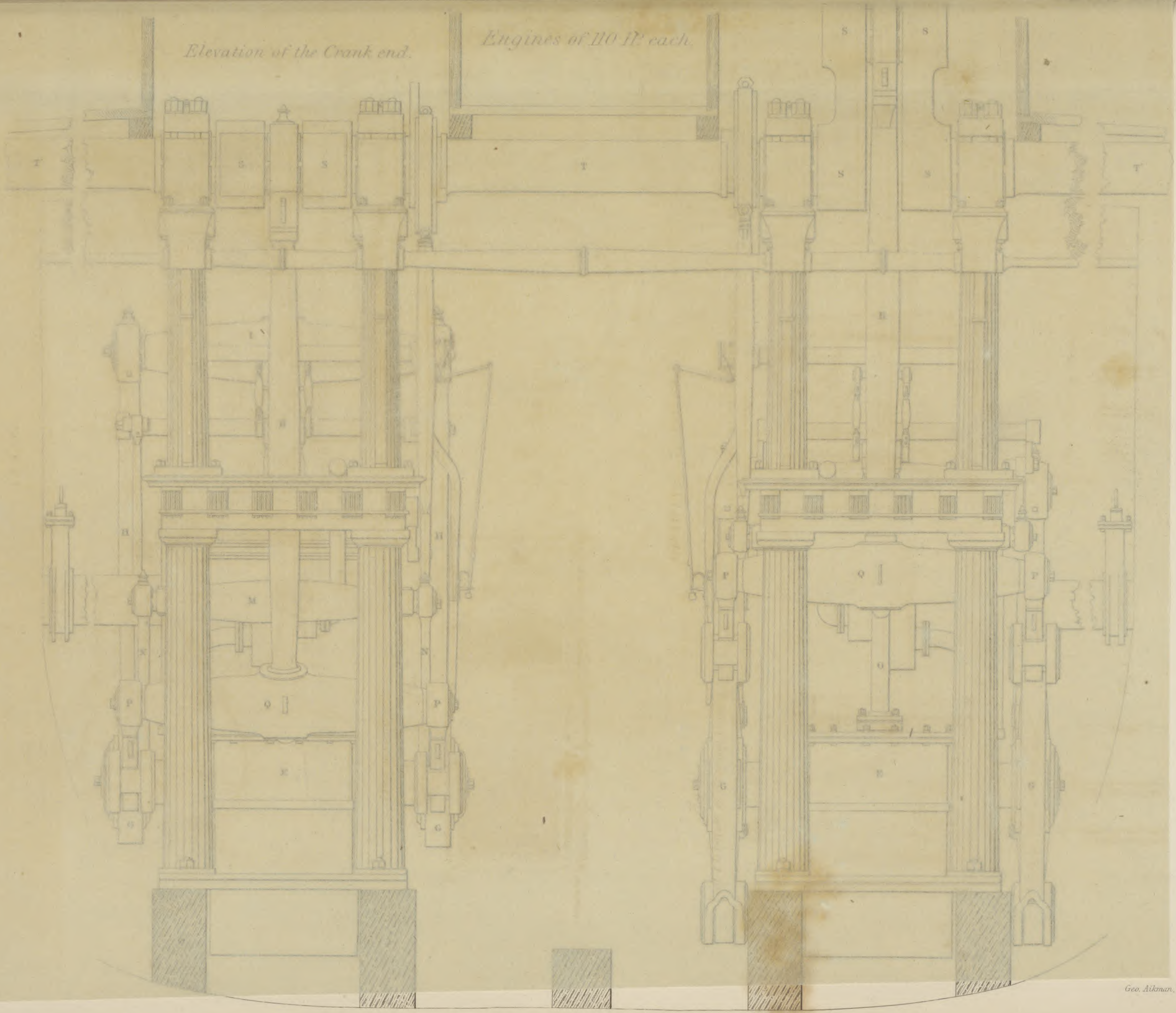
Side Elevation.



Geo. Aikman, Sculp^t.

Elevation of the Crank end.

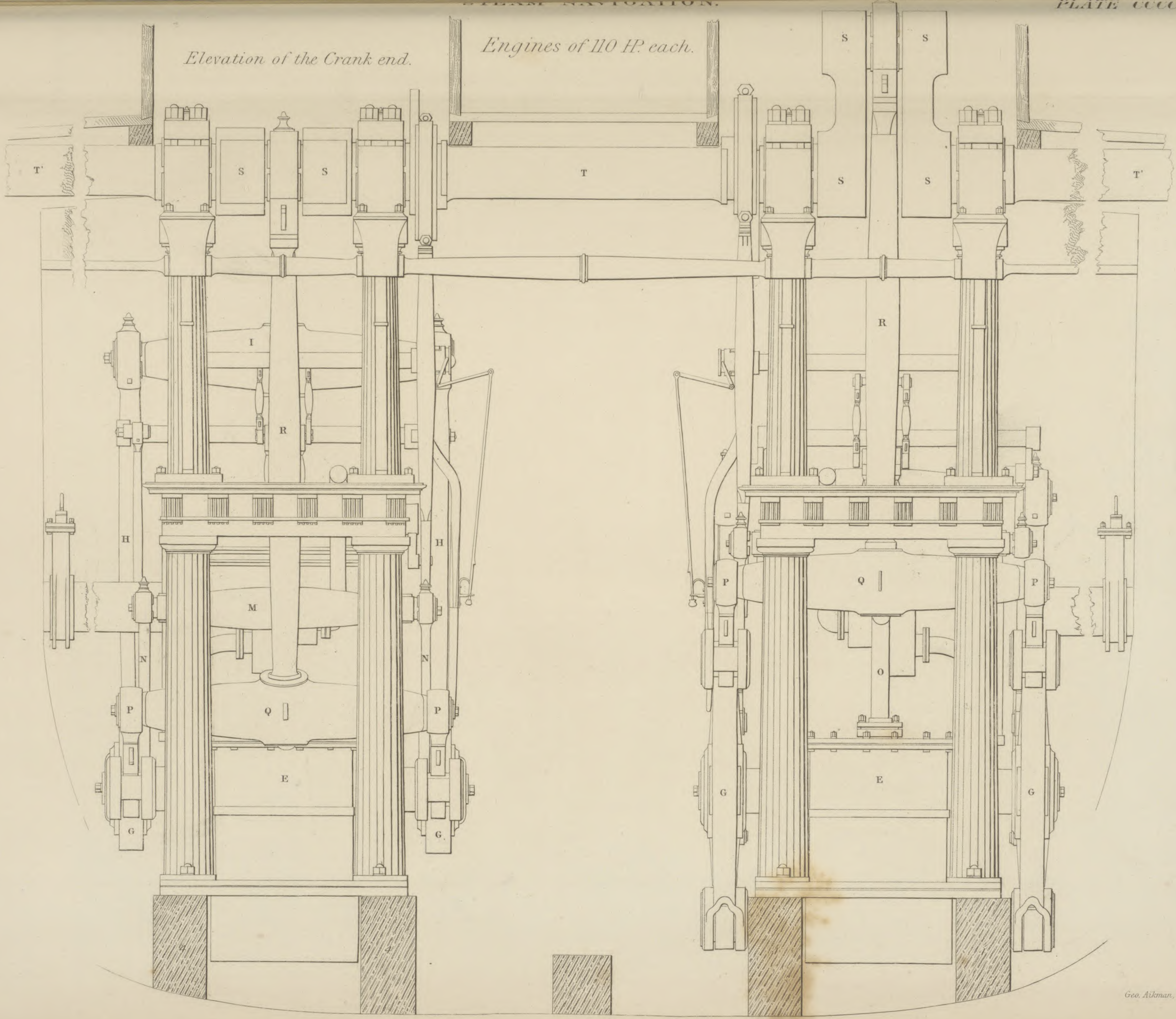
Engines of 110 HP each



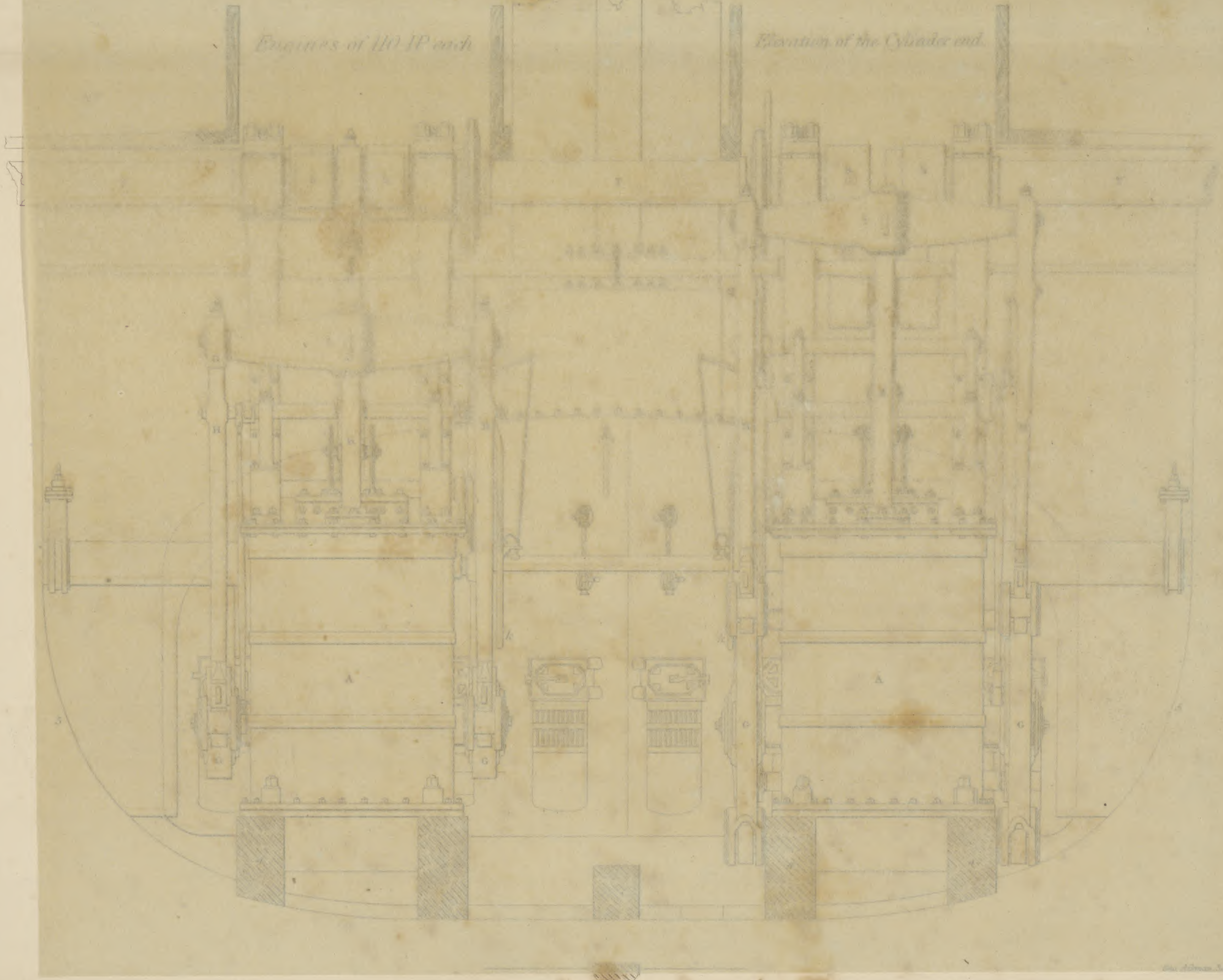
Geo. Aikman, Sculpᵗ

Engines of 110 HP. each.

Elevation of the Crank end.



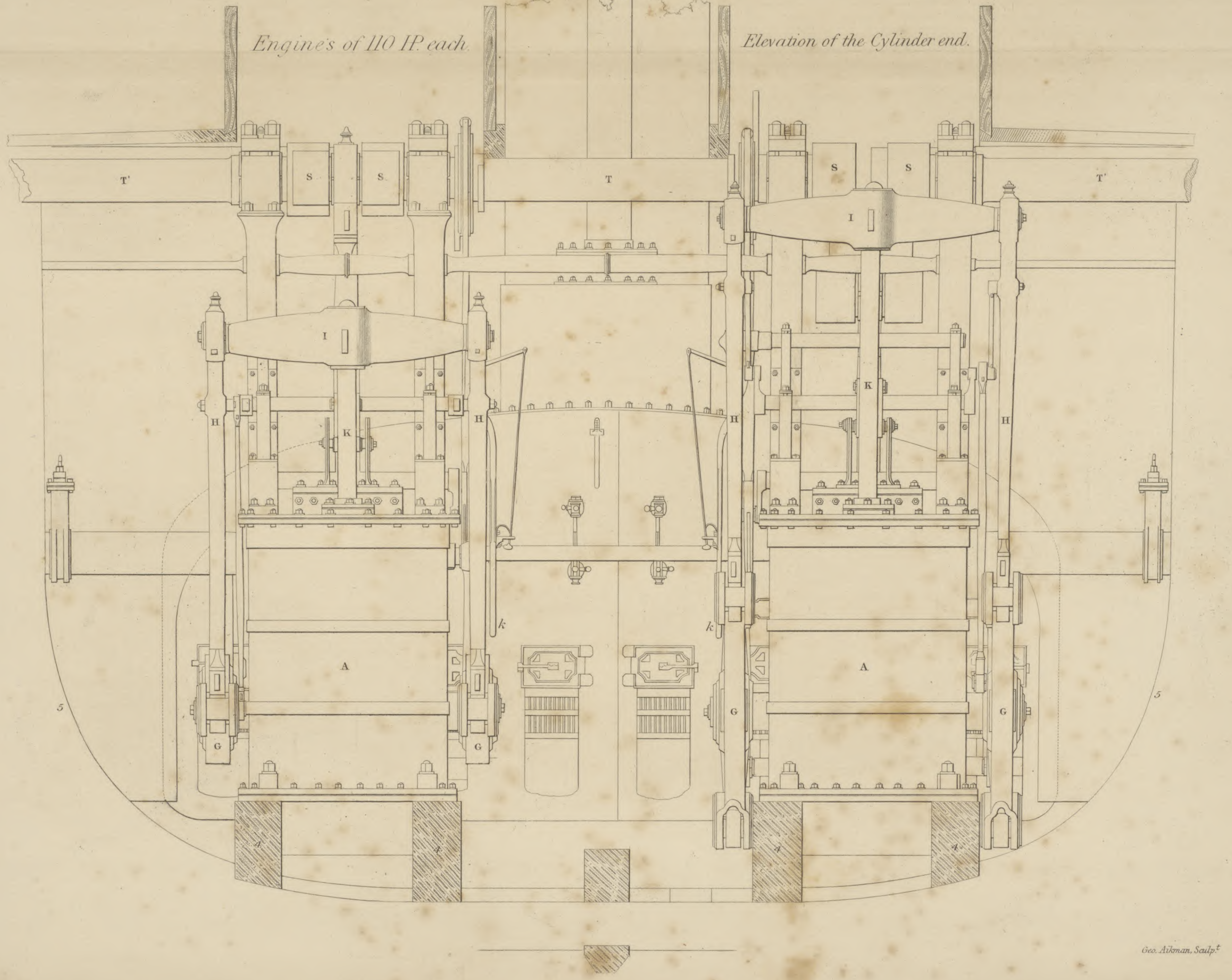
Geo. Aikman, Sculpt.



Engines of 140 HP each

Elevation of the Cylinder end.

Geo. Aikman Sculp^t



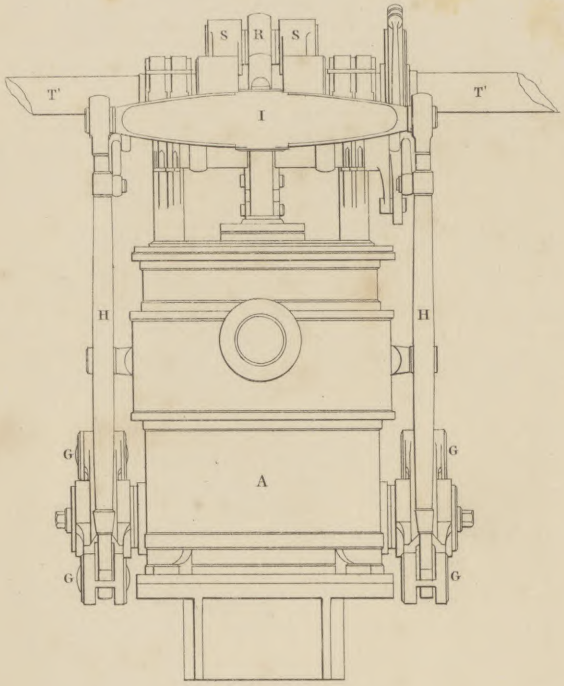
Engine's of 110 HP. each. Elevation of the Cylinder end.

Geo. Aikman, Sculp.t

STEAM NAVIGATI N.

Single Marine Engine of 5 H.P.

Fig. 3.



Elevation of the Cylinder end.

Fig. 1.

Side Elevation.

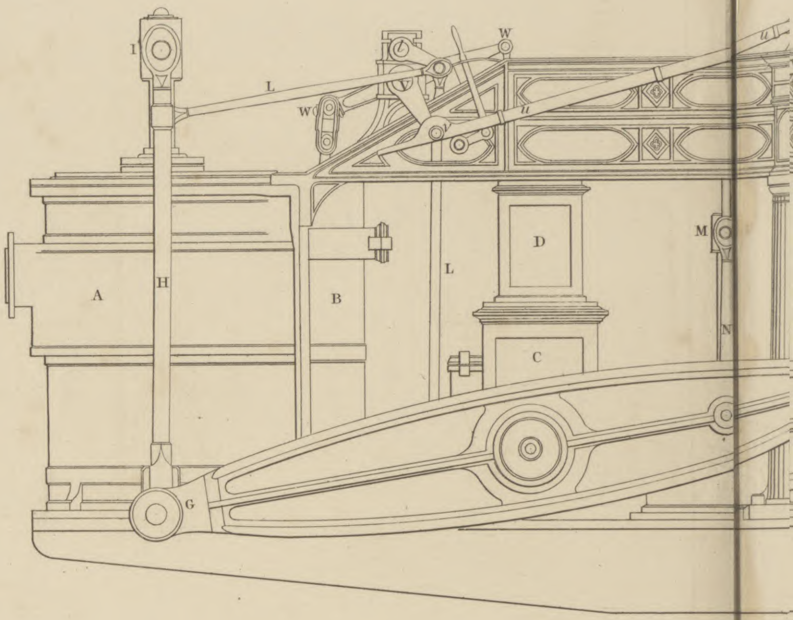
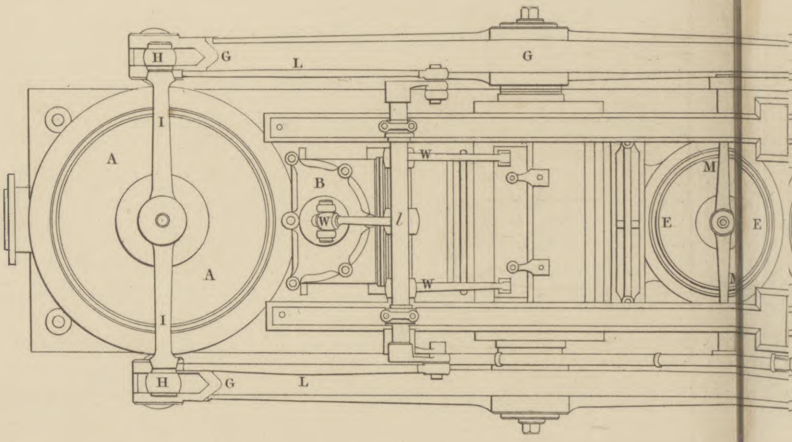


Fig. 2.



Plan.

ne of H.P.

on.

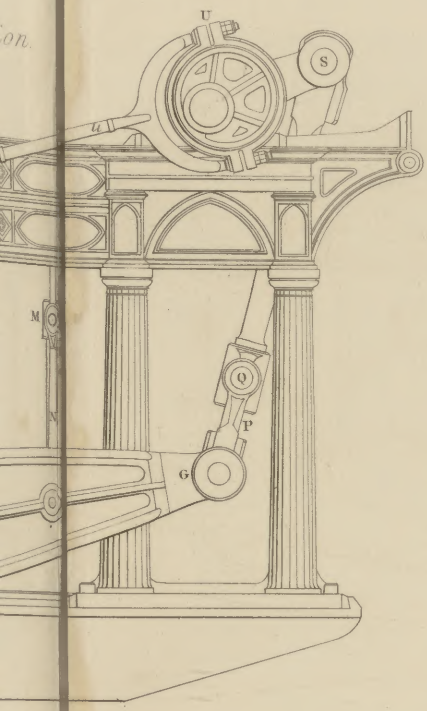
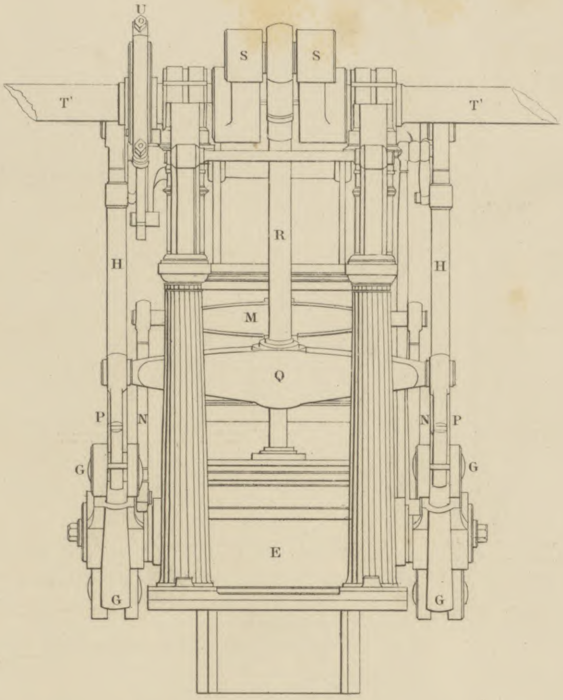
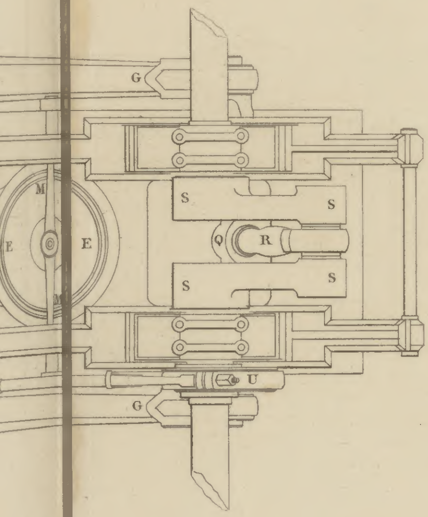


Fig. 4.



Elevation of the Crank end.



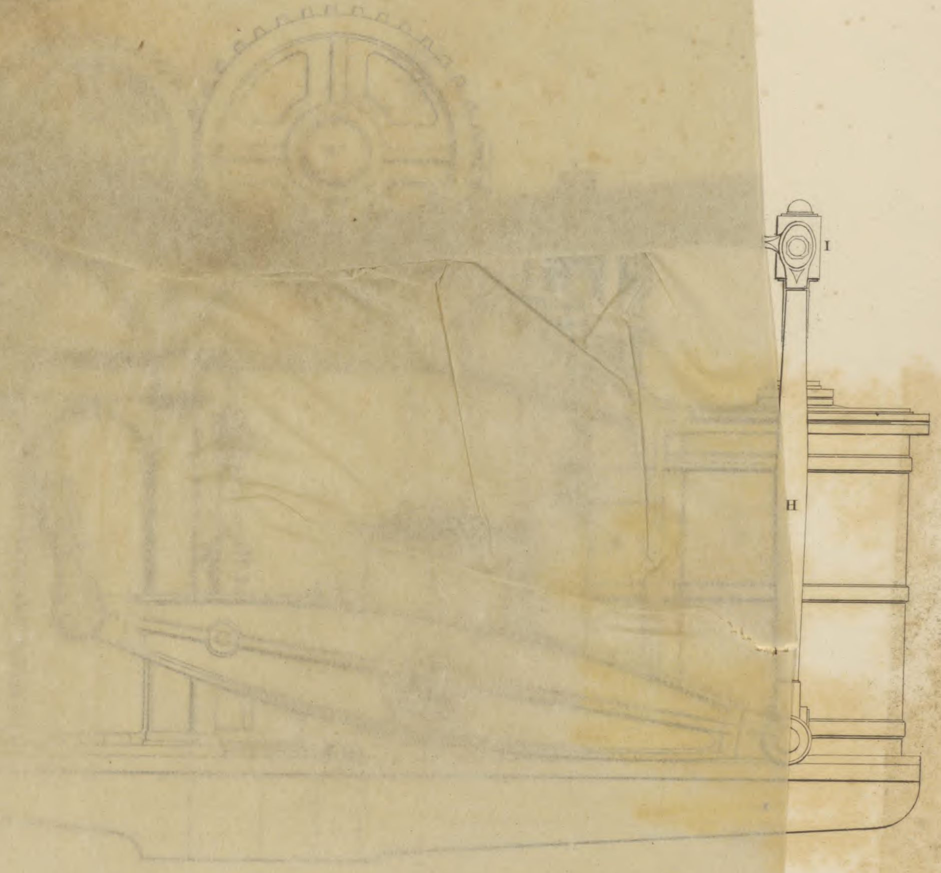
Geo. Aikman, Sculpt

STEAM NAVIGATION.

PLATE CCCCLXXXVIII.

Double Towing Engine of 45

End Elevation



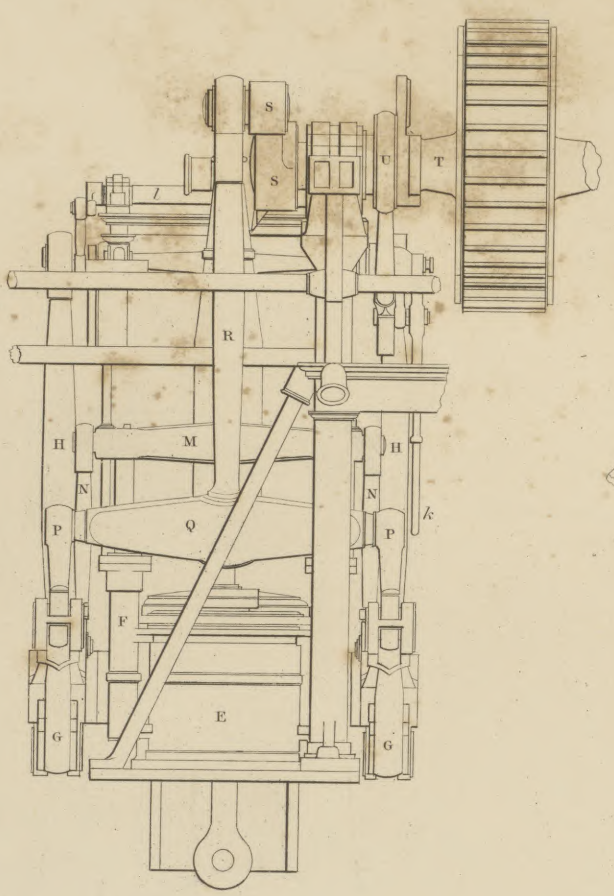
Side Elevation

Geo. Aikman, Sculp.t

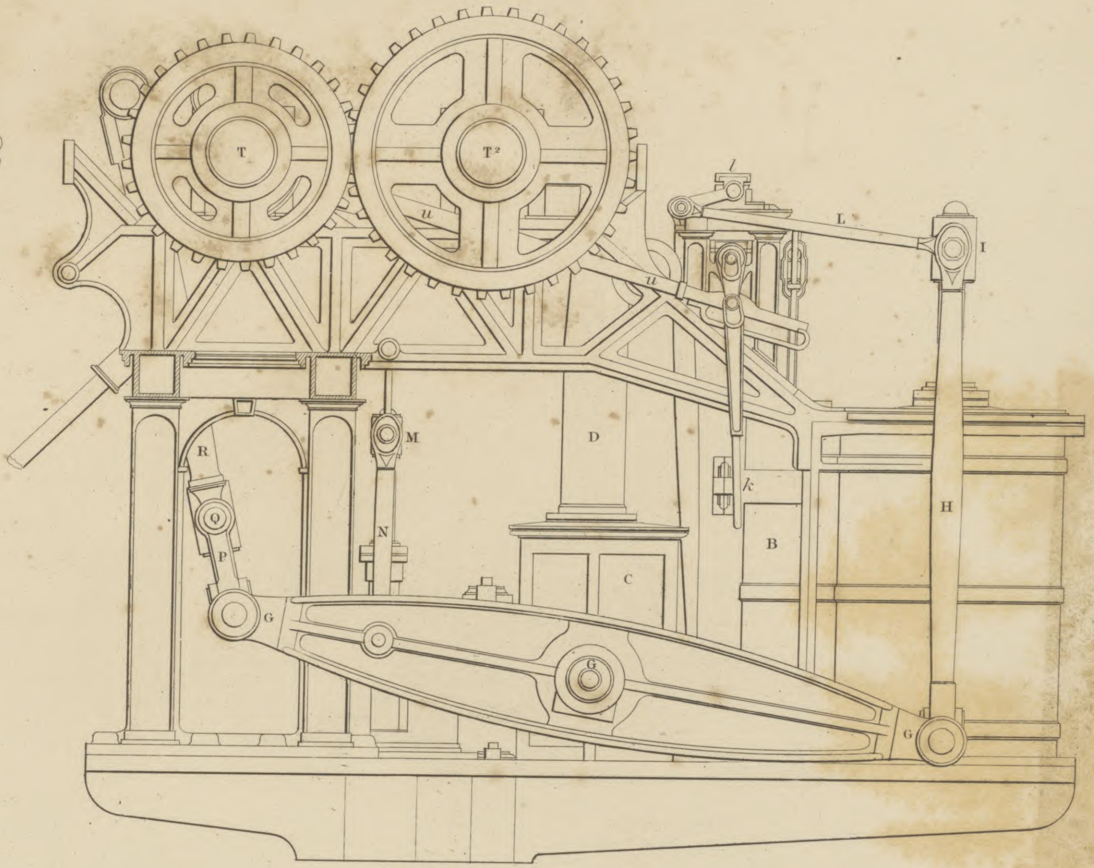
STEAM NAVIGATION.

PLATE CCCCLXXXVIII.

Double Towing Engine of 45 HP.



End Elevation.

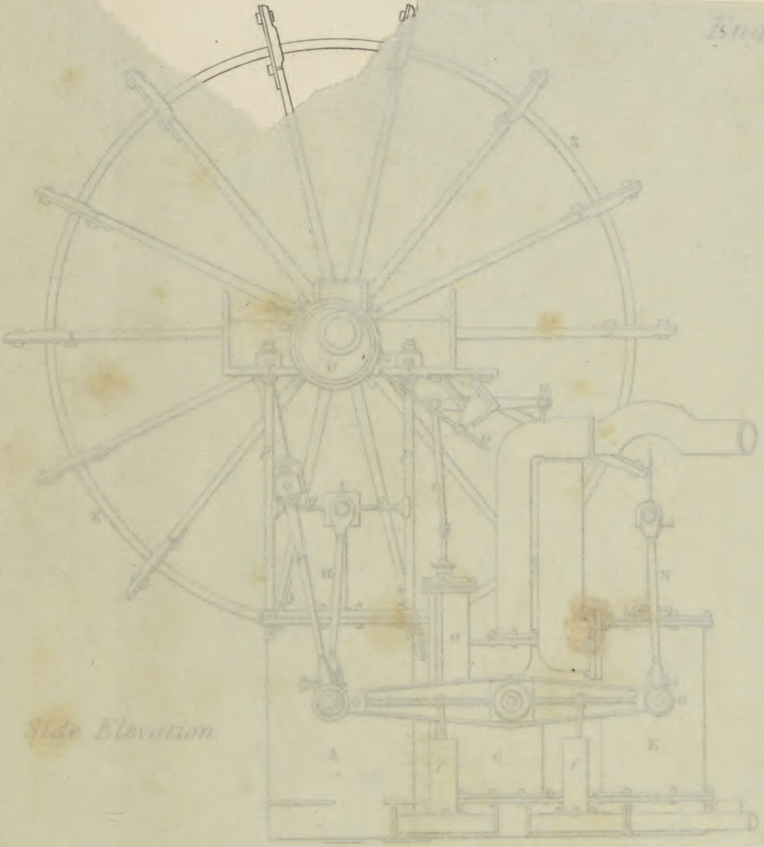


Side Elevation.

Geo. Aikman, Sculpt.

Engines of direct connexion

Fig. 1.



Side Elevation

Fig. 2.

End Elevation

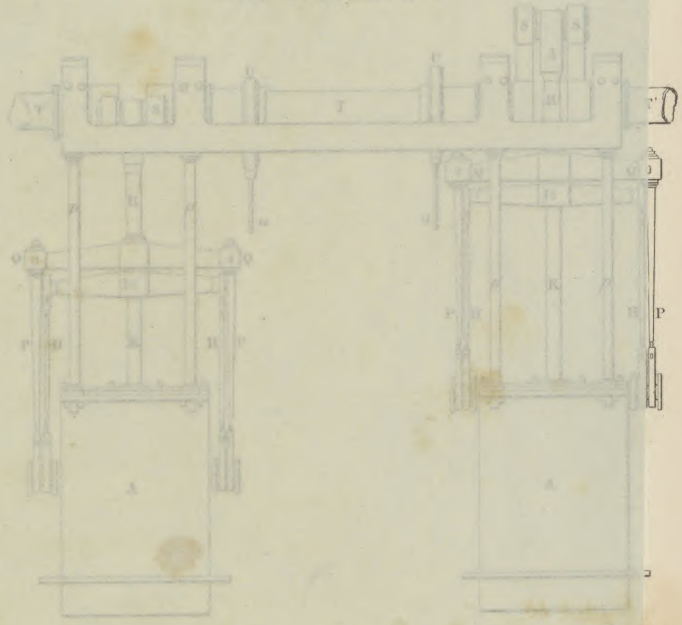
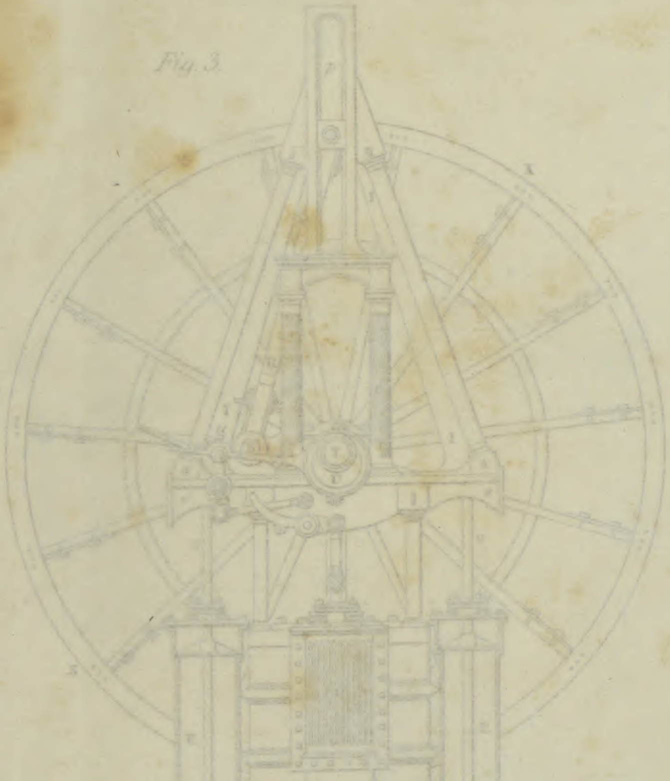
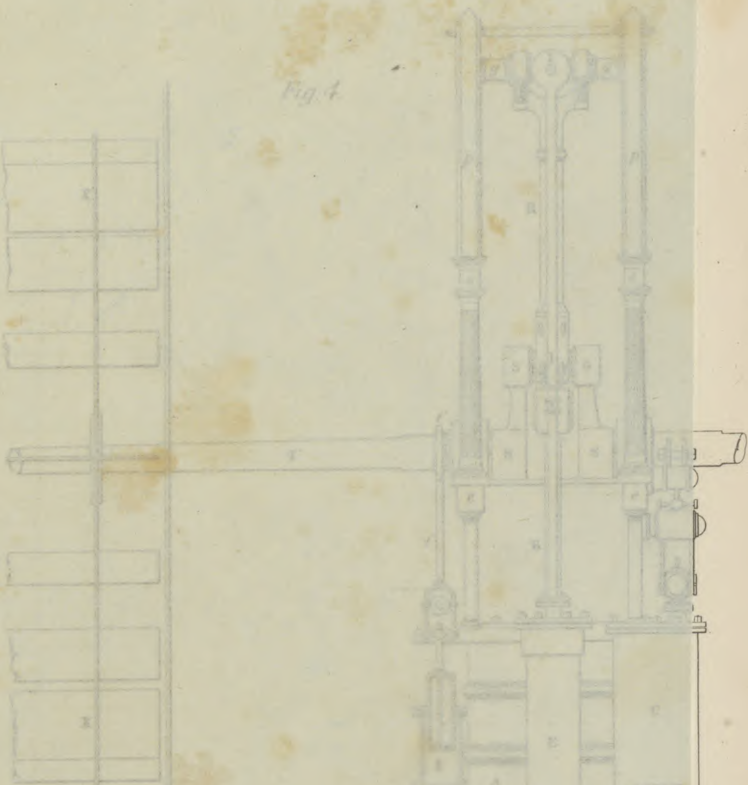


Fig. 3.



Side Elevation.

Fig. 4.



End Elevation

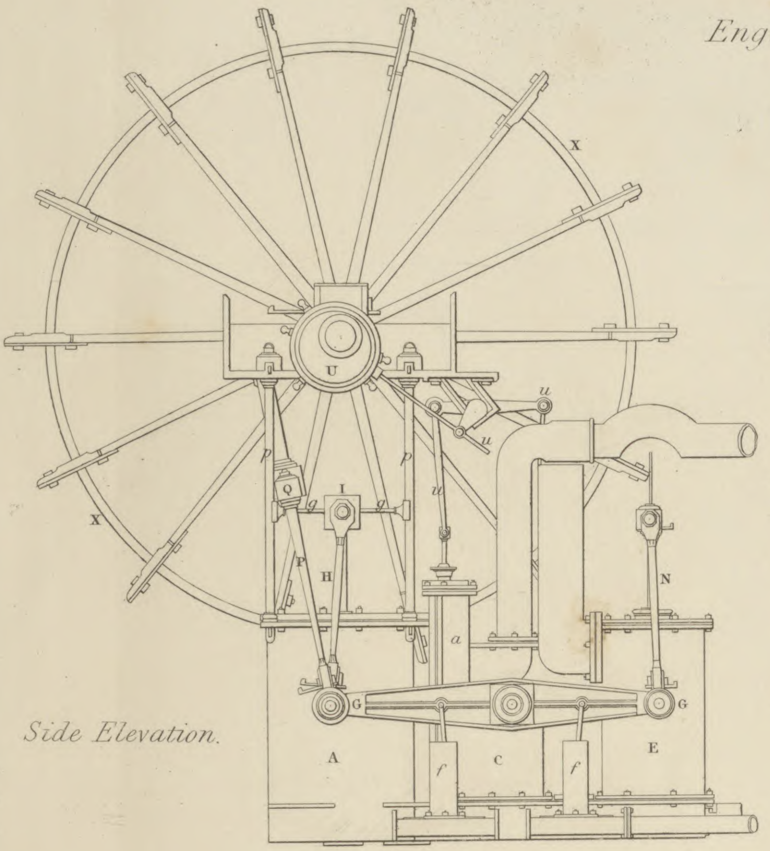
Geo. Aikman, Sculpt.

STEAM NAVIGATION.

PLATE CCCCLXXXIX.

Engines of direct connexion.

Fig. 1.



Side Elevation.

Fig. 2.

End Elevation.

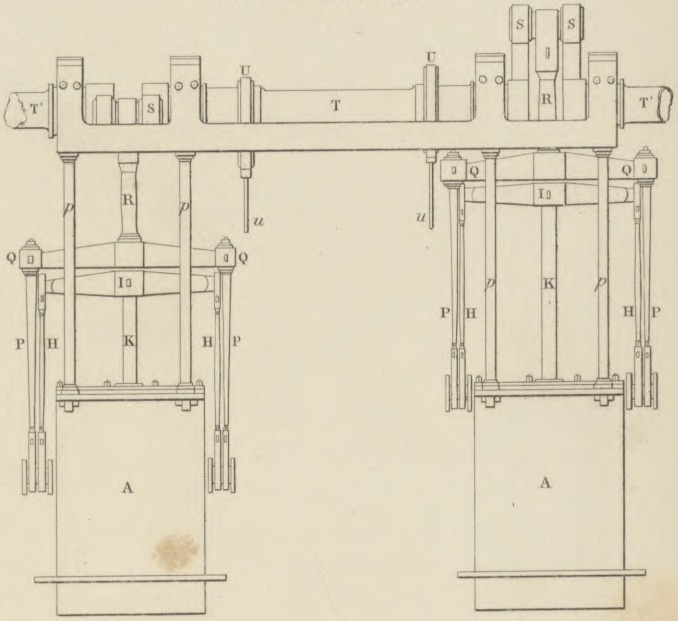
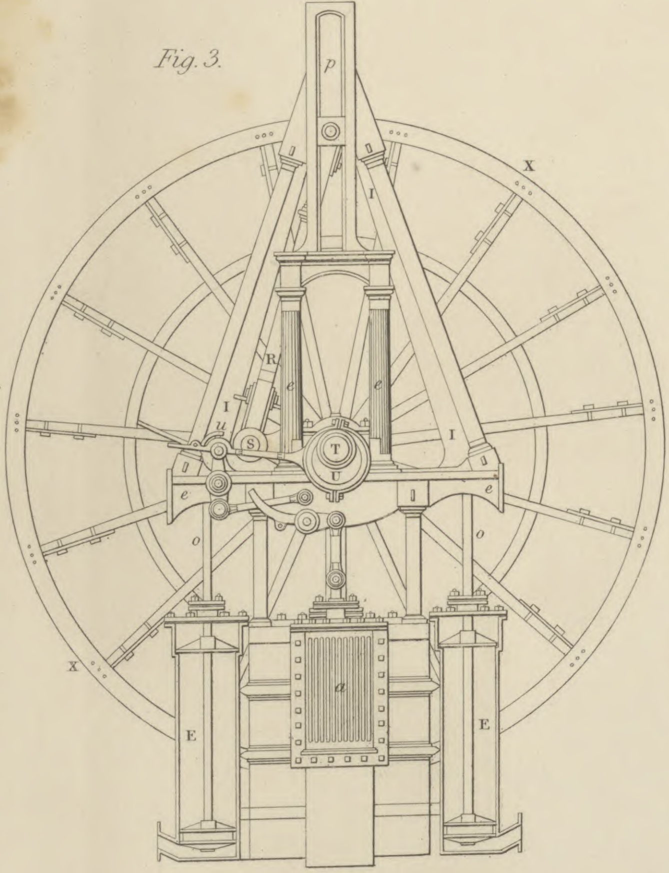
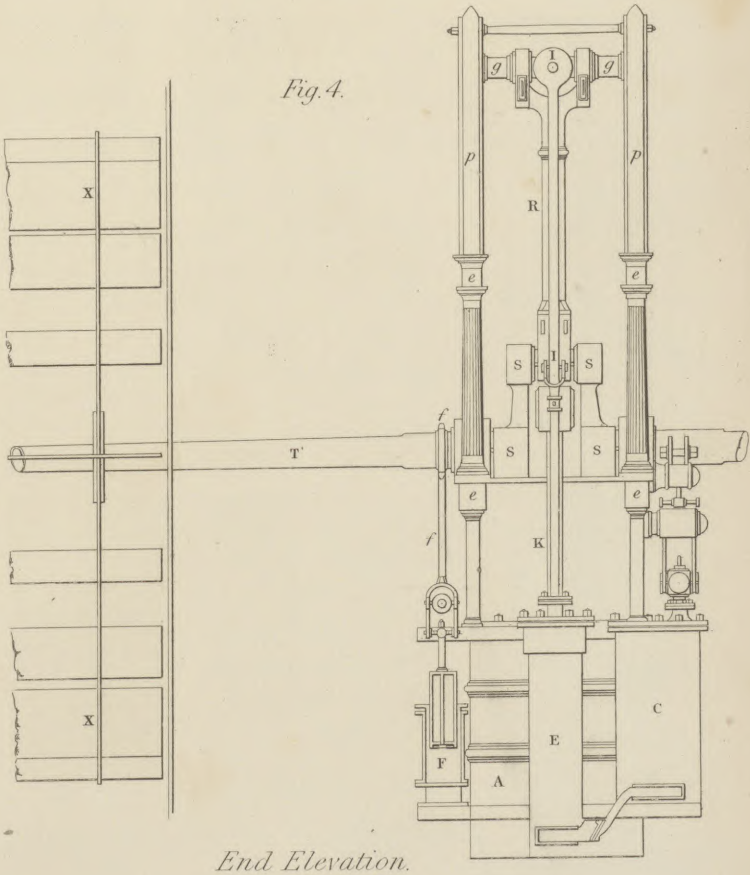


Fig. 3.



Side Elevation.

Fig. 4.

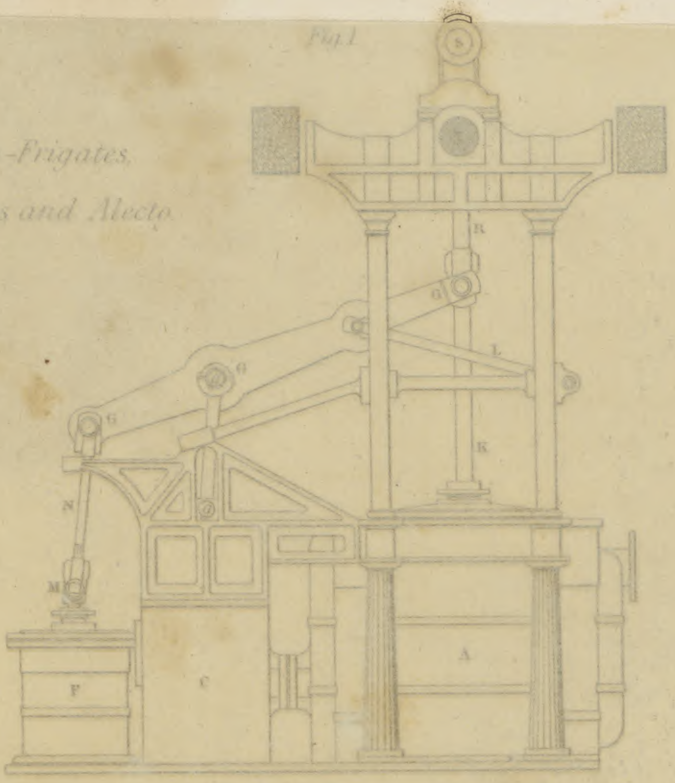


End Elevation.

Geo. Aikman, Sculpt.

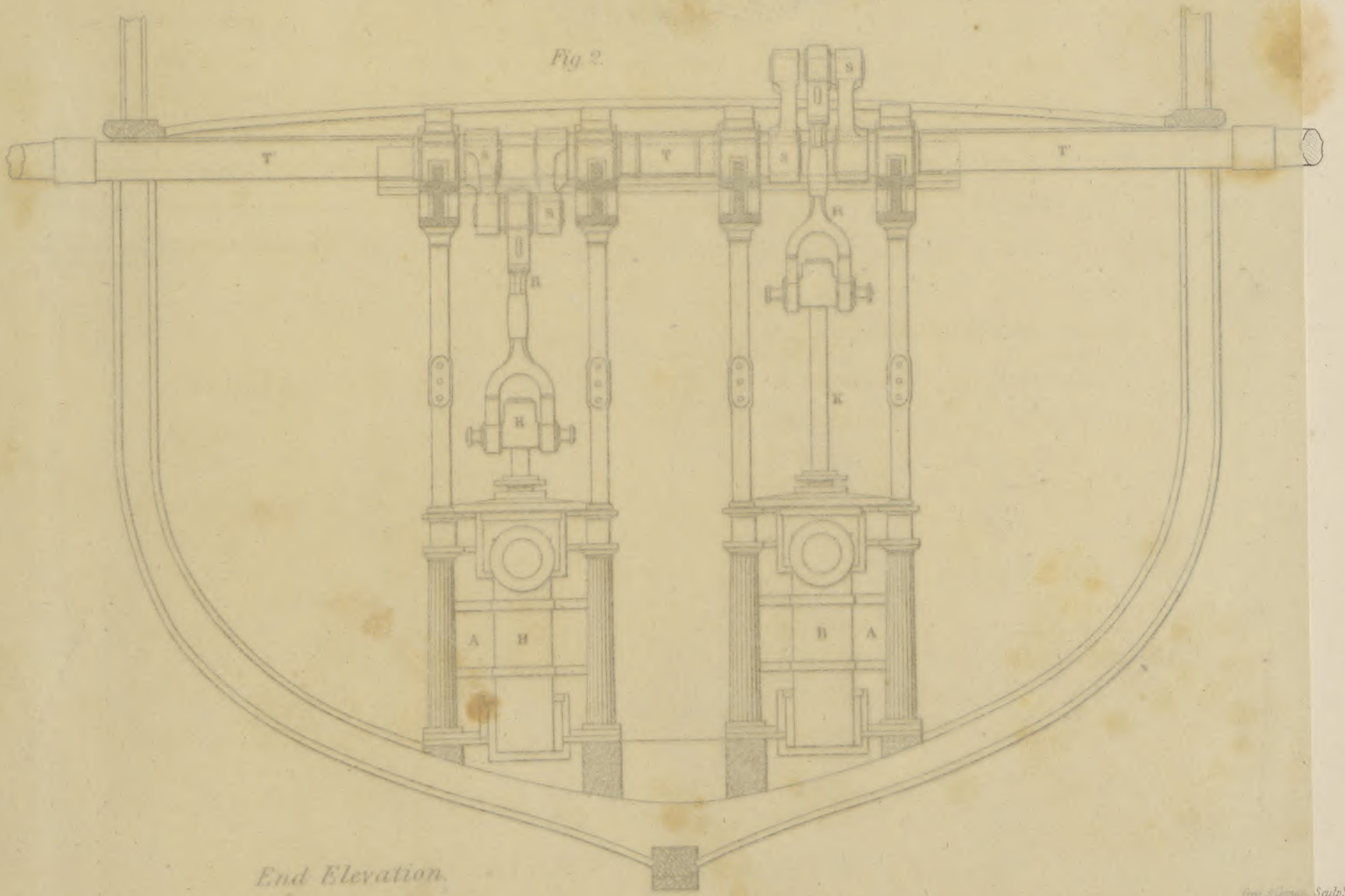
Engines of H.M. Steam-Frigates.
Gorgon, Cyclops, Prometheus and Alecto.

Fig. 1



Side Elevation.

Fig. 2

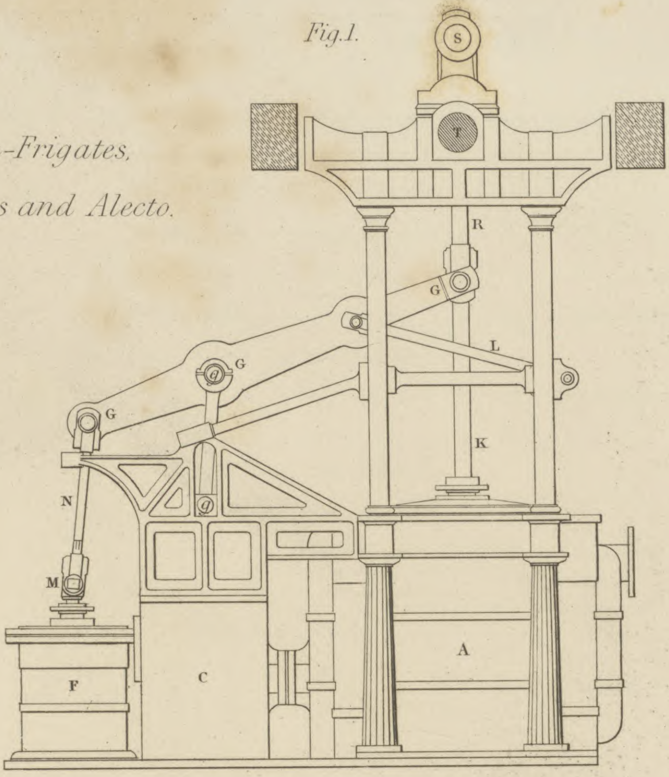


End Elevation.

Geo. Aikman, Sculp^t.

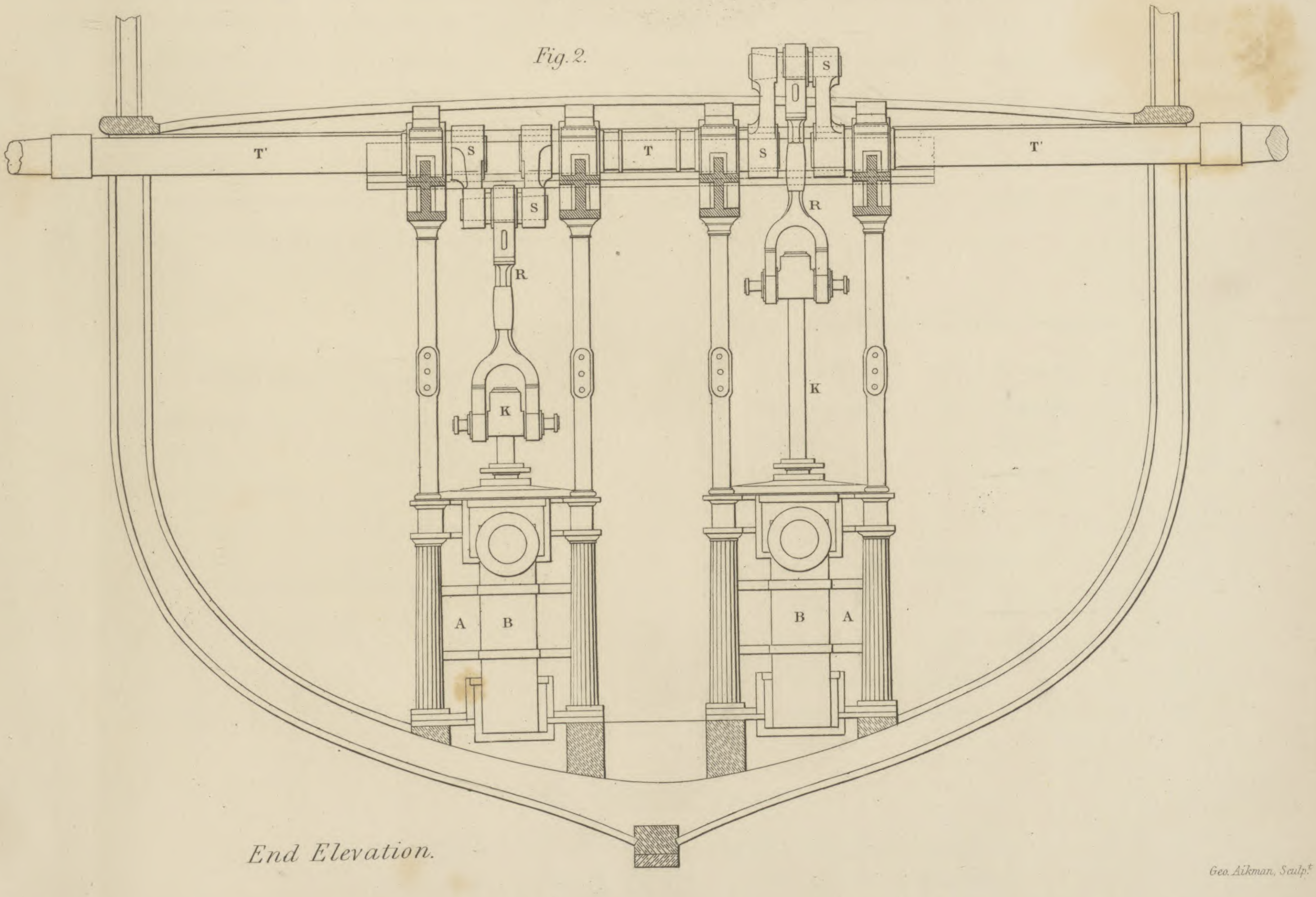
Engines of H.M. Steam-Frigates,
Gorgon, Cyclops, Prometheus and Alecto.

Fig. 1.



Side Elevation.

Fig. 2.



End Elevation.

Geo. Aikman, Sculp^t.

STENOGRAPHY.

PLATE CCCCXCI.

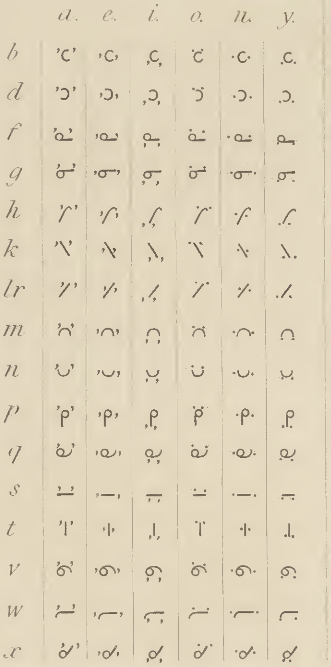
THE ALPHABET

WITH THE DOUBLE & TRIPLE CONSONANTS.

Letters.	Char.	Arbitrary Abbreviations.
a	’	a, an, above
b	c	be, by, because.
c	_	〰
d	ɔ	do, did.
e	,	ever, every, middle
f	⌣	from, if.
g j	σ	God, give, gives.
h	ʃ	he, had, his.
i	,	I, eye, below
k	\\	king, know.
l	/	Lord, will, all.
m	⌒	me, my, most.
n	◡	and, in, nature.
o	·	O, oh, owe, above
p	ρ	people, peace.
q	ə	question, quantity.
r	ɦ	or, are.
s	–	is, us, soon.
t	ı	the, to, it.
v	ɞ	have, save.
u	·	you, view, middle
w	⌐	we, with.
x	∂	except, example.
y	·	ye, your, yes, below
z	⁄	〰.

Dble Cons. &c.	Char.	Arbtry Abbreviations.
ch	\\	each, such.
sh	б	shall, she.
th	ʃ	that, they.
thr	ϱ	therefore.
str	ɑ	strive, strong.
wh	⌣	who, which.

VOWELS PLACES.



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PREPOSITIONS AND TERMINATIONS.

Prepositions.	Char.	Exam.	Signification.
abs, obs	c	ɕ	abstain.
anti, ante anta	,	ʔ	antidote.
contr i a contro counter	\\	\\ɑ	counterfeit.
dis-in-com	ɔ	ɔρ	discompose.
hyp-o-er	ʃ	ʃn	hypocrite.
magn-i-a multi	⌒	⌒⌣	magnify.
omni	·	·◡	omniscience.
int-er-ro enter	◡	◡ɩ	entertain.
post preter	ρ	ρρ	postpone.
recon recom	ɦ	ɦ⌐	reconcile.
satis	–	–⌣	satisfy.
circum			
trans	ı	ıɐ	transfer.
ext-er-in extra	∂	∂ρ	extirpate.

Terminations.	Char.	Exam.	Signification.
able ible	c	ɔ̄c	stable.
flict flect full ference	⌣	◡⌣	conflict.
ing	∘	∂	thing.
ings	·	ʃ	things.
tion cion sion cian tian &c.	∘	ϱ	petition.
tions &c.	·	ρ	petitions.
siss ces sys sus tious cious &c.	⩍	⊏	thesis.
less	/	⌐/	harmless.
ment	⌒	ʔ	indictment.
self	⌣	ɦ⌣	himself.
stract strict	–	~–	substract.
ward	⌐	⌣⌐	forward.

ARBITRARY MARKS.

:	on, one.	„	as.
..	for.	;	only.
∘	of, oft, often.	⊸	nothing.
0	at, am.	∩	where-fore.

FIGURES.

1	2	3	4	5	6	7	8	9	0
,	–	ı	\\	/	⌒	◡	(	)	.

1840 ,ɑ\. £567. 17 ıɒ◡ ,◡

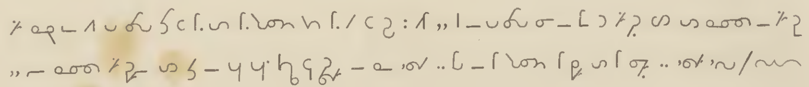
ABBREVIATING MARKS.

A Substantive.	í	Division.	ɔ́
An Adjective.	!	Divisible.	ʔ
A Verb.	i	Divide.	ɔ̇
A Participle.	!	Dividing.	ʔ

POINTS.

A Comma.	‘	A Semicolon.	;
A Colon.	‹	A Period.	/
A Point of Interrogation.	?		
A Point of Admiration.	!		

THE LORD'S PRAYER.



[illegible] Aikman Sculpt.

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